State and Federal Applications for Renewal of the Trans Alaska Pipeline System

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ENVIRONMENTAL REPORT

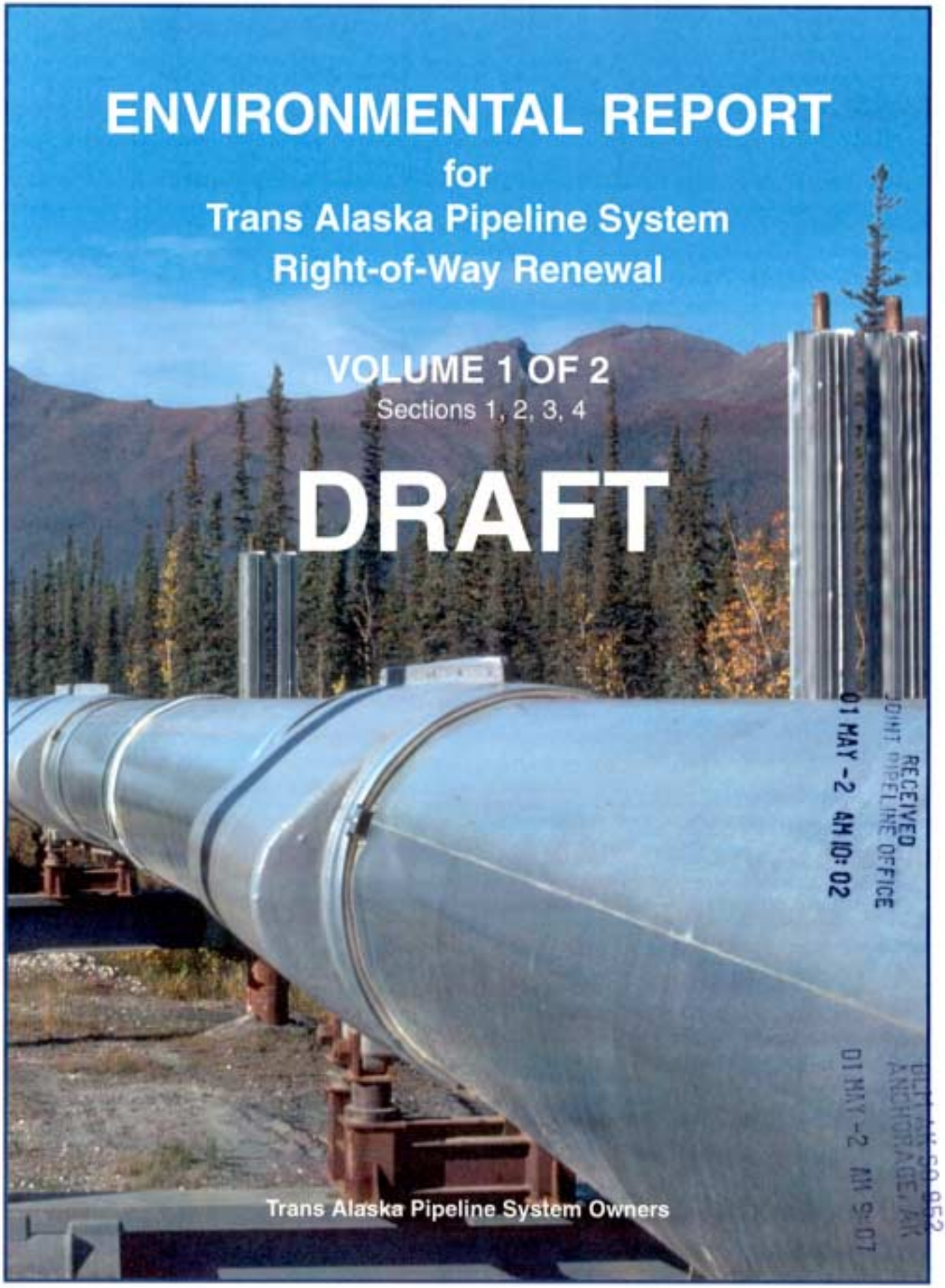
for

Trans Alaska Pipeline System Right-of-Way Renewal

VOLUME 1 OF 2

Sections 1, 2, 3, 4

DRAFT



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Trans Alaska Pipeline System Owners

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Volume 1 of 2
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ENVIRONMENTAL REPORT FOR TRANS ALASKA PIPELINE SYSTEM RENEWAL

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IMPORTANT NOTE

The authors of this Environmental Report have made every effort to gather complete and accurate data for their analysis. Projections of future TAPS throughput and configuration, North Slope oil development, gas commercialization and tanker transportation are necessarily dependent on assumptions about oil and gas production, future technology, and the facilities and equipment needed. The authors' assumptions represent informed projections based on knowledge of current operations and are not meant to imply that these predictions completely and accurately reflect all future scenarios pertaining to TAPS, North Slope oil and gas development, or tanker transportation. Actual outcomes are dependant on many variables including the economics of oil and gas production, changing laws and regulations, and political realities, and may differ significantly from those predicted here.

ENVIRONMENTAL REPORT for Trans Alaska Pipeline System Right-of-Way Renewal

Preparers

This report was prepared by a team of specialists under the auspices of the Owners of the Trans Alaska Pipeline System (TAPS). Section 5 of this report contains a complete list of authors.

Proposed Action

The Permittees propose to renew the Federal Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline to continue operation of TAPS for an additional 30 years beyond expiration of the agreement in 2004. The Permittees also propose to renew the State Right-of-Way Lease, which also expires in 2004, and this Environmental Report supports that application as well.

Abstract

This report provides a comprehensive environmental analysis of the impacts associated with the renewal of the TAPS right-of-way. The federal Council on Environmental Quality guidelines contained in 40 CFR 1500-1517 have been used to prepare this report so that the requirements of the National Environmental Policy Act are satisfied. As such, this report describes the proposed action and the no action alternative which would lead to expiration of the right-of-way and subsequently to the dismantlement and removal of TAPS, and restoration of the right-of-way. The report then details the physical, biological, and social-economic environments and the impacts of the proposed action and the no-action alternative on the environment, including cumulative effects. Measures to mitigate these impacts are also described.

For Further Information

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Executive Summary

Purpose

This Environmental Report supports the application for renewal of the Trans Alaska Pipeline System right-of-way (TAPS ROW). The purpose of TAPS is to transport crude oil from the North Slope of Alaska to the Valdez Marine Terminal, where it is loaded onto tankers for shipment to destination ports. The pipeline is essential to providing oil for the energy needs of the nation — at present, the pipeline carries about 20 percent of all oil produced in the United States. Renewal of the ROW is needed to maintain this critical flow of oil from Alaska.

The TAPS owner companies have applied for renewal of the ROW for the purpose of extending the authorization for the pipeline. The ROW includes both federal and state lands, and agreements governing these rights-of-way were executed in 1974 and will expire in 2004 — the federal Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline (Federal Grant) on January 22, 2004, and the State Right-of-Way Lease for the Trans-Alaska Pipeline (State Lease) on May 2, 2004.

This report follows the guidelines of the federal Council on Environmental Quality (CEQ) for preparing environmental impact statements (EISs) as described in 40 CFR 1500-1517. The report projects the direct, indirect, and cumulative effects of renewing — and of not renewing — the TAPS ROW. However, this Environmental Report is unusual in that the proposed action does not involve construction of a project but rather its continued existence and operation. As a result, this report describes the environment as it now exists following construction and over 20 years of operation of TAPS.

Background

The trans-Alaska pipeline is an 800-mile, 48-inch-diameter crude oil pipeline that is elevated above ground for 420 miles of its length and buried for the other 380 miles. Eleven pump stations were built to move the oil through the pipeline, and four of these are now on standby. The marine terminal at Valdez has storage facilities for over 9 million barrels of oil and loading berths that can accommodate four tankers at once, although only two of these have vapor control and will provide primary loading in the future.

Except for occasional shutdowns for maintenance, the pipeline has operated continuously since June 1977, following three years of construction. TAPS has transported more than 13 billion barrels of crude oil. The peak average daily throughput of 2.03 million barrels per day was reached in 1988, and that rate has dropped to approximately 1 million barrels per day as of the end of 2000.

TAPS is unique among pipelines both for its engineering achievements and for the public controversy generated by its original proposal. Debates surrounding land claims by Alaska Natives, technical challenges, and preparation of an EIS under the newly enacted National Environmental Policy Act (NEPA) delayed construction until 1974 from the original proposal in 1969.

The Department of the Interior released the final EIS for the project in March 1972, but the project was authorized only when President Richard Nixon signed the Trans Alaska Pipeline Authorization Act on November 16, 1973. The Arab oil embargo influenced public opinion in favor of a new domestic source of oil. The pipeline authorization act was intended "to insure that, because of . . . the national interest in early delivery of North Slope oil to domestic markets, the trans-Alaska oil pipeline be constructed promptly without further administrative or judicial delay or impediment." The Act directed the Secretary of the Interior to authorize the federal right-of-way for the pipeline, which he did on January 23, 1974. The State of Alaska issued its right-of-way lease on May 3, 1974.

Report Organization and Summary

In keeping with CEQ guidelines, the body of this report is divided into four major sections:

- Section 1, Purpose of and need for the action.

- Section 2, Alternatives including the proposed action.
- Section 3, Affected environment.
- Section 4, Environmental consequences of proposed action and alternatives.

Section 1 describes the purpose and need for the proposed action or renewal of the TAPS ROW. The section also gives a brief history of TAPS, as well as the assumptions for this report.

Section 2 presents the two alternatives. The *proposed action*, discussed in Section 2.1, entails renewal of the ROW, which means that the pipeline and its appurtenances will stay in operation in essentially the same configuration as now. The *no-action alternative* (Section 2.2) involves expiration of the ROW in 2004. In this case, the pipeline system will have to be removed in accordance with the terms of the Federal Grant and State Lease. Federal and state stipulations contain general provisions for "dismantling, removal, and restoration" (DR&R) of TAPS assets upon completion of use of the TAPS ROW. In that case, it would be necessary to prematurely shut in North Slope production since the pipeline would not be available for transporting crude oil.

This Environmental Report focuses on all of TAPS, which is defined in Stipulation 1.1.1.22 of the Federal Grant to include

> "...all facilities located in Alaska used by Permittees in connection with the construction, operation, maintenance or termination of the Pipeline. This includes, but is not limited to, the Pipeline, storage tanks, Access Roads, communications site, airfields, construction camps, materials sites, bridges, construction equipment and facilities at the origin station and at the Valdez terminal. This does not include facilities used in connection with production of oil or gathering systems, nor does it include such things as urban administrative offices and similar facilities which are only indirectly involved."

Thus, Section 2.1 of this Environmental Report describes all of these elements of TAPS including facilities integral to TAPS but on fee-simple land and not part of the ROW [e.g., Valdez Marine Terminal (VMT), Pump Station 1] and other facilities used in operation such as access roads, the fuel gas pipeline, material sites, and the Dalton Highway (a state highway with its own right-of-way). However, Alyeska operates the Ship Escort/Response Vessel System (SERVS) to provide spill prevention and response in support of the tanker trade, and discussion is provided in this section for convenience. The discussion of the proposed action in Section 2.1 also includes the marine transportation link, which is not part of TAPS.

Other alternatives considered but not included in the analysis are covered in Section 2.3. The original TAPS EIS evaluated such alternatives, which included shipping oil through the Northwest Passage by tanker, trucking oil, and building a pipeline through Canada. Those alternatives were not viable in 1972, and with TAPS already in operation, no practical or economically feasible alternative exists for transporting North Slope crude oil to market.

Section 3 describes the environment affected either by renewal of the TAPS ROW or by its expiration. It is important to note that unlike most projects covered in environmental impact statements, TAPS has been in operation for over 20 years. As a result, the existing environment has already been affected by TAPS. The affected environment as discussed in Section 3 includes the following three study areas (Figure 1):

- Alaska North Slope (ANS),
- The pipeline route from Prudhoe Bay to Valdez, and
- The Prince William Sound (PWS)/North Gulf Coast region.

Section 3 is divided into three major subsections:

- Section 3.1 covers the physical environment, including the terrestrial environment, water resources, and atmospheric environment.
- Section 3.2 describes the biological resources along the TAPS ROW. The ecosystem structure and vegetation of each ecoregion in the ROW are described, as well as the life history and population-level characteristics of the animals in those systems. Important species include caribou, moose, bear, and other terrestrial mammals.
- Section 3.3 provides relevant information about social systems in the affected environment, including the economy; sociocultural systems; subsistence activities and patterns; cultural resources; land ownership, land use, and coastal management; recreation and visual resources; wilderness; and transportation.

Section 4 describes the direct, indirect, and cumulative environmental consequences of the proposed action and the no-action alternative.

- Section 4.1 provides information on the mechanisms of impact, which include ground-impacting maintenance actions such as corrosion digs and workpad maintenance, and oil spills. The discussion on oil spills contains a detailed evaluation of the potential number, size, and location of possible spills.
- Section 4.2 details the existing mitigation measures that are already in place on TAPS to address known impacts.
- Sections 4.3 and 4.4, respectively, address the direct

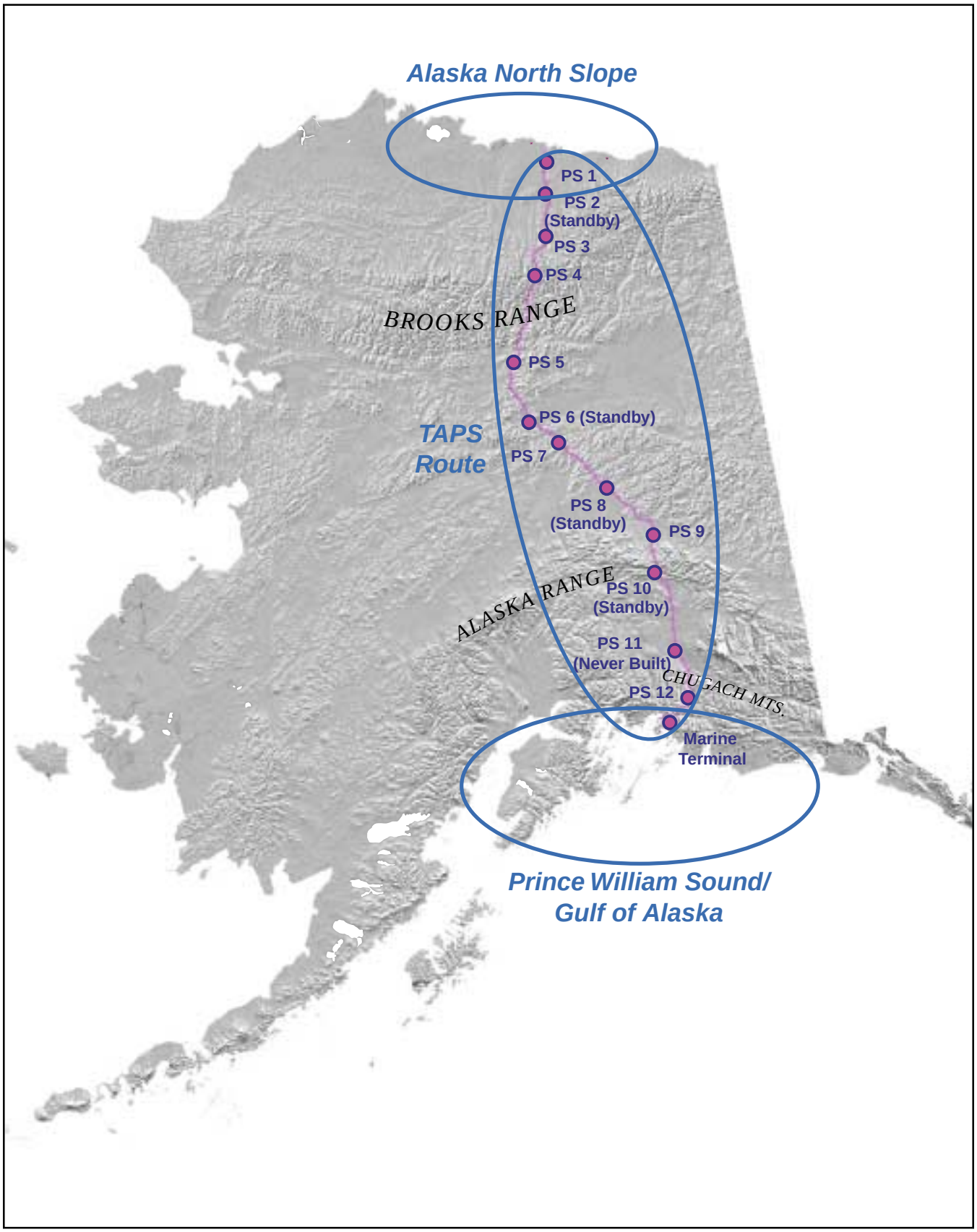

Figure 1. *General study areas used in preparation of this Environmental Report.*

and indirect impacts of both the proposed action and the no-action alternative.
- Section 4.5 discusses the cumulative impacts of both alternatives in light of other past, present, and reasonably foreseeable actions.
- Section 4.6 identifies the unavoidable adverse impacts of the alternatives.
- Sections 4.7 through 4.13 cover miscellaneous impact considerations required by CEQ guidelines.

The remainder of the report contains the following sections and appendices:
- Section 5, List of preparers.
- Section 6, Index.
- Section 7, List of acronyms.
- Section 8, Literature cited.
- Appendix A, TAPS throughput analysis.
- Appendix B, Oil spill analysis.
- Appendix C, TAPS ROW map atlas.
- Appendix D, Historical overview of North Slope oil development.
- Appendix E, Federal Agreement and Grant of Right-of-Way for Trans-Alaska Pipeline.

Summary of Environmental Consequences

Most environmental assessments (EAs) and EISs deal largely or exclusively with future projects. The principal focus of this analysis is the continuation of a system that has been in operation since 1977. Because the system has been in operation for so many years, it is possible to extrapolate from prior experience to develop relatively accurate estimates of possible future effects. Estimates of the incremental effects resulting from future projects (e.g., gas commercialization) are more uncertain but are believed to be reliable nonetheless.

The direct, indirect, and cumulative impacts of both the proposed action and the no-action alternative will vary geographically and will depend on the implementation of mitigation and prevention measures. In general, as long as mitigation and prevention measures are implemented, the direct impacts of TAPS will be limited and manageable. TAPS activities are strictly regulated by the Joint Pipeline Office, other government agencies, and Alyeska policies. Indirect impacts associated with use of the TAPS ROW and adjacent areas by the public may be more substantial than direct impacts, but this activity is also regulated by government. The cumulative impacts — considering the ANS oil fields, tanker operations in Prince William Sound, and other actions — are more extensive because of the increased geographic scope and different types of developments. Following is a summary of important physical, biological, and social effects of both the proposed action and no-action alternative.

Definition of Impacts

The three study areas are treated together in describing the affected environment, but impacts are analyzed separately in Section 4. Sections 4.3 and 4.4 discuss the direct and indirect effects of the proposed action and the no-action alternative on the pipeline route itself, while Section 4.5 analyzes the cumulative impacts. [Note that the CEQ guidelines consider the terms *effect* and *impact* to be synonymous (40 CFR 1508.8).] These analyses follow as closely as possible the definitions provided by the Council on Environmental Quality (CEQ):
- **Direct effects** are “caused by the action and occur at the same time and place” (40 CFR 1508.7).
- **Indirect effects** are “caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems” (40 CFR 1508.7).
- **Cumulative impact** is “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time” (40 CFR 1508.7).

In accordance with these definitions, the direct effects are treated as those directly associated with TAPS as defined above, which includes the pipeline, pump stations, access roads, material sites, VMT, etc. Such effects include ground disturbance from maintenance actions, air emissions from pump stations, and wastewater discharges from ballast water treatment .

For this Environmental Report, the distinction between indirect effects and cumulative impacts is somewhat complex. It would be possible to consider the effects of the Alaska North Slope oil fields and the marine transportation link as indirect effects of TAPS ROW renewal. However, these are treated in the cumulative effects section for two

reasons. First, developments on the North Slope require extensive permitting, have undergone NEPA reviews, and thus are considered separate actions from TAPS ROW renewal. The permitting for such developments usually includes an EA or EIS. Secondly, the marine transportation system, while integral to bringing ANS crude to market, is managed by a separate set of agencies and laws than TAPS itself. For example, the Oil Pollution Act of 1990 (OPA 90) and U.S. Coast Guard regulations mandate how tankers operate in Prince William Sound and the Gulf of Alaska. Alyeska Pipeline Service Company provides tanker escort and spill response support in accordance with OPA 90, but the tankers are not under Alyeska control or the control of the Joint Pipeline Office, which regulates TAPS operation.

As a result, development of Alaska North Slope oil fields and the marine transportation system are treated in Section 4.5 of this Environmental Report as separate actions from TAPS ROW renewal. It is somewhat academic to debate whether their effects are treated as indirect effects of TAPS because they would not exist without TAPS or as cumulative effects since they are separate actions. It is important to adequately assess their separate and cumulative effects.

In general, Section 4.5 of this Environmental Report treats ANS and PWS effects as cumulative effects because these regions are not directly affected by TAPS as defined in Stipulation 1.1.1.22 of the Federal Grant. However, the specific approach for each technical discipline varies based on the requirements of the analysis. For example, the analysis of economic effects in Section 4.3 includes the effects of North Slope oil development and tanker transportation. The model used for this analysis considers the economics of the entire oil production and transportation system because they are inextricably tied together economically.

Consequences of Proposed Action

The proposed action involves continued operation of TAPS for an additional 30 years. Following is a summary of the physical, biological, and social effects of the proposed action.

Physical Characteristics

TAPS operation affects the terrestrial, aquatic, and atmospheric environments. Because the pipeline system has been in continuous operation since 1977 under stringent regulatory controls, its effects on the physical environment — terrestrial, air quality, and water quality — are familiar and can reasonably be expected to continue without significant change under the proposed action. Justification for predictions of low impact is detailed in the remainder of Section 4 and can be summarized in the following conclusions:

- The TAPS pipeline and related facilities already exist with known, observable impacts;
- Major changes to the pipeline system or to the affected physical environment are not expected during the ROW renewal period;
- New surface-disturbance areas associated with TAPS will be small and isolated;
- There would be no unavoidable adverse effect on the physical environment that would not be mitigated to the fullest extent technically feasible.

Terrestrial Environment: Continued operation of TAPS will impact some parts of the terrestrial environment because of maintenance activities, corrosion digs, construction projects for pipeline-related facilities, and the continued presence of a buried warm-oil pipeline in permafrost terrain. Maintenance since startup has caused localized temporary land disturbance but has generally stabilized the ground in and adjacent to the ROW. Since nearly all maintenance activities occur on or along existing stabilized embankments, new major long-term changes to the terrestrial environment are not anticipated.

The pipeline will not affect seismicity, although seismic activity may impact the pipeline. However, seismic risk and mitigation measures to reduce this risk remain and are not expected to increase.

Global climate change may cause more warming on the ground surface, but subsurface permafrost thaw will not advance appreciably more than current projections and will be well within maintenance efforts anticipated for pipe support features.

The impact of the pipeline on the behavior of rivers and floodplains depends on whether river training structures are used and the type of structure used. Buried river crossings with no river training structures have little or no impact on the behavior of rivers. Bridged crossings have little or no impact, except for the local impact of the piers on flow.

Water Resources: Continued operation of TAPS will require continued use of water resources to support operations and maintenance activities. Wastewaters will continue to be treated, discharged, and assimilated by upland and freshwater receiving environments along the pipeline. Marine waters of Port Valdez will continue to be used to assimilate treated discharges from the VMT, including sanitary wastewater and ballast water. Wastewater discharges are strictly regulated, and there is no evidence that these discharges have negatively affected the physical environment. Discharges will continue to be regulated, and significant impacts are not expected.

Atmospheric Environment: TAPS throughput is in decline, and there is a strong likelihood that there will be a corresponding TAPS-wide net decrease in emissions and emission impacts. This prediction is supported by the results of several air quality permit applications and modeling studies, as well as the effect of plant improvements that have occurred at the pump stations and the VMT. Widespread point-source emissions are strictly regulated, and there is no evidence of deterioration in air quality as a result of TAPS. Future emissions are not expected to cause air-quality concerns.

Cumulative Effects: None of the potential physical cumulative effects is considered significant by this analysis. Potential cumulative effects do not meet the intensity and probability criteria for significance because:

- TAPS pipeline and related facilities already exist;
- Major changes to the pipeline system or to the affected physical environment are not expected during the ROW renewal period;
- New surface disturbance areas associated with TAPS will be small and isolated;
- Future North Slope development and potential gas commercialization projects would not cause significant disturbance to the physical environment, with the exception of the transitory construction disturbance.
- Pump stations, potential compressor stations, and marine terminals (VMT and liquefied natural gas) would be widely separated, and their emissions would be relatively small and strictly regulated; and
- There would be no unavoidable adverse effect on the physical environment that would not be mitigated to the fullest extent technically feasible.

With continued regulatory compliance by TAPS and any associated future project, potential cumulative effects on physical resources are not expected to become significant issues during the life of the proposed action.

Biological Resources

Biological resources potentially affected by continued TAPS operation include vegetation and wetlands, fish, birds, and terrestrial and marine mammals. If one examines the ecosystems impacted by the construction and operation of TAPS and associated activity for almost 30 years, their health and integrity is remarkable. With the exception of local impacts described in this section, the vegetation, fish, and wildlife along TAPS have not been impacted at the population level. TAPS can be viewed as another feature on the landscape, to which the flora and fauna have habituated. Even the ANS, with extensive oil fields, has a healthy community of flora and fauna. Populations of large and small mammals, birds, and fish are healthy despite development of the oil fields (Truett and Johnson, 2000). In Prince William Sound, some populations of seabirds and sea otters were reduced substantially by mortality from the *Exxon Valdez* oil spill. However, despite concerns over lingering toxicity from residual oil, populations are generally recovered or recovering from oil spill impacts. In all three areas — the TAPS ROW, the ANS, and Prince William Sound — there are local impacts, but overall, vegetation communities and fish and wildlife populations have fared well and will continue to thrive in the future.

Vegetation and Wetlands: Impacts include loss under gravel fill and changes from water impoundments and thermokarst. These impacts will not increase much in the TAPS ROW because no major new construction is anticipated. New oil and gas developments on the ANS will add to these impacts, but the footprints of new developments are relatively small. The cumulative loss of vegetation and wetlands is small relative to the overall land area along TAPS and on the ANS. Concerns over vegetation and wetlands often stem from their value as fish and wildlife habitat. The lack of negative population-level effects from TAPS and the ANS oil fields on fish and wildlife populations suggests that impacts have not included significant losses of habitat.

Fish: Impacts on fish include obstruction of movements in low water crossings or culverts along TAPS, injury or habitat loss from potential oil spills, and recreational fishing harvests. Obstruction of movements is a continuous problem because of the dynamic nature of the TAPS ROW and associated waterbodies. Adequate monitoring and maintenance of the low water crossings and culverts can mitigate this problem. Oil spills can impact fish, although the duration and extent of impacts are usually limited. The impacts of the *Exxon Valdez* oil spill on fish are widely debated, and the extent of impacts on populations is uncertain. Regardless, prevention of oil spills and rapid response when they occur are necessary to minimize impacts. With the tanker escort system, enhancements to marine safety such as improved navigation systems, and new, state-of-the-art double-hulled tankers, the probability of a large marine spill has been reduced significantly. Sport and subsistence harvest of fish can reduce populations, and this may have occurred in some lakes along the TAPS ROW. Regulation and monitoring by the appropriate agencies is needed to manage this impact.

Birds: Increased predation on waterfowl by mammalian and avian predators may occur if predator populations increase due to access to garbage. This may have impacted

colonial nesting geese and shorebirds on the ANS during the 1990s. This issue has been addressed with proper refuse management along TAPS, and is being addressed with new refuse management systems in the ANS oil fields. Oil spills, such as the *Exxon Valdez* oil spill, can kill large numbers of birds, and prevention and rapid response are very important. As indicated above, there have been significant improvements to marine safety which will minimize the probability of this impact during the proposed action period.

Positive impacts, such as habitat enhancement, result from early snowmelt and green-up in dust shadows along the Dalton Highway and from structures that provide perching and nesting sites.

Terrestrial Mammals: Potential impacts include disturbance and displacement from preferred habitats, mortality from roadkills, increased predator numbers from access to anthropogenic foods, and sport hunting. Of these, only the impacts of sport hunting appear important, although harvest is well-regulated by government agencies to achieve population management objectives. The impact of highway and rail roadkills has not been large along the TAPS ROW. However, it is significant in Southcentral Alaska, and it would be prudent for regulatory agencies to consider mitigation measures for other areas, including that around TAPS, if traffic increases in the future. On the ANS, disturbance and displacement of caribou during the calving period is a potential impact. Although the Central Arctic herd has increased and maintained good calf productivity despite oil field development, there are concerns that at some point development will have a negative impact. Monitoring calving distributions and restricting certain activities can effectively mitigate this impact. Increased predator numbers are thought to have occurred on the ANS due to access to anthropogenic foods. Steps have been taken to prevent access to garbage and intentional feeding of bears, foxes, gulls, and ravens. Continued implementation of these practices is needed.

Marine Mammals: Important impacts include disturbance and displacement during offshore exploration and development, and mortality or injury from oil spills. Extensive monitoring of noise and marine mammal behavior and distribution during offshore operations is mandated in regulations, and mitigation measures have been implemented (e.g., restricting timing of operations) to minimize disturbance and displacement. Oil spills in the Beaufort Sea or Prince William Sound can potentially impact marine mammals, and as for birds and fish, prevention and rapid response are important.

Social Systems

The renewal of the TAPS ROW will provide the opportunity to produce an additional 7 billion barrels of oil from the ANS oil fields, will increase the likelihood of commercializing some 30 trillion cubic feet of currently stranded gas, and result in great economic benefits for the U.S., the state of Alaska, local governments, and residents of Alaska. About 20 percent of current U.S. oil production flows through TAPS, and its continued operation will reduce the U.S. balance-of-payment deficit by approximately $150 billion in 1998 dollars (based on U.S. Department of Energy energy price forecasts) during the renewal period. The economic projections do not include potential gas commercialization and are based on a low oil price of $16 per barrel. Employment opportunities will be enhanced, particularly for Alaska Natives. Social change will continue with both positive and potentially negative effects. Subsistence resources could be affected if there is a large oil spill, but the SERVS system and the phase-in of double-hull tankers greatly reduce the risk of such an event.

Effects on the economy (national, state, and local), environmental justice, sociocultural systems, subsistence, cultural resources, and environmental justice are summarized below.

Economic Effects: Renewal of the TAPS ROW would result in the continuation of substantial economic benefits at the national, state, and local levels. Crude production is expected to decline in the future as ANS fields are gradually depleted but, because the scale of operations is so large, economic benefits will be substantial. (Note that the economic analysis was based on an oil price of $16 per barrel. If oil prices are higher, the impacts will increase proportionately.)

At the national level, future operation of TAPS (and ANS fields) means that an important source of domestic crude production — now accounting for approximately 20 percent of domestic crude production — will continue. The importance of ANS production will decrease as production declines, but still is expected to be substantial. The cumulative value of ANS crude production is projected to be approximately $150 billion in 1998 dollars (based on U.S. Department of Energy energy price forecasts) during the renewal period. Renewal of the ROW would decrease the balance-of-trade deficit by this amount.

ANS output generates federal revenues from income taxes, royalties, and other sources. Continued operation of the ANS fields is estimated to generate approximately $10.8 billion in additional federal revenues. Because of the federal requirement for double-hull tankers, additional

tankers will have to be built for the marine transportation link. These tankers must be U.S. flagged and built, and serviced by U.S. crews. It is estimated that purchase of replacement tankers for the ANS trade will generate 162,000 worker-months of employment at U.S. shipyards.

The State of Alaska receives revenues in the form of royalties and severance taxes on crude oil. Over the renewal duration, these revenues are estimated to total $14.2 billion. These revenues are used to fund continuing state services and to contribute to the Permanent Fund. Since 1977, revenues from the oil and gas industry have accounted for the majority of contributions to Alaska's unrestricted General Fund revenues.

The property tax of North Slope oil-production-related facilities and TAPS continue to be an important source of local government revenues. Local government tax revenues from continued operation of these facilities are estimated to generate more than $2 billion over the renewal period.

The oil and gas industry is a leading component of gross state product and a major economic driver of the economy. Continued operation of TAPS and the ANS fields is essential to the Alaska economy and provides time for a gradual transition from a petroleum-based to a more diversified economy.

The above estimates do not include the potential economic benefits of various projects for commercialization of presently stranded ANS gas reserves. Each of the three gas commercialization options identified above could contribute significantly to the Alaska economy.

Sociocultural Systems: Sociocultural systems continue to evolve in response to many factors, including development of the oil and gas industry in Alaska. Effects have been both negative and positive (e.g., development of improved health care, growth in educational opportunities and attainment, expansion of specific programs for Alaska Natives). Social change is expected to continue whether or not the TAPS ROW is renewed. Renewal provides additional funds to the state and to local communities for maintenance of social programs, and creates employment opportunities.

Subsistence: Subsistence is important to many communities in Alaska, both for economic and sociocultural reasons. Continued operation of TAPS and ANS fields could adversely affect the availability of subsistence resources if there is a large spill in the future. The severity of these effects depends on the quantity of oil spilled, location, season, and other factors. The risk of a large spill from a tanker has been reduced by enhancements to marine safety, and by the reduced volume of oil to be transported over the renewal period. Increased hunter access via the Dalton Highway could increase pressure on subsistence resources, but this issue will remain if the TAPS ROW is not renewed.

Cultural Resources: Adverse effects on cultural sites could result from ground-impacting activities and oil spills. Construction of the pipeline is long-since completed, and impacts associated with maintenance/repairs are not expected to be significant because most ground-impacting activities will occur on previously disturbed soils. Cumulative effects of continued ANS development and of gas commercialization could occur, although new technology has reduced the size of the footprint of exploration and production facilities and construction would be subject to provisions of Section 106 of the National Historic Preservation Act and its state equivalent.

Environmental Justice: Renewal of the ROW enables the continuation of the Permanent Fund Dividend — which has disproportionate benefits for large, low-income families because it provides a fixed amount for each person — and continued revenue to state and local governments for maintenance of social programs. Disproportionately adverse impacts on low-income or minority populations may occur if an oil spill impacts subsistence resources.

Consequences of No-Action Alternative

The no-action alternative involves the end of TAPS operation and the dismantling, removal, and restoration (DR&R) of TAPS facilities. DR&R of TAPS will also result in the end of the ANS oil production. Following is a summary of the physical, biological, and social effects of the no-action alternative.

Physical Environment

In the no-action alternative, it is assumed that above ground facilities related to TAPS will be removed during a 3-year period of DR&R. During that time, major activities will involve the physical removal of equipment and subsequent transportation to disposal sites. For a relatively short time, these activities will result in disruption to the terrestrial environment. These short-term impacts along the TAPS ROW include the potential for spills, increased use of heavy vehicles and traffic with attendant increase in emissions and dust, and increased water discharges from the work camps and from cleaning pipe and equipment. After DR&R, it is likely that some of the workpad, access roads, and the Dalton Highway will remain in place.

Short-term impacts to the physical environment can be identified and mitigated since the impacts are similar to those of original construction. Essentially, DR&R would be

a large-scale construction project in reverse. Following the three-year DR&R effort, impacts would diminish to insignificance.

Terrestrial Environment: Potential short-term impacts to the terrestrial environment may be caused by construction associated with dismantling, by those items left in place, such as pipe in buried river crossings, or by modifications to the terrain that occurred during original construction and continue to have an effect.

Seismic hazards relating to an operating pipeline system would be eliminated, and the pipeline seismic risk is minimal during dismantling.

DR&R of TAPS will have no adverse effect on global warming. However, the increase of air temperature associated with global warming will have an impact on soil temperatures and thus may affect soils in permafrost terrain after the pipeline has been removed and the ground restored.

There is a potential for the lasting presence of the pipeline workpad, rehabilitated material sites, access roads, pump station sites, and other visible signs of the former pipeline system for a period estimated at approximately two decades after restoration, based on observations of abandoned ANS workpads. These visible signs will add to the visible presence of future construction that might occur.

Water Resources: Cessation of operation of TAPS will require continued use of water resources along the ROW to support dismantling. Wastewaters will be produced at accelerated rates by virtue of the intensive labor effort involved. Freshwater receiving environments will have increased potential for adverse impacts from the large camp populations and extensive earth-moving activities involved in dismantling TAPS.

Atmospheric Environment: After DR&R, all TAPS-related air emissions would cease. For most facilities, the direct ambient impact levels would revert to pre-construction levels.

Cumulative Effects: No significant cumulative effects on the physical environment were identified.

Biological Resources

The direct, indirect, and cumulative impacts of the no-action alternative will be different during the DR&R period and the post-TAPS period. As long as mitigation and prevention measures are implemented, the direct impacts of DR&R on biological resources will be limited and manageable. After DR&R, there will be no direct impacts of TAPS. Indirect impacts associated with use of the TAPS ROW and adjacent areas by the public may be more substantial, but this activity is regulated by government. The primary impact after DR&R may be increased pressure from sport and subsistence harvest (legal and illegal) because of decreased employment following the close of TAPS operations. The following paragraphs summarize the important impacts that warrant consideration under the no-action alternative.

With the exception of some disturbance during the DR&R period, the environment along TAPS, on the ANS, and in Prince William Sound will essentially return to its pre-oil-industry state through a combination of active restoration and natural ecosystem succession under the no-action alternative. The use of natural resources, primarily fish and wildlife, may increase following the closing of TAPS as employment and the state economy dramatically decline.

A potentially important impact on fish, birds, terrestrial mammals, and marine mammals is increased harvest, legal and illegal, sport, subsistence, and commercial, after TAPS operations cease. The end of operations of the oil industry in the ANS oil fields, TAPS, and the VMT will be accompanied by significant reductions in statewide employment and incomes. This may increase the pressure on fish and wildlife if residents use wild foods to compensate for the loss of income. This could include hunting of terrestrial mammals along TAPS and on the ANS, marine mammals in the Beaufort Sea and Prince William Sound, and waterfowl on the ANS. Sport, commercial, and subsistence fishing could also increase. If decreased state revenue results in less enforcement of fish and game regulations, this impact could be intensified. However, it is also possible that the human population (and fish and wildlife harvests) will decrease in response to the economic decline. Regulation and monitoring by the appropriate agencies is needed to manage this impact.

Vegetation and Wetlands: Important impacts on vegetation and wetlands include disturbance of vegetation during DR&R, introduction of exotic vegetation, and loss of vegetation under gravel fill left in place along the TAPS ROW and in the ANS oil fields. Along the TAPS ROW the primary impact will be disturbance of vegetation during DR&R. Revegetation of disturbed sites will result in a short-term impact, but also improvement of habitat for some wildlife species that use early-stage vegetation. The impact of introduction of exotic vegetation can be removed with the use of native plants for revegetation. The extent of impacts on the ANS depends on the amount of gravel fill left in place and whether it is revegetated. Because the amount of land covered with gravel is relatively small, this impact will not be significant.

Fish: Obstruction of fish movements in low water crossings or culverts during DR&R, and harvest of fish are po-

tentially significant. Obstruction of movements, and habitat changes due to erosion, during and after DR&R could occur. Adequate design of restoration and monitoring during DR&R can mitigate this problem.

Terrestrial Mammals: An important impact on terrestrial mammals is disturbance and displacement during DR&R. DR&R activities can be timed to minimize impacts in sensitive areas, such as calving areas.

Social Systems

Non-renewal of the TAPS ROW will have devastating effects to the economy of Alaska and will significantly impact the U.S. balance of trade. The opportunity to produce an additional 7 billion barrels of oil from the ANS oil fields will be eliminated. The likelihood of commercializing some 30 trillion cubic feet of currently stranded gas on the ANS will be significantly reduced without the oil production infrastructure. Lost revenues to the state of Alaska ($14.2 billion), local governments ($6.5 billion), and residents of Alaska will cause a severe drop in employment, loss of social services, and economic hardships. About 20 percent of current U.S. oil production flows through TAPS, and without ROW renewal those reserves would be stranded, and the U.S. balance-of-trade deficit would increase by approximately $150 billion in 1998 dollars (based on U.S. Department of Energy energy price forecasts) during the renewal period.

The economic projections are based on an oil price of $16 per barrel and could be much more severe if oil prices are higher. Employment opportunities will decline dramatically, particularly for Alaska Natives. Social change will continue. The only potentially positive benefit will be the reduction of the potential impact of oil spills on subsistence resources, but this might be offset by the increased pressure on subsistence resources as the economy declines.

Key effects of the no-action alternative include the following.

Economic: Selection of the no-action alternative would result in substantial adverse economic effects at the national, state, and local levels. DR&R activities would create some short-lived employment opportunities, one of the few positive elements in an otherwise bleak economic landscape.

At the national level, closure of TAPS and the ANS fields would result in lower federal revenues (e.g., from taxes and royalties), reduced self-sufficiency in crude petroleum, an increase in the balance-of-trade deficit, and adverse impacts on the domestic shipbuilding industry, as well as further losses in employment for domestic seafarers.

The state would receive sharply lower revenues (reduced by $14.2 billion), lower economic activity, reduced employment, personal income, and net out-migration. A severe and prolonged economic contraction is projected to result, which is much more severe in terms of magnitude and duration than the recessions of 1976 and 1985. Indirect and multiplier effects of TAPS shutdown would be felt in many sectors of the state, property values would decline, mortgage defaults would probably increase, and the state would be forced to take draconian measures to bring revenues and expenditures into balance. The Permanent Fund Dividend would be eliminated, and significant pressures would be placed on state budgets, which ultimately would result in fewer and less generous social services.

Local revenues would fall because of the removal of a significant portion of the tax base and the elimination of certain state transfers. From 2004 to 2015, revenues to local governments would be over $6.5 billion less than under the proposed action. Local governments also would face intense pressures to reduce budgets (and, therefore, services) to bring these into line with revenues.

Economic impacts, as measured by employment and personal income, would be severe for residents of many communities, but particularly so for those on the North Slope and Valdez. Reduced revenues for the North Slope Borough would put pressure on municipal jobs, as well as eliminating those in the oil and gas industry.

The lack of infrastructure after DR&R of TAPS would foreclose gas commercialization in the foreseeable future, which would leave at least 30 trillion cubic feet of domestic gas reserves stranded on the ANS. Three refineries in Alaska (two near Fairbanks and one at Valdez), which presently use ANS crude, would be closed and the state would have to import crude oil and/or refined products to satisfy in-state demand.

Sociocultural Systems: Social change will continue even if the no-action alternative is selected. Closure of TAPS and ANS fields will not result in a restoration of the pre-oil culture. To the extent that social ills are related to economic ills, social problems are likely to be exacerbated. Moreover, reduced revenues at all levels of government are certain to reduce the scope and size of social programs designed to ameliorate social programs.

Subsistence: Effects of the no-action alternative on subsistence would be mixed. Closure of oil and gas facilities would eliminate the potential for oil spills on the North Slope or pipeline route, a potential benefit. (Because Alaska would have to import crude and/or refined products to satisfy internal demand, the risk of some oil spills remains.) However, income losses would limit expenditures

for arms, ammunition, boats, motors, snowmachines, and other equipment used for hunting and fishing. Moreover, income and employment losses may mean that there would be more pressure on subsistence resources because more persons would adopt the subsistence lifestyle out of economic necessity.

Cultural Resources/Recreational/Wilderness: The no-action alternative would reduce the potential for adverse impacts. DR&R activities, for example, would remove most visible traces of oil and gas development. Cessation of operations would eliminate possible impacts associated with oil spills of ANS crude.

Environmental Justice: The no-action alternative has environmental justice implications. On the positive side, the probabilities of adverse impacts on subsistence would be reduced (though not eliminated). However, there are also negative effects. Elimination of the Permanent Fund Dividend would have disproportionate adverse effects on large, low-income families, including those of Alaska Natives. The no-action alternative would result in adverse impacts on Native corporations. For example, the Arctic Slope Regional Corporation owns the subsurface rights on selected areas of the North Slope. Foreclosure of exploration and production activities on these lands would adversely impact this corporation and its Alaska Native shareholders.

How to Use This Environmental Report

The body of this Environmental Report is divided into four major sections based on the guidelines of the Council on Environmental Quality (40 CFR 1500-1517). It is important to read these section in order because each builds on the one before it.

- Section 1 describes the ***purpose of and need for the action***, and provides background on the history of the Trans Alaska Pipeline System (TAPS).
- Section 2 describes the ***proposed action*** (renewal of the TAPS right-of-way) and ***the no-action alternative*** (non-renewal). This section provides a detailed description of the facilities that make up TAPS and the removal of the system that would ensue in the no-action alternative.
- Section 3 describes the ***physical, biological, and social features*** of the affected environment to form the basis for the analysis of environmental consequences.
- Section 4 analyzes the ***environmental consequences*** of the proposed action and the no-action alternative. First, however, the section describes the ***ground-impacting maintenance actions*** that would occur during the renewal period, as well as the ***mitigation measures*** that are built into TAPS design and operation. In addition, the section provides a discussion of oil spill potential, which is analyzed in detail in Appendix B. Section 4 also addresses the potential ***cumulative effects*** of the alternatives in relation to past, present, and reasonably foreseeable future actions.

The mechanical and organizational conventions followed in the report are summarized below:

- ***Authors*** of individual report sections are identified as bylines in the text and are compiled in Section 5. Where more than one author is identified in a byline, the first author listed is the principal author for the section. The byline is provided once for a given section, and subsequent subsections by the same author(s) have no byline. When the author(s) change, a new byline is given.
- Both metric and English ***units of measurement*** are used in this report, generally according to the custom of each technical discipline. Where appropriate for clarity, conversions are provided.
- An ***alphabetical subject index*** for the report is contained in Section 6. This index consists of key words and subjects and the most important pages on which they occur in the text.
- ***Acronyms*** are defined in the text the first time they occur in each major section (i.e., Sections 1, 2, 3, etc.). Section 7 provides an alphabetical list with definitions for all acronyms used in the report.
- A complete list of ***literature cited*** for the text is contained in Section 8, while literature cited for each appendix are provided at the end of that appendix. Literature are arranged alphabetically by author last name and date of publication. Personal communications are treated in the same manner, with the author being the person consulted and the date the year of the contact.
- ***Maps*** are provided in the text for important place names along the pipeline route and in the state of Alaska. Refer to Appendix C for a set of 25 detailed maps of TAPS based on U.S. Geological Survey topographic data. These maps contain the following information:
  - TAPS pipeline and facilities, including pump stations, valves, access roads, and material sites.
  - Topography and place names.
  - Glaciers.
  - Water bodies.
  - Township and range.
  - Roads.
  - Land ownership of the right-of-way.

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SECTION 1

PURPOSE OF AND NEED FOR THE ACTION

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Introduction: Section 1

The proposed action analyzed in this Environmental Report is renewal of the Trans Alaska Pipeline System (TAPS) right-of-way (ROW) for a 30-year period from 2004 to 2034. Section 1 provides introductory and background material for the report.

Section 1.1 explain the assumptions underlying this report and details how the report is organized Section 1.2 states the purpose of and need for the proposed action. Since TAPS has already been built and has been in operation for nearly 30 years, Section 1.3 offers a brief history of the system to set the stage for the discussion of the proposed action in Section 2.

1.1 Assumptions and Report Organization

This Environmental Report discusses the environmental effects of renewing and of not renewing the right-of-way (ROW) for the Trans Alaska Pipeline System (TAPS). The purpose is to support applications for renewing the Federal Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline (Federal Grant) to continue operation of TAPS for an additional 30 years beyond expiration of the agreement in 2004. The Permittees also propose to renew the State Right-of-Way Lease (State Lease), which also expires in 2004, and this Environmental Report supports that application as well. This Environmental Report concentrates primarily on the Federal Grant, since most stipulations of the Federal Grant and State Lease are the same.

This report is organized and written according to the federal Council on Environmental Quality (CEQ) environmental impact statement guidelines contained in 40 CFR 1500-1517. In order to follow those guidelines, assumptions had to be made concerning the definition of the proposed action, the extent of the study areas considered, and the nature of direct, indirect, and cumulative effects. In addition, predictions of environmental effects are based on assumptions that include uncertainties related to potential technical enhancements, future exploration and development opportunities, disposition of existing and future gas reserves, and other considerations which might influence future operations of the pipeline and associated facilities. The primary assumptions upon which this report is based are summarized below.

1.1.1 Assumptions and Definitions

1.1.1.1 Alternatives Analyzed

The *proposed action* is renewal of the existing Federal Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline. The proposed action is compared with the *no-action alternative*: allowing the Federal Grant to expire in the year 2004.

With the proposed action, discussed in Section 2.1, the pipeline and its appurtenances will stay in operation in essentially the same configuration as now. Some physical changes to TAPS are anticipated during the ROW renewal period in response to throughput decline, required maintenance and repairs, and future system upgrades.

The no-action alternative (Section 2.2) involves expiration of the Federal Grant in 2004. In this case, the pipeline system will have to be removed in accordance with the terms of the Federal Grant. Federal and state stipulations contain general provisions for “dismantling, removal, and restoration” (DR&R) of TAPS assets upon completion of use of the TAPS ROW.

Other alternatives considered but not included in the analysis are covered in Section 2.3. Similar alternatives were evaluated in the original TAPS environmental impact statement (EIS) and dismissed because of their impracticality. These included shipping oil through the Northwest Passage by tanker, trucking oil, and transporting by railroad. With TAPS already built and in operation, no practical or economically feasible alternative exists for transporting North Slope crude oil to market.

1.1.1.2 Federal Grant and State Lease

Both the Federal Grant and State Lease contain numerous provisions that identify mitigating measures and duties to abate/rehabilitate damages relevant to possible environmental impacts. For example, several sections of the Federal Grant require measures that limit, mitigate, or require rehabilitation of potentially adverse TAPS impacts. These include:

- Section 9, Construction Plans and Quality Assurance Program.
- Section 10, Compliance With Notices To Proceed.
- Section 13, Damage to United States Property; Repair, Replacement or Claim for Damages (including requirements to rehabilitate any natural resource that shall be seriously damaged or destroyed).
- Section 16, Laws and Regulations.
- Section 23, Port Valdez Terminal Facility (including

provisions to minimize environmental impacts).
- Section 24, Duty of Permittees To Abate.
- Section 29, Training of Alaska Natives.
- Section 30, Native and Other Subsistence.

Most stipulations are designed to prevent, mitigate, or rehabilitate potential impacts. Three categories of stipulations are included in the Federal Grant: *general, environmental*, and *technical.* Appendix E of this Environmental Report contains a complete copy of the Federal Grant, and relevant sections and stipulations are referenced in the text of this Environmental Report as appropriate.

1.1.1.3 Definition of Pipeline System

This Environmental Report focuses on all of TAPS, which is defined in Stipulation 1.1.1.22 of the Federal Grant to include

> "...all facilities located in Alaska used by Permittees in connection with the construction, operation, maintenance or termination of the Pipeline. This includes, but is not limited to, the Pipeline, storage tanks, Access Roads, communications site, airfields, construction camps, materials sites, bridges, construction equipment and facilities at the origin station and at the Valdez terminal. This does not include facilities used in connection with production of oil or gathering systems, nor does it include such things as urban administrative offices and similar facilities which are only indirectly involved."

Thus, Section 2.1 of this Environmental Report describes all of these elements of TAPS including facilities integral to TAPS but on fee-simple land and not part of the ROW [e.g., Valdez Marine Terminal (VMT), Pump Station 1] and other facilities used in operation such as access roads, the fuel gas pipeline, material sites, and the Dalton Highway (a state highway with its own right-of-way). For the reader's convenience and for continuity, the discussion of the proposed action in Section 2.1 also includes the marine transportation link, which is not part of TAPS.

TAPS Configuration and Operation during the Renewal Period

It should be recognized that actual TAPS configurations could differ from the following assumptions because of uncertainty in North Slope oil production, development of new technology, or changes in operating efficiencies.

When the Federal Grant expires in 2004, the pipeline will most likely be operating with Pump Stations 1, 3, 4, 7, 9, and 12 (with PS 5 operating as a pressure relief station). Pump Station 12 may operate intermittently in response to throughput variations and the economic balance between the cost of fuel and that of drag reducing agent (DRA). Pump Stations 7 and 12 will be ramped down as future throughputs decline and based on the economic balance between fuel and DRA costs. At the VMT, Berths 4 and 5, which have vapor-control systems, will provide primary loading capacity. Berths 1 and 3, which do not have vapor control, may be used in special situations. Either Berth 1 or 3 or both berths could be demobilized before 2034 if remaining loading capacity does not constrain TAPS throughput. Use of DRA will continue. It is also assumed that the pipeline system will continue to meet its obligations under the Federal Grant and State Lease over the renewal period. However, the potential for accidents and failures is recognized, and the environmental effects of those events are evaluated.

Other possible modifications are identified along with potential environmental impacts. Possible modifications are addressed in Section 4.1.1 and may include the following:
- Rework of some vertical support members.
- Rehabilitation of some buried pipe in areas of corrosion.
- Possible addition of crude-oil heaters or additives with lower crude-oil temperatures, which could affect pigging, wax control, and tank-roof snow-load maintenance.

Pipeline Oil and Throughput

The pipeline will continue to transport "oil" as defined in current agreements ("unrefined liquid hydrocarbons, including gas liquids"). If a gas-to-liquid (GTL) project is implemented and the pipeline liquids are transported by TAPS, the definition of fluids allowed to be transported would need to be modified as part of the GTL permitting process.

Appendix A of this report provides a detailed analysis of throughput assumptions for TAPS. This analysis adopts as its *baseline throughput assumption* the most recent U.S. Department of Energy projection (USDOE, 1998b). The USDOE projection published in the *Annual Energy Outlook 1999* forecasts Alaska oil production to decline at a rate of 4.1 percent per year from 1997 through 2020. The reference-case (most-probable) production rates are as follows: 2010, 0.78 million barrels per day (bbl/day); 2015, 0.61 million bbl/day; and 2020, 0.49 million bbl/day. It is then assumed that throughput remains constant at 0.49 million bbl/day from 2020 until 2034 — the end of the 30-year TAPS ROW renewal period.

North Slope Oil Field Development

Under the proposed action, it is assumed that North Slope oil fields currently developed will continue operating during the renewal period and that only the new fields identified in Section 4.5 of this report will be developed. Development of the Arctic National Wildlife Refuge is not included.

Dalton Highway

The Dalton Highway was originally built to support construction of TAPS, but it is now a state highway (Alaska State Route 11). Current use as a public highway will continue in both the proposed action and no-action alternative.

Tanker Utilization

The tanker fleet will be modified as necessary to accommodate the declining production rate, and double-hulled tankers will be phased into operations according to current U.S. Coast Guard regulations.

1.1.1.4 Affected Environment

Nearly all environmental assessments (EAs), environmental reports (ERs), and or environmental impact statements (EISs) are drafted before the project. This was the case for the original TAPS EIS, but for the TAPS renewal decision, the pipeline system has existed for over 20 years and is now part of the affected environment. The same is true for the ANS oil fields and marine transportation.

The affected environment as discussed in Section 3 includes the following three study areas (Figure 1.1-1):

- Alaska North Slope (ANS),
- The pipeline route from Prudhoe Bay to Valdez, and
- The Prince William Sound (PWS)/North Gulf Coast region.

Numerous EAs, ERs, and EISs have examined various portions of the study areas over the years. Relevant literature includes reports on Alpine (USACE, 1997); Northstar (USACE, 1999); NPR-A (BLM and MMS, 1998); Alaska Natural Gas Transportation System (BLM, 1976); Trans-Alaska Gas System (BLM and USACE, 1988; FERC, 1995); various Beaufort Sea oil and gas lease sale EISs, including Sale 97 (MMS, 1987a); Sale 124 (MMS, 1990); Sale 144 (MMS, 1996a); Sale 170 (MMS, 1998); various Alaska Chukchi Sea oil and gas lease sale EISs, including Sale 109 (MMS, 1987b); Sale 126 (MMS, 1991) and the original TAPS EIS prepared by the Federal Task Force on Alaskan Oil Development (BLM, 1972).

These documents fulfilled requirements of the National Environmental Policy Act (NEPA), and along with permitting comment periods, have allowed public and agency review of these developments. In this report, relevant material in these and other reports is summarized and updated where appropriate and feasible, and pertinent new material is presented where appropriate.

1.1.1.5 Analysis of Effects

The three study areas are treated together in describing the affected environment, but impacts are analyzed separately in Section 4. Sections 4.3 and 4.4 discuss the direct and indirect effects of the proposed action and the no-action alternative on the pipeline route itself, while Section 4.5 analyzes the cumulative impacts. [Note that the CEQ guidelines consider the terms *effect* and *impact* to be synonymous (40 CFR 1508.8).] These analyses follow as closely as possible the definitions provided by the Council on Environmental Quality (CEQ):

- **Direct effects** are “caused by the action and occur at the same time and place” (40 CFR 1508.7).
- **Indirect effects** are “caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems” (40 CFR 1508.7).
- **Cumulative impact** is “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time” (40 CFR 1508.7).

In accordance with these definitions, the direct effects are treated as those directly associated with TAPS as defined above, which includes the pipeline, pump stations, access roads, material sites, VMT, etc. Such effects include ground disturbance from maintenance actions, air emissions from pump stations, and wastewater discharges from ballast water treatment .

For this Environmental Report, the distinction between indirect effects and cumulative impacts is somewhat complex. It would be possible to consider the effects of the Alaska North Slope oil fields and the marine transportation

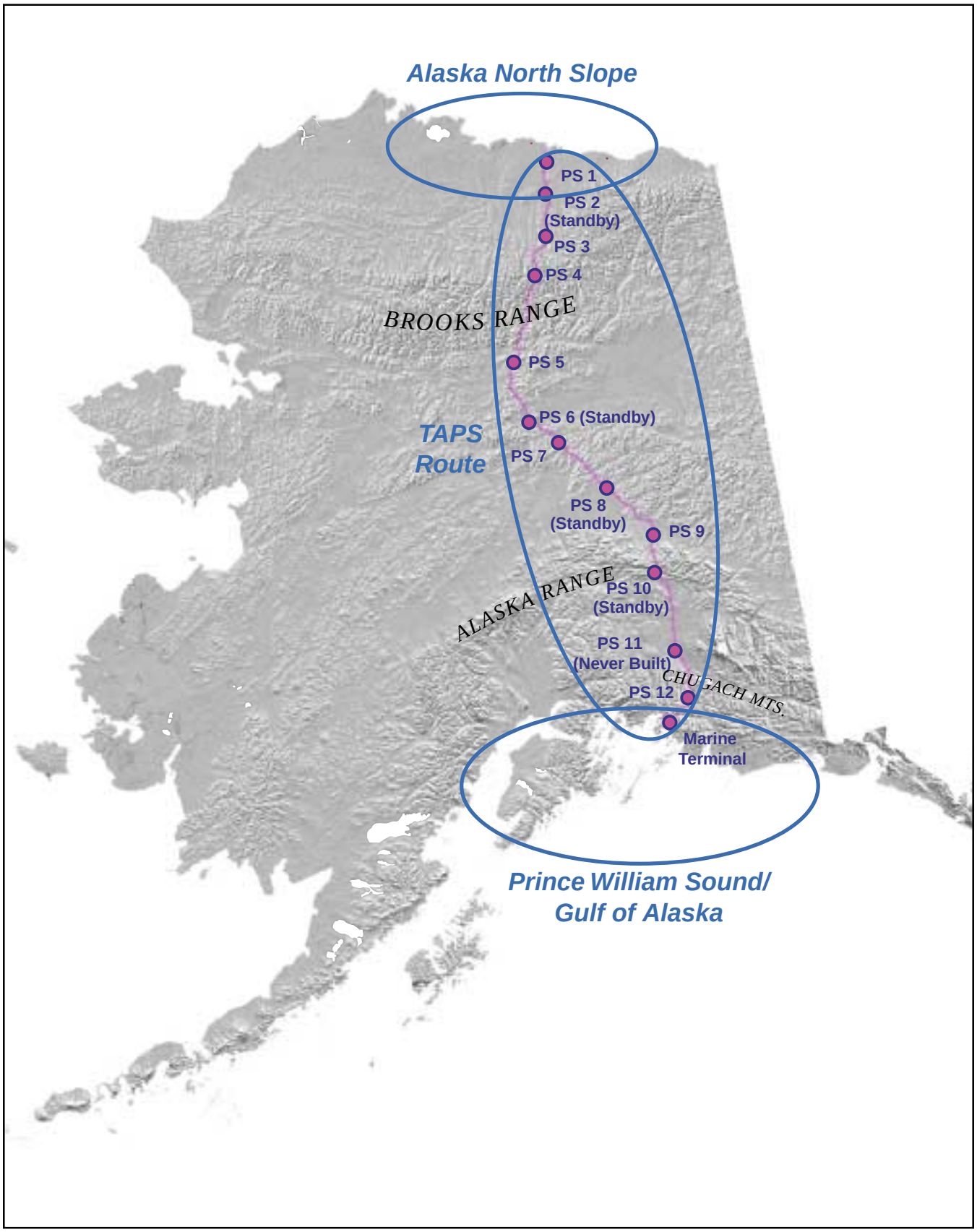

Figure 1.1-1. *General study areas used in preparation of this Environmental Report.*

link as indirect effects of TAPS ROW renewal. However, these are treated in the cumulative effects section for two reasons. First, developments on the North Slope require extensive permitting, have undergone NEPA reviews, and thus are considered separate actions from TAPS ROW renewal. The permitting for such developments usually includes an EA or EIS. Secondly, the marine transportation system, while integral to bringing ANS crude to market, is managed by a separate set of agencies and laws than TAPS itself. For example, the Oil Pollution Act of 1990 (OPA 90) and U.S. Coast Guard regulations mandate how tankers operate in Prince William Sound and the Gulf of Alaska. Alyeska Pipeline Service Company provides tanker escort and spill response support in accordance with OPA 90, but the tankers are not under Alyeska control or the control of the Joint Pipeline Office, which regulates TAPS operation.

As a result, development of Alaska North Slope oil fields and the marine transportation system are treated in Section 4.5 of this Environmental Report as separate actions from TAPS ROW renewal. It is somewhat academic to debate whether their effects are treated as indirect effects of TAPS because they would not exist without TAPS or as cumulative effects since they are separate actions. It is important to adequately assess both their separate and cumulative effects.

In general, Section 4.5 of this Environmental Report treats ANS and PWS effects as cumulative effects because these regions are not directly affected by TAPS as defined in Stipulation 1.1.1.22 of the Federal Grant. However, the specific approach for each technical discipline varies based on the requirements of the analysis. For example, the analysis of economic effects in Section 4.3 includes the effects of North Slope oil development and tanker transportation. The model used for this analysis considers the economics of the entire oil production and transportation system because they are inextricably tied together economically.

1.1.2 How to Use This Report

The body of this Environmental Report is divided into four major sections based on the guidelines of the Council on Environmental Quality. It is important to read these section in order because each builds on the one before it.

- **Section 1** describes the ***purpose of and need for the action*** and gives background on the history of TAPS.
- **Section 2** describes the ***proposed action*** (renewal of the Federal Grant) and ***the no-action alternative*** (non-renewal). This section provides a detailed description of the facilities that make up TAPS and projected use during a 30-year renewal period, as well as activities required for the removal of the system that would ensue in the no-action alternative.
- **Section 3** describes the ***physical, biological, and social features*** of the affected environment to form the basis for the analysis of environmental consequences.
- **Section 4** analyzes the ***environmental consequences*** of the proposed action and the no-action alternative. First, however, the section describes the ***ground-impacting maintenance actions*** that would occur during the renewal period, as well as the ***mitigation measures*** that are built into TAPS design and operation. In addition, the section provides a discussion of oil spill potential, which is analyzed in detail in Appendix B. Section 4 also addresses the potential ***cumulative effects*** of the alternatives in relation to past, present, and reasonably foreseeable future actions.

The mechanical and organizational conventions followed in the report are summarized below:

- ***Authors*** of individual report sections are identified as bylines in the text and are compiled in **Section 5**. Where more than one author is identified in a byline, the first author listed is the principal author for the section. If a byline does not appear for any given section, the authors are the same as the section preceding it. An alphabetical listing of authors cross-referenced to sections to which they contributed is included in Section 5.
- Both metric and English ***units of measurement*** are used in this report, generally according to the custom of each technical discipline. Where appropriate for clarity, conversions are provided.
- An ***alphabetical subject index*** for the report is contained in **Section 6**. This index consists of key words and subjects and the most important pages on which they occur in the text.
- ***Acronyms*** are defined in the text the first time they occur in each major section (i.e., Sections 1, 2, 3, etc.). **Section 7** provides an alphabetical list with definitions for all acronyms used in the report.
- A complete list of ***literature cited*** for the text is contained in **Section 8**, while literature cited for each appendix is provided at the end of that appendix. Literature is arranged alphabetically by author last name and date of publication. Personal communications are treated in the same manner, with the author being the person consulted and the date the year of the contact.
- ***Maps*** are provided in the text showing important

place names along the pipeline route and in the state of Alaska. Refer to Appendix C for a set of 25 detailed maps of TAPS based on U.S. Geological Survey topographic data. These maps include the following information:

- TAPS pipeline and facilities, including pump stations, valves, access roads, and material sites.
- Land ownership of the right-of-way.
- Topography, place names and roads.
- Glaciers and water bodies.

1.2 Purpose and Need

By K. Rubin

The trans-Alaska pipeline right-of-way (ROW) includes both federal and state lands. The agreements that govern these rights-of-way were executed in 1974 and will expire in the year 2004 — the federal Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline (Federal Grant) on January 22, 2004, and the State Right-of-Way Lease for the Trans-Alaska Pipeline (State Lease) on May 2, 2004. While this Environmental Report was prepared primarily to address the environmental issues for renewal of the Federal Grant, the report covers the entire TAPS ROW. The TAPS owners will apply for renewal of the State Lease, and this report applies to that renewal as well.

The original right-of-way on federal lands was authorized and issued pursuant to Section 28 of the Mineral Leasing Act, as amended by the Trans-Alaska Pipeline Authorization Act of 1973 (43 U.S.C. §1651). Under Section 28(n) of the Mineral Leasing Act [30 U.S.C. §185(n)], the federal Bureau of Land Management (BLM) "shall renew" a right-of-way, upon request of an applicant, in accordance with Section 28(n). This statutory mandate for renewal is incorporated into the right-of-way. Section 7(C) of the Federal Grant, entered on January 23, 1974, states that "the Right-of-Way shall be renewed, subject to and in accordance with the provisions of the Trans-Alaska Pipeline Authorization Act." The TAPS owner companies have applied for renewal of the right-of-way for the purpose of extending the authorization for this essential pipeline.

The purpose of the trans-Alaska pipeline is to transport crude oil from the North Slope of Alaska to the marine terminal at Valdez. The pipeline is essential to providing oil for the energy needs of the nation — at present, the pipeline carries about 20 percent of the oil produced in the United States. Renewal of the right-of-way is needed to maintain this critical flow of oil from Alaska.

The need for the pipeline has been declared by an Act of Congress. In Section 202 of the Trans-Alaska Pipeline Authorization Act, Congress specifically made the following findings and declaration:

- "The...delivery of oil...from Alaska's North Slope to domestic markets is in the national interest because of growing domestic shortages and increasing dependence upon insecure foreign sources."
- "The...trans-Alaska Oil Pipeline from the North Slope of Alaska to Port Valdez...will best serve the national interest."

1.3 History of Trans Alaska Pipeline System

By L.J. Clifton and B.J. Gallaway

After oil was discovered at Prudhoe Bay in 1968, a reliable system was needed to transport crude oil from Alaska's North Slope to Lower 48 refineries. Many methods were discussed — ice-breaking tank vessels to traverse the Northwest Passage, giant tanker airplanes, and extending the Alaska Railroad to Prudhoe Bay. Ultimately, the oil companies determined that the most economic transport method was a hot-oil pipeline from the North Slope oil fields to the Port of Valdez, where the oil could be loaded onto tank vessels and shipped to the U.S. West Coast.

As a result of disputes over Native land claims, in 1966, then Secretary of the Interior Stewart Udall called a temporary halt on development, homesteading, and federal and state land selection on all public lands in Alaska. This freeze was still in effect when the oil companies applied for a federal right-of-way permit for the pipeline in 1969.

In 1969 Congress passed the National Environmental Policy Act (NEPA), requiring an environmental impact statement (EIS) for major federal actions that significantly affect the quality of the human environment. At about the same time, several Native villages claimed land that the pipeline and haul road would cross, and filed suit in federal court to halt construction of the haul road. In addition, three environmental organizations filed a federal suit claiming the pipeline project violated NEPA and the Mineral Leasing Act of 1920 (MLA).

Native land claims were mostly settled in December 1971 when the Alaska Native Claims Settlement Act (ANCSA) was signed. ANCSA created Alaska Native regional corporations and provided almost $1 billion and 44 million acres to Alaska Natives. As part of this legislation, Native land claims along the proposed pipeline right-of-way were resolved, making it possible for the federal and state governments to grant essential licenses and permits. Meanwhile, the U.S. Department of the Interior was drafting an EIS for the pipeline project, which generated 12,000 pages of testimony during the public comment period. One issue raised was the lack of discussion on an alternate pipeline route through Canada to the U.S. Midwest. The court of appeals for the District of Columbia subsequently ruled that broad consideration of alternatives was required under NEPA, and as a result, the Canadian route had to be evaluated. The final EIS determined that neither route presented a distinct environmental advantage. Ultimately, timing was a critical factor — the Canadian route was forecast to take two to six years longer to complete than the Alaskan route.

The Department of the Interior released the final EIS in March 1972 (BLM, 1972). The six-volume report stressed the need for Alaskan oil on the U.S. West Coast and the country's immediate need for domestic oil. Later that year, in an atmosphere of growing concern over U.S. dependence on foreign oil, then Secretary of the Interior Rogers C.B. Morton declared the trans-Alaska pipeline to be in the national interest. The federal injunction against the pipeline project was lifted. However, in 1973, the appeals court ruled that the proposed right-of-way and special land use permits for the pipeline did not comply with the MLA. In places, the proposed right-of-way exceeded the 54-foot width allowed under the MLA. To obtain a wider right-of-way, approval from Congress was required.

Extensive debate surrounded the pipeline issue in Congress. Environmentalists remained concerned about potential risks associated with the pipeline. However, the Arab oil embargo influenced public opinion in favor of a new domestic source of oil. President Richard Nixon signed the Trans-Alaska Pipeline Authorization Act on November 16, 1973, after a vote cast by Vice President Spiro Agnew broke a deadlock in the Senate. The pipeline authorization act was intended "to insure that, because of...the national interest in early delivery of North Slope oil to domestic markets, the trans-Alaska oil pipeline be constructed promptly without further administrative or judicial delay or impediment." The Act directed the Secretary of the Interior to authorize the federal right-of-way for the pipeline, which he did on January 23, 1974. The State of Alaska issued its right-of-way lease on May 3, 1974.

Both the Federal Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline (Federal Grant) and the State Right-of-Way Lease for the Trans-Alaska Pipeline (State Lease) were negotiated agreements entered into by the

TAPS owners. Under the Federal Grant, the owner companies agreed to: 1) "employ all practicable means and measures to preserve and protect the environment..." in construction, operation, and maintenance of the pipeline; 2) "balance environmental amenities and values with economic practicalities and technical capabilities..."; and 3) "manage, supervise and implement the construction, operation, maintenance and termination of the Pipeline System in accordance with sound engineering practice, to the extent allowable by the state of the art and development of technology."

Through the delays in the early 1970s, Alyeska Pipeline Service Company — the company established by the owners to build and operate the Trans Alaska Pipeline System (TAPS) — worked on the design and specifications of the pipeline in coordination with the U.S. Geological Survey, the Bureau of Land Management, the U.S. Army Corps of Engineers, the Alaska Department of Fish and Game, and other federal and state agencies. Data from pipeline field tests, simulation modeling, and a detailed study of permafrost slowly altered the shape of the project. Where permafrost was mapped as thaw-unstable, and in earthquake zones — both regions mainly south of the Brooks Range — plans for a buried pipeline were changing to an aboveground mode. Once the rights-of-way were obtained, Alyeska had to obtain more than 1,300 federal and state permits for constructing and operating the pipeline (Table 1.3-1).

Construction of the pipeline system finally began in April 1974 when Alyeska began moving 37,500 tons of equipment by air and truck to the Yukon River, then north by ice road. Construction of TAPS required that 73 million cubic yards of gravel be mined, stockpiled, hauled, and laid down. This meant designing and permitting hundreds of detailed gravel-mining plans.

Construction of the permanent Haul Road (now the Dalton Highway, or Alaska State Route 11) was started on April 29, 1974, and completed on September 29 of that year. The first pipe was laid at the Tonsina River crossing of the Richardson Highway, 75 road miles north of Valdez, on March 27, 1975; the final pipeline weld was finished on May 31, 1977. Oil began flowing down the pipeline on June 20, 1977, and on August 1, the *ARCO Juneau* was the first tanker to leave Valdez carrying North Slope crude oil — after six years of controversy, an additional three years of construction, a workforce that ultimately totaled 70,000 people, and $8 billion (Table 1.3-2).

TAPS and the VMT are described in detail in Sections 1 and 2 of this Environmental Report. The 800-mile-long pipeline crosses 34 major rivers and some 800 smaller streams and three mountain ranges. The VMT includes facilities for crude oil storage and ballast water treatment, as well as fixed-platform and floating berths for oil tankers.

The baseline and environmental monitoring studies conducted along the pipeline by industry and agency researchers over the past 20 years has included water quality studies in Port Valdez; long-term revegetation experiments; fisheries investigations of water bodies crossed by or near the pipeline; and surveys of caribou, moose, bear, waterfowl, and other wildlife. (These studies are discussed as appropriate in the relevant sections of this Environmental Report.) The result is that the TAPS ROW, like the North Slope oil fields, is one of the most intensively studied regions in Alaska.

During the past 20 years, Alyeska's engineers have worked with other experts to develop innovations in low-

Table 1.3-1. *Facts about construction of TAPS, 1974-1977 (APSC, 2000).*

Category	Data
Archaeological Surveys before Construction	Approximately 330 sites, cost approx. $2.2 million
Soils Surveys before Construction	Approximately 3,500 bore holes and 15,000 soil samples
Permits Required	515 federal, 832 state
Notices to Proceed Required	465 federal, 403 state
Temporary Facilities	29 construction camps, 14 airfields (3 became permanent)
Materials	Approximately 3 million tons shipped to Alaska, approx. 73 million cubic yards of gravel used
Workforce	Approximately 70,000 over life of construction project (1969 - 1977), peak was 28,072 in October 1975

temperature engineering (Gilders, 1997). Alyeska also pioneered other advancements in pipeline operation. For example, a drag reducing agent was initially injected into the pipeline at Pump Station 1 in July 1979, two years after startup. It was considered experimental at the time but is now standard procedure. Alyeska developed the world's first ultrasonic corrosion-inspection pig. This pig measures and records the thickness of the pipeline's walls using ultrasonic transducers, identifying areas of possible corrosion before they become problems.

On March 24, 1989, the *Exxon Valdez* ran aground on Bligh Reef in Prince William Sound and spilled 257,000 barrels of oil. The spill brought about changes designed to prevent future spills of this magnitude. The Ship Escort/Response Vessel System (SERVS) was established following the *Exxon Valdez* spill in response to an executive order by the Governor of Alaska requiring every outbound tanker to be accompanied by two escort vessels until the tanker had left Prince William Sound.

The 1989 oil spill also gave added impetus to the establishment of a coordinated regulatory body to oversee the planning, construction, operation, and maintenance of all Alaska pipelines and associated facilities. The Joint Pipeline Office (JPO) was established in 1990 with representatives from various federal and state agencies. The JPO now includes the following agencies:

State of Alaska Agencies:

- Department of Natural Resources
- Department of Environmental Conservation
- Department of Fish and Game
- Department of Labor
- Division of Governmental Coordination
- Department of Transportation/Public Facilities

Federal Agencies:

- Bureau of Land Management
- Department of Transportation/Office of Pipeline Safety
- Environmental Protection Agency
- U.S. Coast Guard
- U.S. Army Corps of Engineers

Agency representatives conduct unannounced inspections of facilities, review permit applications, and oversee every aspect of pipeline operations in Alaska.

In 1991, Alyeska began the largest post-construction project in the pipeline's history: the Atigun reroute. The reroute began as a result of information supplied by smart pigs used during the first years of the ongoing corrosion investigation. Discovery of corrosion in the buried section of pipe running through Atigun River valley led to the replacement of an 8.5-mile section of pipe.

Table 1.3-2. *Key events in the history of the Trans Alaska Pipeline System.*

Date	Event
March 1968	Oil discovered at Prudhoe Bay
August 14, 1970	Alyeska Pipeline Service Company incorporated by the owner companies
March, 1972	Department of Interior issues final environmental impact statement for TAPS
November 16, 1973	Trans-Alaska Pipeline Authorization Act signed into law
January 23, 1974	Federal Agreement and Grant of Right-of-Way
May 3, 1974	State Lease
April 29, 1974	Haul Road construction begins
September 29, 1974	Haul Road construction completed
May 27, 1975	First pipe laid (Tonsina River)
October 11, 1975	Yukon River bridge completed
May 31, 1977	Final pipeline weld
June 20, 1977	First oil flows from Pump Station 1
July 28, 1977	First oil reached VMT
August 1, 1977	First oil-laden tanker (ARCO Juneau) leaves Valdez Marine Terminal
July 1, 1979	Drag reducing agent first used
1988	Peak average daily throughput of 2.03 million bbl/day
March 24, 1989	Exxon Valdez oil spill
July 10, 1989	Alyeska Ship Escort/Response Vessel System established
1990	Federal Oil Pollution Act of 1990
1990	Joint Pipeline Office established
1990	Prince William Sound Regional Citizens Advisory Council contract signed with Alyeska
1990	HB 567 enacted by Alaska Legislature amending oil pollution laws
1991	Atigun reroute
1993	Congressional hearings on TAPS operations
March 5, 1994	10 billionth bbl reaches VMT
1996-1997	Pump Stations 2, 6, 8, and 10 taken offline and placed on standby due to lower throughput
1997	Tanker vapor recovery system added at VMT
August 12, 1997	15,000th tanker leaves VMT
April 27, 2000	13 billionth barrel reaches VMT

Except for occasional shutdowns for maintenance or troubleshooting, the pipeline has operated continuously since June 1977. TAPS has transported approximately 13 billion barrels of crude oil. The peak average daily throughput of 2.03 millions barrels per day was reached in 1988, and that rate dropped to approximately 1.08 million barrels per day in 1999.

SECTION 2

ALTERNATIVES INCLUDING THE PROPOSED ACTION

2.1 Description of Proposed Action: Renewal of Right-of-Way 2.1-1
2.1.1 Trans Alaska Pipeline System 2.1-1
2.1.2 Pipeline-Associated Marine Transportation 2.1-14
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Introduction: Section 2

Alternatives Analyzed

This section describes the alternatives including the proposed action. The proposed action is renewal of the existing right-of-way for the Trans Alaska Pipeline System (TAPS) (Figure 2-1). The proposed action is compared with the "no-action alternative": allowing the existing right-of-way (ROW) to expire in the year 2004.

The *proposed action*, discussed in Section 2.1, entails renewal of the ROW, which means that the pipeline and its appurtenances will stay in operation in essentially the same configuration as now. The *no-action alternative* (Section 2.2) involves expiration of the ROW in 2004. In this case, the pipeline system will have to be removed in accordance with the terms of the Federal Grant and State Lease. Federal and state stipulations contain general provisions for "dismantling, removal, and restoration" (DR&R) of TAPS assets upon completion of use of the TAPS ROW. In that case, it would be necessary to prematurely shut in North Slope production since the pipeline would not be available for transporting crude oil.

Photo 2-1. *Vertical support members (VSMs) elevate the trans-Alaska pipeline in areas of thaw-unstable permafrost.*

Other alternatives considered but not included in the analysis are listed in Section 2.3. Similar alternatives were evaluated in the original TAPS environmental impact statement (EIS) (BLM, 1972) and dismissed because of their impracticality. These included shipping oil through the Northwest Passage by tanker, trucking oil, and transporting by railroad. With TAPS already built and in operation, no practical or economically feasible alternative exists for transporting North Slope crude oil to market.

Definition of Pipeline System

While the proposed action involves only the pipeline ROW itself, the environmental effects associated with the proposed action come from operation of the Trans Alaska Pipeline System (TAPS) and not from the existence of the ROW. As a result, this Environmental Report focuses on all of TAPS, which is defined in Stipulation 1.1.1.22 of the Federal Grant to include "all facilities located in Alaska used by Permittees in connection with the construction, operation, maintenance or termination of the Pipeline." As a result, Section 2.1 describes all of these elements of TAPS.

Stipulation 1.1.1.22 excludes from the definition of TAPS those "facilities used in connection with production of oil or gathering systems" and "urban administrative offices and similar facilities which are only indirectly involved." By this definition, the Alaska North Slope (ANS) oil fields and the marine transportation link are not parts of TAPS. However, for the convenience of the reader and for the sake of continuity, the discussion of the proposed action in Section 2.2 includes the marine transportation link.

Figure 2-1.
State of Alaska map showing place names and trans-Alaska pipeline route.

2.1 Description of the Proposed Action: Renewal of Right-of-Way

This subsection provides an overview of the system's major components, as well as projections for future use and maintenance. For purposes of this Environmental Report, the proposed action is renewal of the Federal Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline (Federal Grant). The Trans Alaska Pipeline System (TAPS) is defined in Stipulation 1.1.1.22 of the Federal Grant to include:

> "...all facilities located in Alaska used by Permittees in connection with the construction, operation, maintenance or termination of the Pipeline. This includes, but is not limited to, the Pipeline, storage tanks, Access Roads, communications site, airfields, construction camps, materials sites, bridges, construction equipment and facilities at the origin station and at the Valdez terminal. This does not include facilities used in connection with production or oil or gathering systems, nor does it include such things as urban administrative offices and similar facilities which are only indirectly involved."

Thus, Section 2.1 describes all of these elements of TAPS including facilities integral to TAPS but on fee-simple land and not part of the ROW (e.g., Valdez Marine Terminal, Pump Station 1) and other facilities used in operation such as access roads, the fuel gas pipeline, material sites, the Dalton Highway, etc. However, Alyeska operates the Ship Escort/Response Vessel System (SERVS) to provide spill prevention and response in support of the tanker trade, and discussion is provided in this section for convenience.

2.1.1 Trans Alaska Pipeline System

By J.D. Norton and J. Riordan

2.1.1.1 Description by Major Component

The Trans Alaska Pipeline System, which occupies 16.3 square miles in Alaska, consists of the pipeline, pump stations, Valdez Marine Terminal (VMT), and associated facilities (Table 2.1-1). The *Alyeska Design Basis Update* (DB-180) contains the approved design criteria and descriptions for all components of the pipeline system.

The Pipeline

The 800-mile, 48-inch-diameter crude oil pipeline begins about 6 miles from the Arctic Coast of Alaska and ends at the VMT on Port Valdez (Figure 2.1-1). The pipeline is elevated above ground for 420 miles of its length and buried for the other 380 miles. Eleven pump stations were built to move the oil through the pipeline (Table 2.1-1).

The pipe itself was specially engineered and manufactured for TAPS in two wall thicknesses (0.462 and 0.562 inches) with three grades of steel (with specified minimum yield strengths of 60,000, 65,000, and 70,000 pounds per square inch). The pipe is epoxy-coated and taped for protection from corrosion. To provide additional corrosion protection from defects in the coating or tape, zinc ribbons are buried parallel to the underground pipe and are galvanically coupled to it to provide a sacrificial anode (Figure 2.1-2). Most sections of below-ground pipe are protected by an impressed-current system.

At more than 800 river and stream crossings, the pipe either bridges the waterways or is buried beneath them. At most small streams, the pipe bridges the water channel on conventional supports. At 13 locations, however, special bridges were built: one highway bridge, nine standard plate-girder bridges, two special suspension bridges, and one tied-arch bridge (Photo 2.1-1). At critical locations where the pipeline crosses or parallels rivers, "river training structures" protect the pipeline from erosion of the river bank, riverbed, or floodplain. These structures are typically gravel embankments and riprap that deflect the river's flow.

The temperature of the composite crude oil leaving Pump Station 1 on the North Slope is around 115°F. At a flowrate of 1.0 million barrels per day (bbl/day), the oil is around 60°F when it arrives at Valdez — cooler with lower flow rates. About half of the pipeline corridor traverses ice-rich soil that becomes unstable if thawed. To avoid exposing these soils to the warm pipe, over half of the pipeline is

David Predeger

PS 1

Pump Station 1 is located in the North Slope tundra lakes area. PS 1 receives and meters oil from the producers.

PS 3

Pump Station 3 provides pumping for the pipeline enroute to Atigun Pass. PS 3 has a heavy equipment maintenance facility.

PS 5

Pump Station 5 is a relief station and the first station south of Atigun Pass.

PS 7

Pump Station 7 is about 1.3 miles southeast of the Tatalina River in a wooded area. PS 7 is similar to PS 2 with two mainline pumps instead of three.

PS 9

Pump Station 9 is located in a flat area adjacent to the Richardson Highway and the adjoining Fort Greely Military Reservation.

PS 12

Pump Station 12 helps push oil over the Chugach Mountains located between PS 12 and the Valdez Marine Terminal.

Photos courtesy of Alyeska Pipeline Service Company

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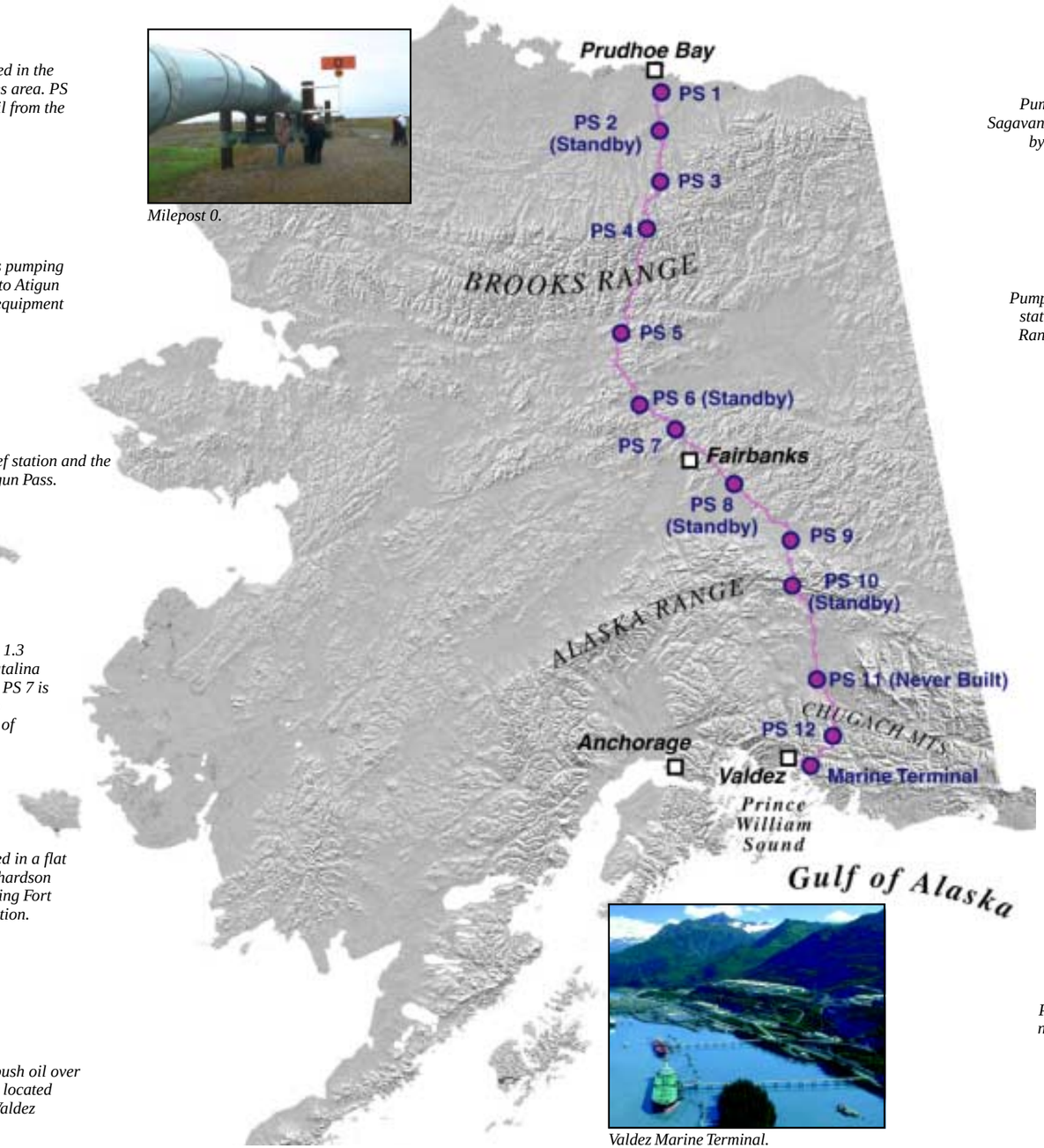


Valdez Marine Terminal.

PS 2 (currently on standby)

Pump Station 2 is west of the Sagavanirktok River and is fueled by North Slope natural gas.

PS 4

Pump Station 4 is the last pump station upstream of the Brooks Range — the highest elevation along the pipeline.

PS 6 (currently on standby)

Pump Station 6 is located in a wooded area on the south bank of the Yukon River.

PS 8 (currently on standby)

Pump Station 8 is southeast of Fairbanks. The surrounding terrain is heavily wooded.

PS 10 (currently on standby)

Pump Station 10 is located near the Denali Fault in an area of high seismic probability.

NOTE: PS 11 was never built

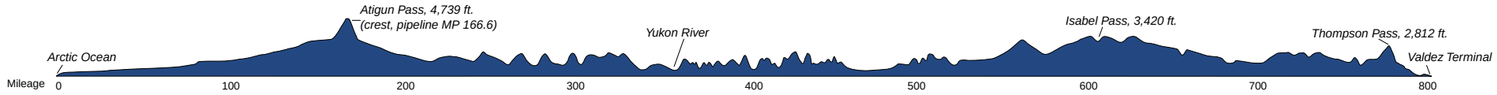
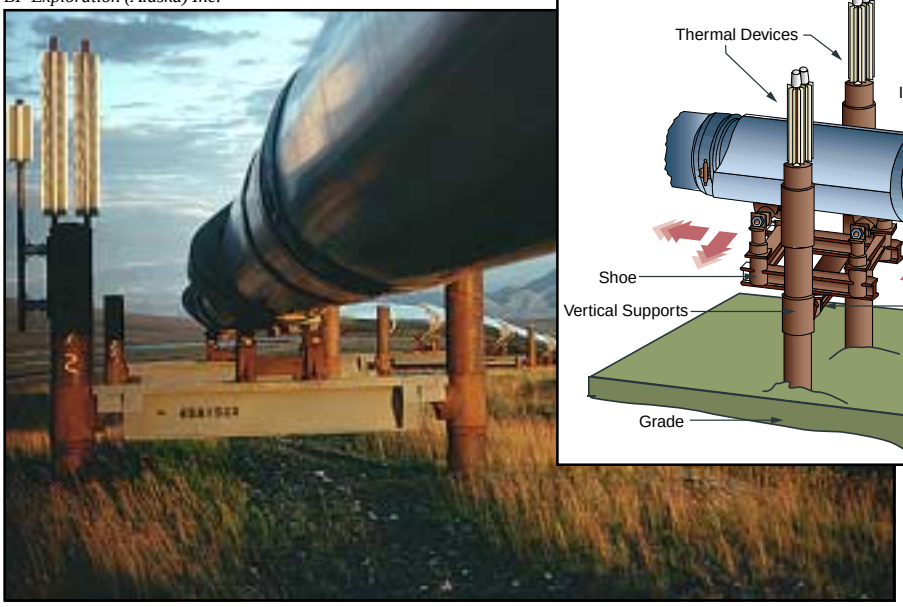


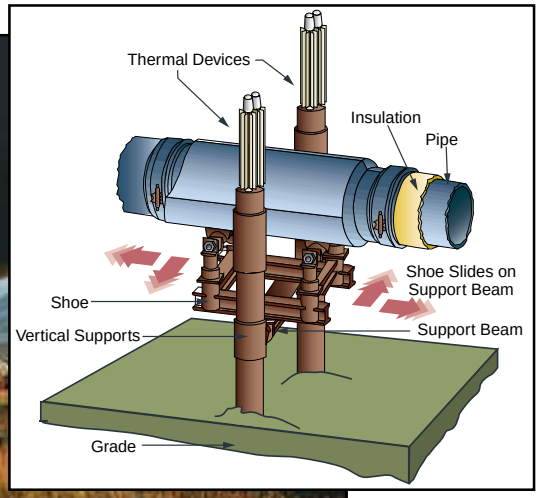
Figure 2.1-1.
Trans-Alaska Pipeline System.

Table 2.1-1. *Summary of major features of the Trans Alaska Pipeline System.*

Component	Type	Data
Area Covered by TAPS	--	16.3 square miles (includes VMT)
Length of Pipeline	--	800 miles
Design Mode	Above-ground	420 miles
	Conventional below-ground	376 miles
	Refrigerated below-ground	4 miles
Typical Right-of-Way Width	Federal lands, buried pipe	54 feet
	Federal lands, elevated pipe	64 feet
	State lands	100 feet
	Private lands	54 to 300 feet
Vertical Support Members	Number	78,000
	Types	16 for different soil and permafrost conditions
	Diameter	18 inches
	Number with heat pipes	61,000
	Depth embedded	15 to 70 feet
Animal Crossings	Elevated	554
	Buried	23
	Buried (refrigerated)	2 (MP 645 and 649)
Bridges	Orthotropic box girder	1 (Yukon River: shared with Alaska Dept. of Transportation)
	Plate girder	9 (Atigun, Dietrich, Koyukuk [south and middle forks], Hammond, and Tatalina rivers; Unnamed, Hess, and Shaw creeks)
	Suspension	2 (Tanana and Tazlina rivers)
	Tied arch	1 (Gulkana River)
Pump Stations	Operating (1999)	PS 1, PS 3, PS 4, PS 7, PS 9, PS 12
	Stand-by	PS 2, PS 6, PS 8, PS 10
	Relief	PS 5
Pipeline Valves	Check valves	81
	Gate valves	95 (including pump station isolation valves)
	Ball valves	1
Fuel Gas Line	Buried natural gas pipeline	From PS 1 to PS 3 and PS 4; 8 to 10 inches diameter; approximately 144 miles long
Access Roads		Approximately 225 secondary roads (from 120 feet to 7.5 miles long) linking state roads with pipeline, pump stations, material sites, disposal sites, and airfields
Valdez Marine Terminal	Total area	1,000 acres
	Crude oil storage	9.18 million barrels total in 18 tanks (510,000 barrels each)
	Tanker berths	4 (1 floating, 3 fixed platform)
Ship Escort/Response Vessel System (SERVS)	Tugs	2 enhanced tractor tugs, 3 prevention/response tugs, 4 other
	Other vessels	10 workboats, 7 response barges, 48 mini-barges
	Skimmers	Over 70
	Containment boom	Over 42 miles
	Response centers	5 (Valdez, Cordova, Whittier, Chenega Bay, Tatitlek)
Communications Sites	Microwave stations	42 (operated by AT&T)
	Satellite earth stations	7 (operated by AT&T)
	VHF repeaters	22

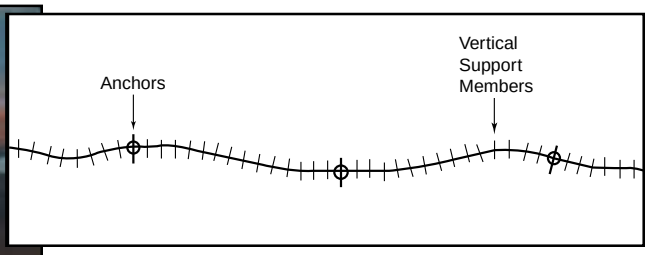
BP Exploration (Alaska) Inc.



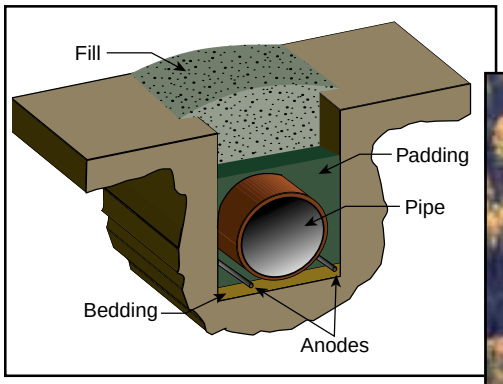


Vertical support members consist of crossbeams installed between vertical supports placed in the ground. The above-ground pipe is insulated, jacketed with galvanized steel, and mounted on a Teflon-coated shoe that can slide back and forth on the VSM crossbeams.

John Warden for BP Exploration (Alaska) Inc.



To allow for thermal expansion and contraction of the above-ground pipe, the pipeline was constructed in a flexible zigzag configuration. This design allows lengthwise expansion of the pipe to be translated into sideways movements. The photo at left shows the pipeline on the left and the Dalton Highway on the right.



Pipeline buried in the standard method lies on a layer of bedding material (well-drained sandy gravel without sharp rocks) covered with prepared gravel padding and soil fill material. The photo at right shows a transition between elevated and buried pipe.

Alyeska Pipeline Service Company

Figure 2.1-2. *Pipeline construction modes for the Trans Alaska Pipeline System.*

Photo 2.1-1. *The above-ground pipeline is carried across the Gulkana River on a tied-arch bridge (top), the Yukon River on the same bridge as the Dalton Highway (bottom left), and the Tanana River on a suspension bridge (bottom right). (Alyeska photos)*

above ground. In stable soils, where thawing would not result in disturbed terrain or pipe settlement, the line is buried. Several sections of pipe (about 4 miles total) are buried in thaw-unstable soils for big game passage and a highway crossing. These sections are mechanically refrigerated to maintain soil stability. Two sections of pipeline in Atigun Pass are buried in insulated boxes to keep the permafrost from thawing and to protect the pipeline from avalanches.

The 420 miles of above-ground pipeline are supported by vertical support members, or VSMs, located about every 60 feet (Figure 2.1-2). Anchor structures approximately every 800 to 1,800 feet hold the above-ground pipe in position. Between anchors, the pipe can move up to 170 inches side-to-side for thermal expansion and seismic movement. The pipeline crosses five seismic zones and is designed and constructed to withstand the most severe earthquake that could reasonably be expected within each zone. Most pump stations and the VMT are equipped with seismic instrumentation that detects, measures, and records earthquake-induced ground motion and processes the data to estimate the distribution of earthquake ground-shaking effects along the pipeline route.

Valves are strategically placed along the pipeline to isolate sections of the pipeline and minimize the size of potential spills in the event of a pipe rupture (Figure 2.1-3). Most of the gate or ball valves can be controlled from the Operations Control Center (OCC) at the VMT or from the pump stations. All valves can be operated manually for maintenance of the line or for spill isolation, if necessary. TAPS has 177 pipeline valves: 95 are gate valves (86 remote-controlled, 9 manually operated), 1 is a remote-controlled ball valve, and 81 are check valves that automatically prevent backflow when the pipeline shuts down. Eighty-five valves are above-ground and 92 are below-ground. Twenty-four of the gate valves are battery-limit valves that serve to isolate the pump stations.

Valve locations are based on environmental and resource considerations, as well as on construction and operating requirements. The valves are placed so as to limit the amount of a spill at any point to a maximum of 50,000 bbl from static drain-down. Check valves would limit backflow drainage in the event of a leak or break. Remotely operated valves are placed at major river crossings and other locations where quick closure would be necessary in an emergency. Power for each remote-control valve is provided by batteries that are kept charged by two propane-fired generators or by commercial electrical utilities where available. The batteries provide an uninterrupted power supply. Propane-fired systems serve as backup battery chargers where commercial power is the primary source.

TAPS was built from a gravel workpad ranging from 18

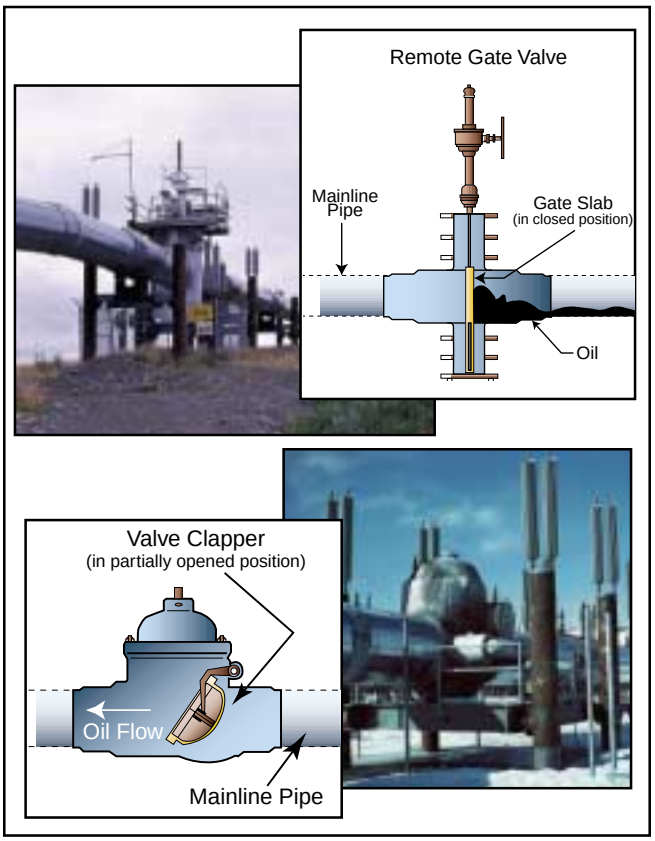


Figure 2.1-3. *TAPS gate valve (top) and check valve (bottom). (Alyeska photos)*

to 48 inches thick and designed to protect the underlying soils and provide a safe working surface for construction. The width of the workpad varies depending on the terrain, pipeline construction mode, soil conditions, and land ownership. The workpad occupies only a portion of the ROW. Typical ROW widths range from 54 feet for below-ground pipe on federal land to 100 feet on state land.

Construction actually took place on a construction zone width of up to 115 feet or more, which included the workpad as well as the pipeline itself and the spoils from the trench for the buried pipeline. This was wider than the permanent right-of-way but was permitted for use during construction. Following construction, the entire construction zone width was restored for erosion control, drainage, and revegetation. The workpad now provides access and a work platform for surveillance and maintenance and includes a 15-foot-wide drive lane along most of the pipeline.

Connections are provided from TAPS to three commercial oil refineries at North Pole and Valdez. These connections comprise offtake and return lines, isolation valves, and metering facilities. North Slope crude oil is delivered to TAPS by several feeder pipelines, including Endicott, Lisburne, Kuparuk, and Prudhoe Bay East and West (the Northstar pipeline is complete and is expected to be online in late 2001). These pipelines and the refinery delivery lines are not part of the TAPS ROW.

Pump Stations

The 11 pump stations are located at intervals of approximately 50 to 100 miles to boost crude oil pressure and provide relief tankage. Pump Station 5, however, does not have mainline pumps and serves to relieve pressure on the downslope side of Atigun Pass. TAPS was originally designed for 12 pump stations, but Pump Station 11 was not built because the development and use of drag reducing agent (DRA) allowed the numbers of downstream pump stations to be reduced (DRA is a long-chain hydrocarbon polymer injected into the oil to reduce the energy loss due to turbulence. See Section 2.1.1.2 for further discussion of DRA.)

The TAPS pump stations (Table 2.1-2, Figure 2.1-4) are similar in layout and function, although there are certain differences due to location and station tasks. The stations include pumps and turbine drivers (except PS 5), isolation valves, relief tanks with secondary containment, fuel handling facilities, station and pipeline control facilities, living facilities (except PS 1, 8, and 9), office buildings, shops/warehouses, and other facilities for pipeline operation and maintenance. A fence and round-the-clock security protect each station. Pump Station 1 has a vapor recovery system for the crude oil tanks. Pump Stations 1, 3, 4, 5, 7, 9, and 12 are currently operating (2000). Due to declining production and the use of DRA, Pump Stations 2, 6, 8, and 10 were placed on standby in 1996 and 1997 as part of the "rampdown" program. Pump Stations 7 and 12 may be placed on standby over the next 5 to 10 years, with the exact timing dependent on throughput and the economic balance between fuel and DRA costs. Table 2.1-2 summarizes the characteristics of TAPS pump stations.

The turbines at Pump Stations 1 through 4 are powered by Prudhoe Bay natural gas provided by a buried pipeline (the "fuel gas line") that parallels the TAPS crude oil pipeline from Pump Station 1 to Pump Station 4. Approximately the first 34 miles from Pump Station 1 south are 10-inch-diameter pipe, and the remainder is 8-inch-diameter pipe. Turbines at the other pump stations are powered with liquid turbine fuel, which is purchased from commercial fuel vendors who deliver the fuel in tanker trucks. If there is an interruption of natural gas supply, the turbines at Pump Stations 1, 2, 3, and 4 can be converted to operate on turbine fuel.

DRA injection facilities are located at Pump Stations 1, 7, and 9, and at Pipeline MP 238. DRA injected into the pipeline reduces the required pumping horsepower. As its name implies, DRA reduces drag, permitting more oil throughput at any given pumping horsepower.

In normal operating mode, most pump station functions are controlled from the OCC. If required, the pipeline controller at OCC can adjust pressure controls to increase or decrease the throughput, within capacity limits. Main pumps at the stations can be shut down locally or from the OCC by a single command. The speed of the turbines that drive the main pumps can be changed, and pressure controllers automatically vary pump speeds to keep line pressure within preset limits. Under emergency conditions, the OCC or the pump station control room can shut down the station and close remote gate valves (RGVs). All critical station equipment is fully automatic with local manual override capability.

Pressure relief systems at the pump stations are designed to keep the pressure from surges and other deviations from normal operations from exceeding 110 percent of the mainline pipe maximum allowable operating pressure at any point along the pipeline. The pump speed controllers keep pipeline pressure below the maximum allowable operating pressure during normal operations.

Valdez Marine Terminal

The Valdez Marine Terminal (Photo 2.1-2) is the southern terminus of the trans-Alaska pipeline and is located on

Table 2.1-2. *Trans Alaska Pipeline System pump station summary.*

Pump Station	Location (MP)	Elevation (ft)	Crude Tank Capacity (bbl)	Living Quarters (Y/N)	No. of Mainline Pumps	Turbine Fuel Capacity (bbl)	Crude Oil Topping Unit (Y/N)	Refrigerated Foundation (Y/N)	Significant Features
PS 1	0	39	420,000	N	3	10,000	N	Y	Meters; pig launcher
PS 2	58	602	55,000	Y	2	798	N	Y	Standby
PS 3	104	1,383	55,000	Y	3	20,000	N	Y	--
PS 4	144	2,763	55,000	Y	3	20,000	N	N	Pig receiver/ launcher
PS 5	275	1,066	150,000	Y	0	20,000	N	Y	Pressure relief station
PS 6	355	881	55,000	Y	3	40,000	Y	Y	Standby
PS 7	414	904	55,000	Y	2	40,000	N	N	--
PS 8	489	1,028	55,000	N	3	40,000	Y	N	Standby
PS 9	549	1,509	55,000	N	3	40,000	N	N	--
PS 10	586	2,392	55,000	Y	3	40,000	Y	N	Standby
PS 12	735	1,821	55,000	Y	3	40,000	N	N	--

NOTE: Pump Station 11 was never built. Y = yes; N = no.

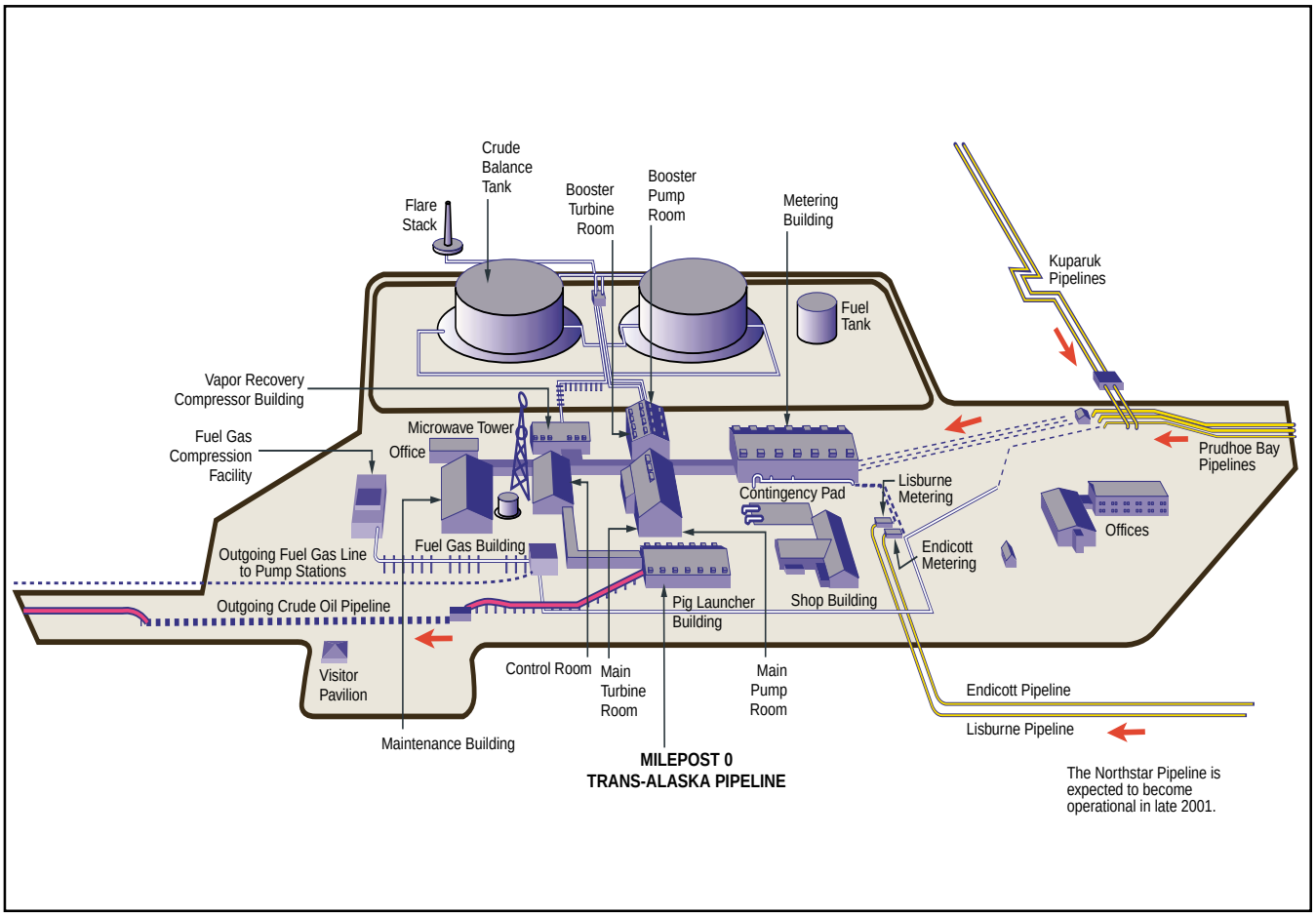


Figure 2.1-4. *Pump Station 1 at TAPS Milepost 0.*

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Photo 2.1-2. *Valdez Marine Terminal.*

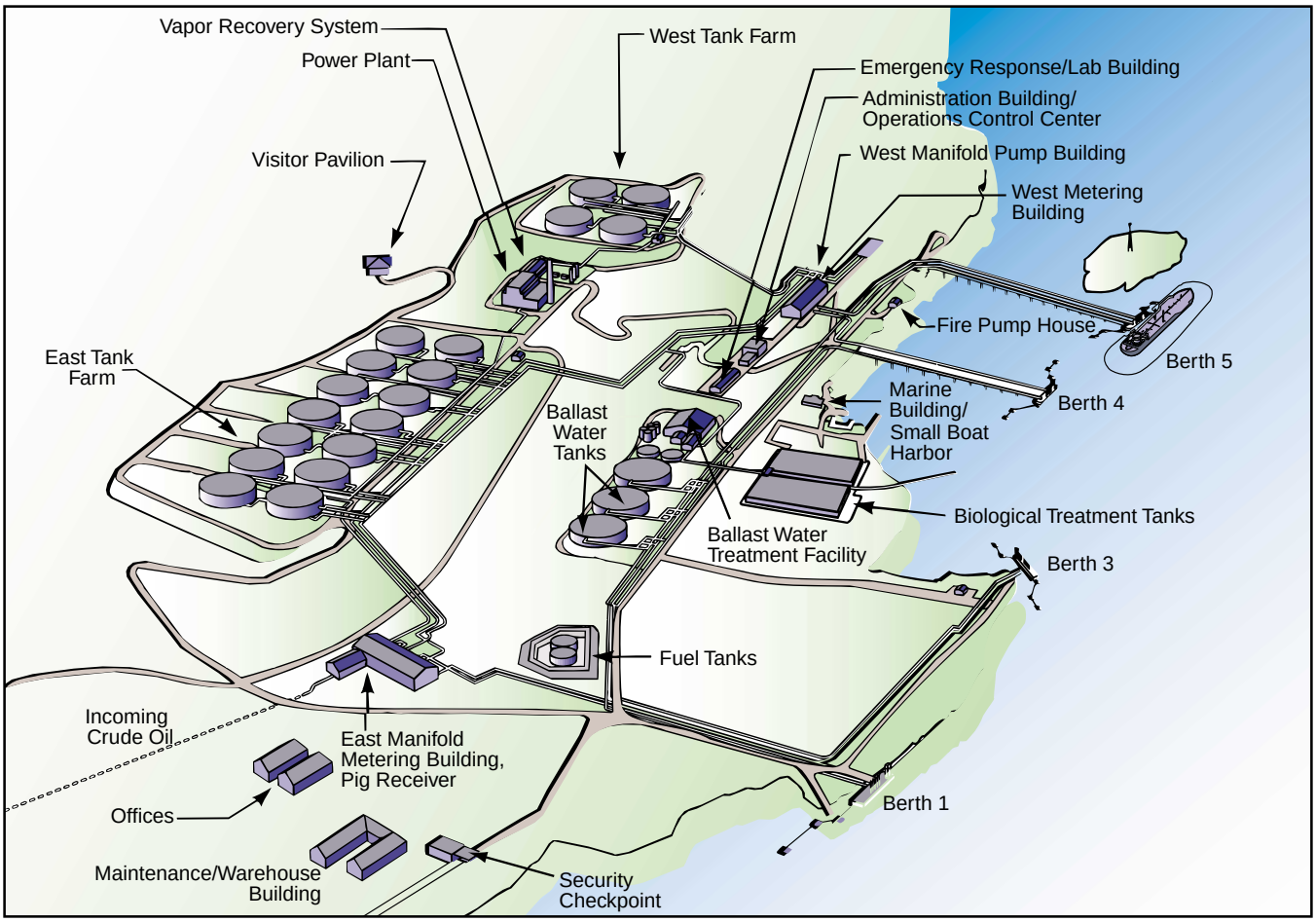

Figure 2.1-5. *Layout of Valdez Marine Terminal.*

ice-free Port Valdez at the northeastern end of Prince William Sound. The VMT site occupies approximately 1,000 acres on the southern shore of Port Valdez, extending from sea level to 538 feet in elevation at the West Tank Farm (Figure 2.1-5).

Table 2.1-3 summarizes the facilities located at the VMT, where oil is loaded onto tankers for shipment to markets. The vast majority has been shipped to the U.S. West Coast, with minor amounts to the Far East. The terminal has storage facilities for 9.18 million bbl of crude, and four loading berths. Berths 4 and 5 have vapor-control systems and will be the primary loading berths in the future. Berths 1 and 3 are not vapor-controlled but remain available for use in special situations. Future use of Berths 1 and 3 is under study.

Crude oil arriving at the VMT is measured at the East Metering Building and then goes to storage tanks or can be directly loaded onto tankers. Ballast water from incoming tankers is piped to the Ballast Water Treatment Facility for treatment before discharge to Port Valdez in accordance with state and federal permits. Vapor from tankers and crude storage tanks is piped to the vapor recovery system.

Operations and Control

Alyeska uses microwave, satellite, and radio technology for remote monitoring and control of pipeline operations. The TAPS voice communication system consists of a private telephone network and a mobile radio system. Two party-line channels on the microwave system are allocated for voice communications between all stations and Valdez. The mobile radio system consists of a VHF radio base and microwave repeater stations located at strategic sites, microwave control channels, and interconnecting links to the telephone network throughout the system.

A fiber-optic communication system has been installed along the TAPS ROW; however, its reliability has not yet proven sufficiently high for critical control-system communications. It is anticipated that the existing analog microwave system, which has demonstrated extremely high reliability in over 20 years of operation, will be upgraded to a more modern and technically superior digital microwave system for such communications. The fiber-optic network may ultimately be used for non-critical voice and data communications.

The OCC (Photo 2.1-3) continually monitors the status of all pump stations and valves using supervisory control and data acquisition (SCADA) systems with remote sensors. Data such as pressures, flow rates, temperatures, tank levels, and valve positions are recorded and analyzed for abnormal operations or any indication of a pipeline leak.

Table 2.1-3. *Valdez Marine Terminal facility summary.*

Facility	Function
Operations Control Center	• Controls entire pipeline. • Directs flow of oil to the tank farms and to vessels at the berths. • Monitors operation of the ballast water treatment system and the tanker loading berths.
18 Crude Oil Holding Tanks	• Four tanks at West Tank Farm, 14 at East Tank Farm. • Each tank has 510,000 barrels capacity; total capacity is 9.18 million barrels. • All tanks are within secondary containment and are connected to a vapor control system.
Two Manifold/Metering Buildings	• Measure incoming oil from the pipeline (East Manifold/Metering Building). • Pressure relief valves prevent incoming oil pressure from exceeding design limits and divert oil to relief tanks, if necessary. • Route oil to berth meters for loading onto tankers or to storage tanks (East Metering). • Measure oil loaded into tankers.
Four Tanker Loading Berths (1, 3, 4, and 5; 2 was never built)	• One (Berth 1) floating with up to 80,000 bbl/hr capacity. • Three fixed with up to 110,000 bbl/hr capacity each. • Two loading arms at Berth 1 can also offload fuel oil from tankers. • Berths 4 and 5 have tanker vapor collection systems.
Ballast Water Treatment (BWT) System	• All oily water collected in the VMT, including ballast water, is processed through the BWT system; handles an average of 400,000 bbl/day. • Recovered oil is returned to the crude oil system; recovers an average of 2,000 bbl/day of oil. • After treatment, ballast water is discharged into Port Valdez.
Major Support Systems	• Power generation and other utility systems • Maintenance • Security • Materials receiving and control • Emergency response (SERVS) • Tanker escort (SERVS) • Harbor facilities for support vessels • Tanker and tank farm vapor recovery

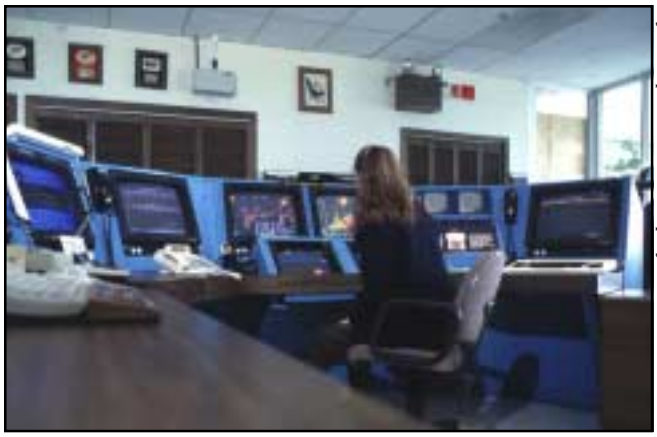

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Photo 2.1-3. *Operators at the Valdez Operations Control Center monitor the performance of all aspects of pipeline operation via modern communications and computer technology.*

The pipeline controller at the OCC can rectify any abnormal operation by changing settings for pump speed or relief valves or by issuing idle or stop commands to the mainline pumps. The OCC controller can also activate remote control valves. The monitoring and analysis systems include backup communications equipment and computers.

Leak detection for the pipeline consists of three independent systems: line volume balance (LVB) compares the volume of oil entering the line with the volume leaving the line; transient volume balance (TVB) compares reported flow with calculated flow and can identify the probable location of a leak by pipeline section; and alarms will signal deviations in pressure, flow, or flow rate balance.

If emergency conditions occur, the pipeline controller can shut down an entire pump station and isolate it from the line, or shut down the entire pipeline. Pressure relief systems are in place to prevent overpressure during each type of shutdown.

2.1.1.2 Projected Use

The projected use of TAPS is a continuation of its current use as an oil pipeline linking the North Slope to in-state refineries and the VMT. The TAPS design was based on crude oil from Sag River State Well #1, which represented the Sadlerochit zone, the major producing zone in the Prudhoe Bay oil reservoir (APSC, 1973), but other crude oils or hydrocarbons may be safely transported. By design, crude oils from the different fields are blended at Pump Station 1. The composite crude oil is known as Alaska North Slope (ANS) crude. Since TAPS startup in 1977, additional North Slope oil fields have been discovered and developed.

Not all North Slope oil fields share processing facilities, but all use TAPS for transportation to Valdez. Consequently, TAPS allows North Slope petroleum to be marketed by providing the critical land transportation link between the North Slope oil fields and in-state refiners and waterborne tankers. Figure 2.1-6 shows the daily average oil throughput for TAPS since startup, while Appendix A addresses projected throughput estimates.

Although the projected use of TAPS is essentially a continuation of its current use, some physical changes to TAPS are anticipated during the ROW renewal period. These changes would be in response to throughput decline, re-

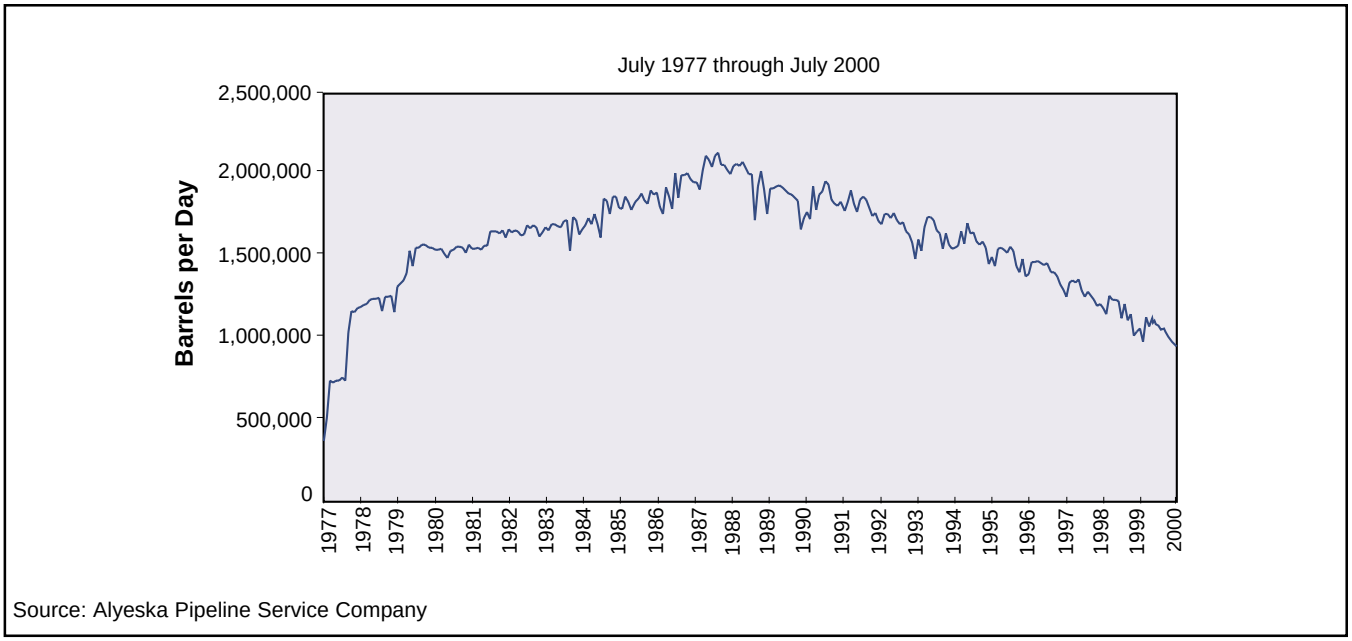


Figure 2.1-6. *Daily average TAPS throughput since startup.*

quired maintenance and repairs, and future system upgrades, and would be subject to regulatory oversight. Some of the more significant changes are discussed in the following sections.

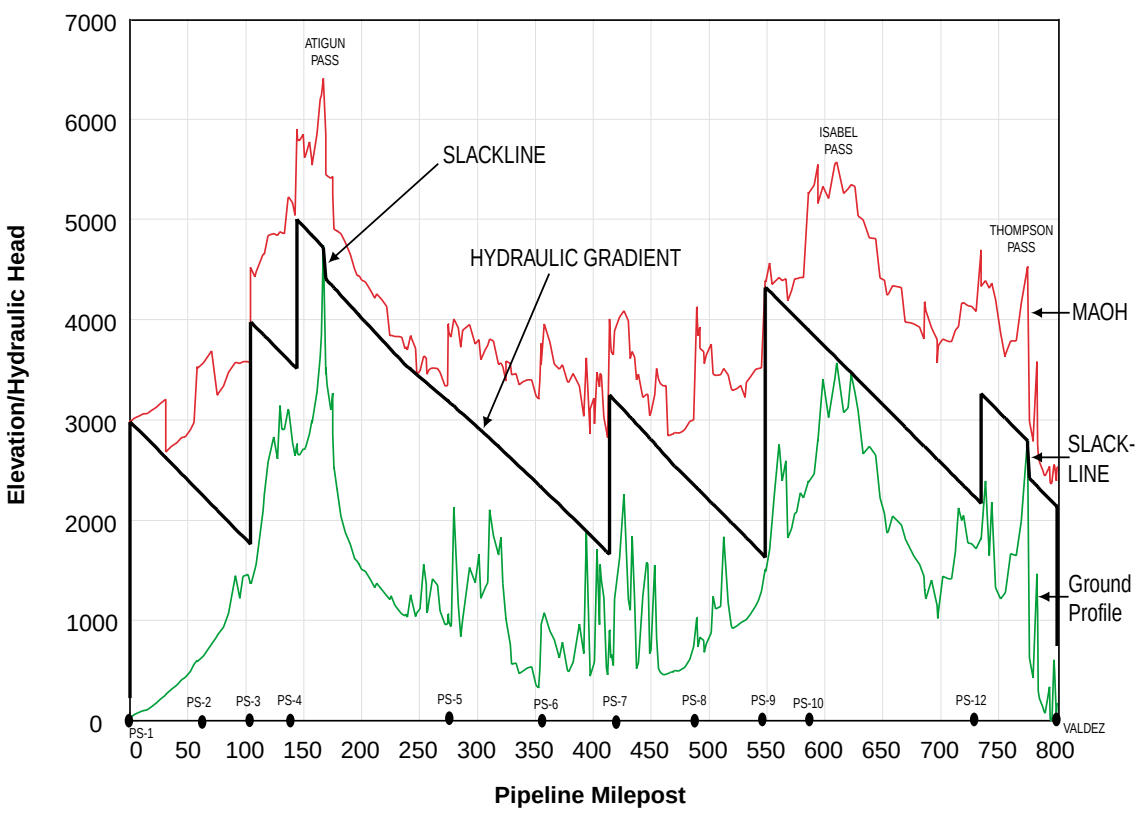
Future TAPS Pipeline Hydraulic Configuration

Changes in TAPS to accommodate lower throughputs are expected. These changes will include standby pump stations and DRA equipment/injection enhancements to optimize the hydraulic performance. Pump Stations 1, 3, 4, and 9 are critical to moving oil though TAPS and cannot be shut down while TAPS operates. Pump Stations 7 and 12 will likely be put on standby as throughput continues to decline. At lower throughputs, slackline conditions must be managed for leak detection and DRA optimization.

Slackline occurs when the pressure exerted on the crude oil falls below its vapor pressure. This is most common on the downhill side of a slope where the leading edge of the fluid pulls away from the trailing edge. The liquid between the leading and trailing edges vaporizes to fill the void. This condition remains until the exerted pressure increases to the vapor pressure of the fluid, at which point the vapor returns to the liquid state at the slackline/tightline interface. The terms *tightline* or *packed line* refer to a pipeline that is operating at a pressure above the vapor pressure of the fluid and is completely filled with liquid (i.e., no vapor).

Slackline operation can be helpful in reducing hydraulic pressure quickly, but on the other hand, it can degrade the effectiveness of DRA. Leak detection is less sensitive under slackline conditions; therefore, more sophisticated leak detection is required for slackline operation. TAPS was designed for slackline operation, and depending on throughput, there could be as many as three slackline areas on TAPS: Atigun Pass (MP 166.7-175.6), Isabel Pass (MP 610.3-628.1), and Thompson Pass (MP 775.0-775.8) (Baskurt et al., 1998; Tonkins et al., 1998). A backpressure-control system at the VMT mitigates pipe vibrations from slackline operation at Thompson Pass (Norton et al., 1998).

Hydraulic gradient is the change in pressure of a fluid over distance. It is a function of the energy gained (e.g., from a pump) or lost (due to friction) as the fluid travels down the pipeline. The hydraulic gradient is typically represented as a saw-tooth pattern between the elevation and the maximum allowable pressure (converted to head of liq-



MAOH = Maximum allowable operating head

Figure 2.1-7. *Hydraulic gradient graph for operating condition of 1.1 million bbl/day with Pump Stations 1, 3, 4, 7, 9, and 12 operating; Pump Stations 2, 6, 8, and 10 on standby; and Pump Station 5 as a pressure relief station.*

uid) profiles on an hydraulic gradient graph (Figure 2.1-7). TAPS must be configured so that the combination of pumps and pipeline friction losses always maintain the hydraulic gradient between the ground profile and the maximum allowable operating head.

Drag reducing agent, or DRA, is a chemical which, when added to the crude oil stream, reduces the loss of energy due to friction as fluid travels through the pipeline (Photo 2.1-4). DRA is made of a long-chain polymer that uncoils in crude oil. DRA is believed to stretch out into stringers, reducing the friction loss between the crude oil and the pipe wall. Since slackline conditions or passage through a mainline pump easily destroys these stringers, DRA is useful only for non-slackline operation between pump stations. A flattening of the hydraulic gradient slope is evidence of the effect of DRA. DRA allows higher throughput without additional pumps and allows earlier rampdown of pump stations as throughput declines.

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Photo 2.1-4. *Drag reducing agent (DRA).*

Projected Maintenance, Repairs, and Upgrades

Changes to TAPS due to lower throughput are anticipated to involve additional standby pump stations and equipment changes for hydraulic optimization. Other changes may include leak detection improvements or modifications necessitated by cooler crude oil. During the past 20 years of operation, changes to TAPS have already occurred as throughput increased and then decreased after 1988. Therefore, the pipeline has successfully operated at the throughput levels anticipated in the future. However, some changes are anticipated as technology improves and the pipeline matures.

Future TAPS Reconfigurations: In the future, reconfigurations of physical TAPS facilities will allow the flexibility to adapt to changes in the crude oil transported through TAPS, throughput decline, technology improvements, and optimization of support infrastructure and resource utilization.

TAPS was originally designed to transport 2 million bbl/day using 48 mainline pumps at each of 12 pump stations (3 operational and 1 spare at each pump station). During TAPS construction, DRA was introduced and eliminated the requirement for mainline pumps at Pump Stations 5 and 11. Consequently, Pump Station 5 was constructed for pressure relief purposes only and Pump Station 11 was never built. Moreover, high reliability of turbine-driven pumps eliminated the requirement for a fourth spare unit at operating pump stations, and reduced the requirement at Pump Stations 2 and 7 to two online pumps. In 2000, TAPS transports approximately 1 million bbl/day using 7 mainline pumps at 5 pump stations with 10 online spare pumps.

At throughputs less than 830,000 bbl/day, only 4 pumps at 4 pump stations are required. In that case, a potential system configuration in 2010 could include Pump Stations 1, 3, 4, and 9 operating with one mainline pump unit each and Pump Station 5 operating as relief facility and cold restart contingency. Pump Stations 7 and 12 would be kept on standby with provisions for cold restart. In this configuration, most of the buildings and equipment at Pump Stations 2, 6, 8, 10, and VMT Berth 1 would be removed (Pomeroy, 2000, pers. comm.).

Reconfiguration of TAPS may also require upgrades to communications systems and pipeline control systems, as well as initiatives to further automate remaining pump stations.

- Many pump station activities that currently require manual intervention, data collection, interpretation, or decision making are suitable for automation, and upgrades to these systems could occur with reconfiguration efforts.
- TAPS voice and data communications systems are undergoing significant changes. A fiber-optic network intended to provide for higher data and voice transmission speed and capacity has been installed primarily along the TAPS ROW. The reliability of the system has not proved sufficient for critical-control system communications; however, non-critical voice and data communications capability along TAPS would be enhanced by use of the fiber-optic network. It is anticipated that the existing highly reliable analog microwave system will be upgraded to a digital microwave system. With its backup satellite capabilities, the microwave system will continue to be used for critical control-system communications. The fiber-optic network may ultimately be used for non-critical voice and data communications. Communications systems will continue to be evaluated to ensure that

the systems continues to provide a very high degree of reliability and service.

- Significant advances in pipeline control have been made in the decade since the current TAPS control system was installed. Alyeska expects to upgrade this system with reconfiguration efforts to take advantage of faster, higher-volume, better-quality information. Moreover, new-generation control systems offer improved sharing of data that is projected to increase efficiency of operation.

Mainline Pipe Repair: An instrumented internal inspection of the pipeline is performed every three years to measure corrosion or wall thinning. Based on the corrosion data, repair areas are identified and prioritized, thus allowing pipeline repairs to be performed on a schedule that ensures pipeline safety.

Over the past five years, excavations of mainline pipe have averaged 14 digs per year. This may continue and possibly will increase to 20 digs per year over the next 30 years (Flanders, 2000, pers. comm.) (see Section 4.1.1.1). However, depending on the performance of the new impressed-current cathodic-protection systems installed along the pipeline, the number of pipeline excavations may remain constant or possibly decline.

Mainline Refrigeration: Three sections of TAPS approximately 4 miles in total length near Gulkana are buried in thaw-unstable permafrost. These sites are mechanically refrigerated to prevent thawing of the soil surrounding the warm pipeline and possible settlement of the pipeline. The pipeline was buried and mechanically refrigerated rather than being built above-ground to allow for animal crossings. Wildlife data available at the time of construction were inconclusive as to whether big game animals would cross under elevated sections of pipe. Mechanical refrigeration systems may require replacement or upgrade for improved performance and durability during the ROW renewal period.

Mainline Valves: The TAPS mainline valves are periodically tested and, as necessary, repaired or replaced. Future valve replacements may include upgrades to improve functionality or durability. The work on mainline valves is scheduled to minimize impact on pipeline throughput.

Mainline Pumps: Since the mainline pumps are centrifugal and driven by turbines on variable speed control, they perform efficiently across a wide range of flow rates. During the rampup years, the number of spare pumps decreased to virtually zero as pumps were brought online to increase throughput. Moreover, modifications were made to the pumps to gain increased performance at peak throughputs. Similarly, the pumps may be modified in the future to maintain optimum performance at the lower throughputs. As throughput declines, the number of spare pumps increases.

Projected Crude Characteristics

Initially, ANS crude consisted primarily of one crude type from the Sadlerochit zone of the Prudhoe Bay oil field. As new fields were developed, the characteristics of the composite crude oil changed. TAPS was designed to handle this change. Overall, the composite crude stream has become lighter as the amount of natural gas liquids introduced immediately upstream of Pump Station 1 has increased. In addition, crude oil temperature in the line is decreasing with decreased throughput (Figure 2.1-8).

Crude composition and temperature changes may result in increased wax content, which, if not addressed, could affect the sensitivity of detection capability by smart pigs, as well as the sensitivity of the leak detection system. Waxing problems are typically handled by increased scraper pig runs, which remove wax from the internal pipe wall.

Pump Station Rampdown

A pump station becomes a candidate for *rampdown* status when the cost of adding DRA is less than cost of operating the pump station. Once ramped-down stations are isolated from the pipeline, they are placed in a standby condition that would allow restarting within 180 days in the event of unanticipated throughput increase or a contingency event at an adjacent station.

Due to declining pipeline throughput, Pump Stations 8 and 10 were placed on rampdown status in 1996, and Pump Stations 2 and 6 in 1997. Depending on economic factors, Pump Station 12 may be a candidate for rampdown when throughput declines below about 1.1 million bbl/day, and Pump Station 7 when below about 900,000 bbl/day.

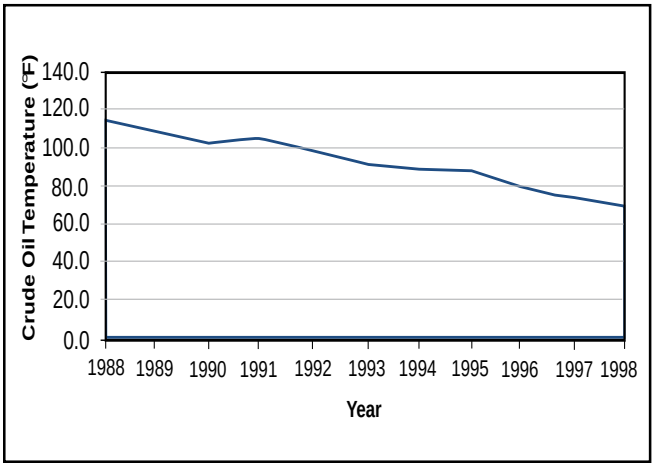

Figure 2.1-8. *Average incoming crude-oil temperature at Valdez.*

Rampdown of Pump Station 5 could occur when throughput declines below approximately 380,000 bbl/day. Pump stations are taken off-line in a different order than they were started up because of cost savings and DRA enhancements that were realized after TAPS startup.

The maximum throughput of TAPS without DRA, using the original pumping facilities and original ANS crude composition, is approximately 1.4 million bbl/day. Throughputs above this amount require DRA, whereas throughputs below this amount require less horsepower or fewer facilities. As throughput declines to the point that an upstream pump station using DRA can compensate for the hydraulic requirements for a downstream station, then the downstream station becomes a candidate for rampdown. Once the station pumps no longer operate, additional horsepower and DRA are added at the upstream station to make up for the loss in power.

TAPS is designed such that Pump Stations 1, 3, 4, and 9 are necessary to move any amount of oil. Additional stations are required with increased throughput.

Rampdown of Crude Oil Topping Units

Some pump stations have crude oil topping units (COTU), which are small refineries formerly used to produce turbine fuel from crude oil to power mainline pumps on TAPS. Although all COTUs on TAPS have already been ramped down, it is illustrative to discuss the effect of the changes to address issues relating to future configuration changes, oil spill risk from fuel hauling, and the effect of residual oil from commercial refineries that is reinjected back into the TAPS crude stream.

TAPS was originally designed for COTUs at all pump stations south of the Brooks Range (those not fueled by natural gas) due to the lack of commercially available fuel in the remote interior. During construction, it was decided that topping units would be eliminated at Pump Stations 5, 9, and 12 and the COTUs at Pump Stations 6, 8, and 10 would fuel these stations and the VMT. Consequently, TAPS mainline units representing most of the fuel needs were supplied from startup until 1997 using fuel distilled at Pump Stations 6, 8, and 10 topping plants. The topping units received crude oil from the pipeline and removed the diesel fuel portion and returned the residual oil to the pipeline. The relatively small quantity of residual oil was blended with the crude oil stream.

Since construction of TAPS, commercial refineries built in Fairbanks and Valdez have provided another source of fuel for the pump stations. When the pipeline hydraulics indicated that DRA could offset the need for fuel-burning mainline pumps at certain stations and that commercial sources of fuel could replace COTU-produced fuel, the cost of fuel produced by topping units became comparable to commercial sources. A risk assessment was also conducted that concluded that commercial purchases of fuel reduced the potential for spills from trucking accidents due to shorter distances between refineries and the TAPS fuel-burning equipment. That is, the total number of truck/tanker-miles for hauling fuel from commercial sources was less than for hauling from the TAPS topping units. Since the pump stations north of Pump Station 5 use fuel gas instead of liquid fuel for mainline pumps, only minor amounts of liquid fuel for ancillary purposes are required at those locations. Consequently, the COTUs were placed in standby status along with the rampdown of Pump Stations 6, 8, and 10, and commercial fuel purchases replaced the topping units.

The commercial refineries at North Pole and Valdez operate similarly to the TAPS topping units in that they are supplied with crude oil from the pipeline and return residual oil to a downstream location on the pipeline. Therefore, the effect on the composite crude quality due to idling of the TAPS topping units was largely displaced by the increased production from the commercial sources. In the case of fuel purchases from refineries not connected to TAPS, the effect on the composite crude oil stream is to theoretically improve it slightly due to reduced volumes of residual oil, although the effect is virtually not discernible due to the small volumes involved.

As TAPS throughput decreases, the effect of the residual oil on the composite stream will increase and will require monitoring to ensure that it does not adversely affect TAPS operations.

Cold Restart

Station facilities and insulation on the above-ground sections of the pipeline are designed to permit restarting after a prolonged winter shutdown. A 21-day shutdown was selected because it is the estimated maximum time required to make major repairs to the pipeline system. The design criteria involve a 21-day shutdown with an ambient air temperature of -40°F and a wind velocity of 20 mph.

The primary concern is the impact from gelled crude oil in the pipeline at low temperatures. Gelling results when high-molecular-weight hydrocarbons such as waxes and asphaltenes crystallize and precipitate out of solution. Since it is necessary to pump nongelled crude into the upstream end of a pipeline segment to displace the gelled crude, the hydraulic profile of the segment will develop a two-part characteristic separated by a change in slope as the injected slug moves down the line. An essential aspect of this pro-

cess is the gradual increase in throughput in each segment over many hours as the high-resistance gelled crude is cleared from the segment and liquefied by friction along the wall of the pipe and from passing through the pumps at the downstream pump station.

2.1.2 Pipeline-Associated Marine Transportation

By L.D. Maxim

2.1.2.1 Tanker Traffic

Oil tankers loaded with ANS crude oil at the VMT in Port Valdez deliver crude oil to various markets. All tankers pass through Prince William Sound en route to the Gulf of Alaska, and then alter course in accordance with their destination (Figure 2.1-9).

The primary market for ANS crude is the U.S. West Coast. Small shipments also have been sent to Kenai, Alaska, and the Hawaiian Islands. On November 28, 1995, President Clinton signed legislation [30 USC 1859(s)] that authorized the export of ANS crude oil when transported in U.S.-flagged tankers. The President found that such exports were in the national interest, and in May 1996, the first shipment went to the Asia Pacific market. Laden tankers proceeding there are required to remain over 200 miles offshore, outside the U.S. Exclusive Economic Zone.

Several classes of tanker, ranging in size from 50,000 to 262,000 deadweight tons, have been involved in the Valdez trade. Cargo capacities have ranged from 660,000 to 2,000,000 bbl.

The size and composition of the tanker fleet serving TAPS will be changing over the next several years. Section 4115 of the Oil Pollution Act of 1990 (OPA 90; 33 CFR 157.10d) imposes certain requirements on tankers calling at U.S. ports and specifies which vessels are permitted to use U.S. ports by year, size of vessel (gross tons), hull design (single hulls, double bottoms, or double sides), and age of vessel. By the year 2015, all tankers calling on U.S. ports must have double hulls (double bottoms and sides). OPA 90 contains a schedule with eligibility requirements.

The current fleet serving the VMT consists of 26 tankers (NRC, 1991) — three with double hulls and 13 with double sides. However, the composition of the fleet must change in the future to stay in compliance with OPA 90. Figure 2.1-10 shows the planned phaseout schedule for existing Prince William Sound tankers based on U.S. Maritime Administration estimates published in a recent U.S. Government Accounting Office study (GAO, 1999). According to this schedule, the last of the present tankers will be phased out by the end of the year 2013, and the fleet will consist exclusively of double-hulled tankers beginning in 2014. Double-hulled tankers offer environmental advantages in terms of a reduced likelihood and volume of oil spills (NRC, 1991; NRC, 1998).

There are substantial economies of scale in the construction and operation of tankers (GAO, 1999; NRC, 1998), whether constructed in the U.S. or abroad. This consideration alone argues for construction of relatively large tankers. However, determining the optimal size for tankers serving the VMT is more complex, because draft constraints at many ports limit the utility of large tankers.

The costs of new double-hulled tankers are likely to be

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Photo 2.1-5. *Escort vessels accompany a tanker through Prince William Sound.*

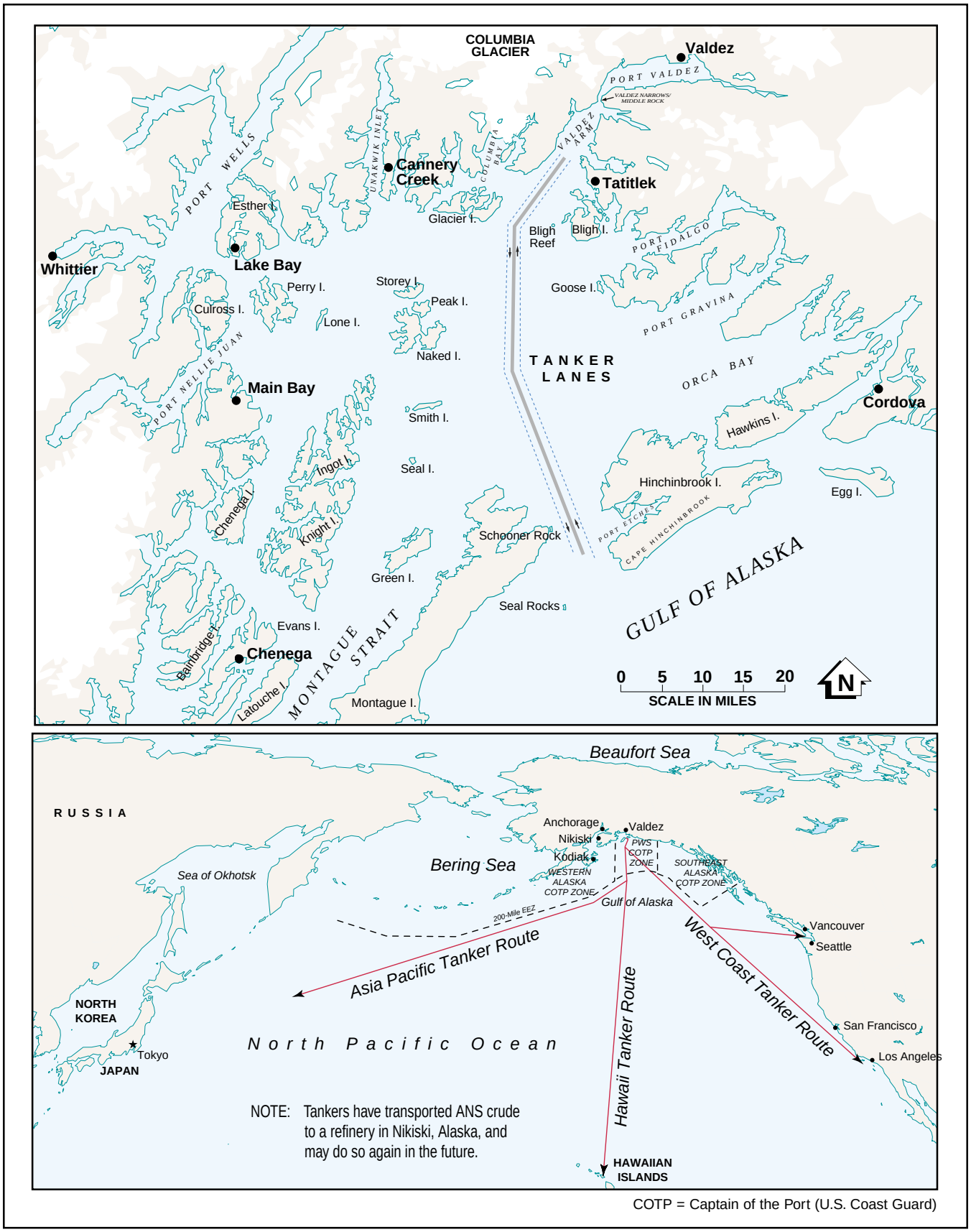
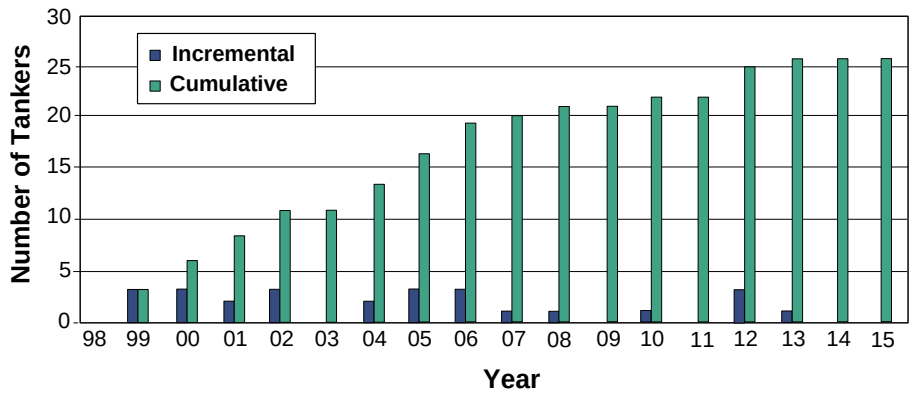
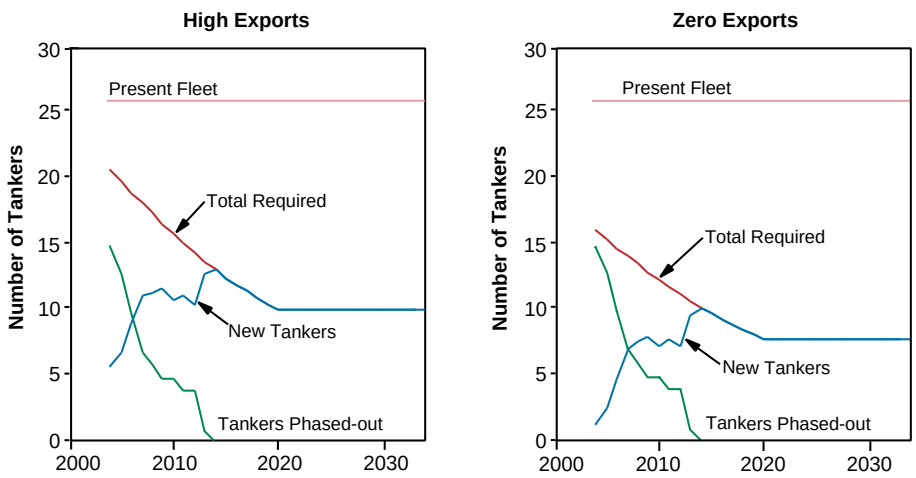


Figure 2.1-9. *Routes from Valdez for tankers carrying Alaska North Slope crude.*



Source: GAO (1999).

Figure 2.1-10. *Planned phaseout for existing TAPS-related tankers.*



Source: ECA (1999a).

Figure 2.1-11. *Tanker projections.*

comparable to those for the Phillips Millennium Class tankers currently under construction at $166 million each. Thus, the total cost of the 8 to 10 new tankers will be from $1.3 billion to $1.7 billion — a substantial investment in future marine transportation.

The number of tankers will decrease substantially from the present 26 tankers to 8 to 10 tankers by 2020 (Figure 2.1-11). Fewer tanker transits and the use of double-hulled tankers and other improvements will substantially reduce annual accident and oil spill probabilities.

A smaller tanker fleet will require fewer berths at the VMT. There are four berths at present — one floating and three fixed-platform berths. One or two of these berths may be shut down in the future. The two berths with tanker vapor control facilities will remain in operation.

Alyeska manages the largest spill response equipment stockpile in the world, including more than 70 oil-skimming systems, 7 storage barges, and 35 miles of containment boom. Equipment is stationed in Port Valdez and at five Response Centers across the Sound. In addition, Alyeska has contracts with over 300 fishing-vessel owners to respond to a potential spill. Fishermen also provide local knowledge to help identify at-risk areas and provide protection methods.

Other improvements made in the wake of the *Exxon Valdez* oil spill include:

- Regular oil spill drills and training exercises are conducted at a variety of locations along the pipeline and

in Prince William Sound.

- The Prince William Sound Regional Citizens Advisory Council was formed in accordance with the Oil Pollution Act of 1990. This citizens group has participated actively in issue related to the VMT and to spill prevention and response in Prince William Sound.

Alyeska spends $60 million annually on an organization with over 200 people engaged in prevention and response activities in Prince William Sound.

2.1.2.2 Ship Escort/Response Vessel System

Prevention and cleanup of oil spills have always figured in the design and operation of TAPS; however, in the aftermath of the *Exxon Valdez* oil spill in 1989, Alyeska, the TAPS Owners, regulators, and Congress conducted a comprehensive examination of ways to improve oil spill performance. Among other things, this resulted in the passage of OPA 90, which includes requirements for spill prevention and response.

Significant improvements have been made in spill prevention and response capability for Prince William Sound, including the creation of Alyeska's Ship Escort Response Vessel System (SERVS). SERVS is responsible for the safe transit of oil tankers from the VMT to international waters. Its duties are primarily related to spill prevention and spill response.

A study by Det Norske Veritas et al. (1996), which did not consider future benefits of double-hulled tankers, estimated that the risks of a large oil spill were reduced by 75 percent with the creation of SERVS and related measures.

SERVS has nine vessels assigned to escorting, docking, and response duties, and at least two escort vessels are required for each laden tanker transiting the sound. Tethered escort is required through Valdez Narrows. In the northern sound, the escort vessels will be within one-quarter nautical mile of the tanker when not tethered. In the central sound, a conventional tug or a prevention and response tug (PRT) will maintain close escort, while the second escort vessel goes on sentinel duty to provide response coverage to a larger area. A vessel is on sentinel duty in the Hinchinbrook Entrance area. A third escort vessel may be added, depending on weather conditions. Additional vessels are available if needed for a response or to fill in during scheduled and unscheduled maintenance.

- Currently, the three PRTs and two enhanced tractor tugs (ETTs) are designated to fill escort and response duties. These vessels carry response equipment such as boom and skimmers. The escort vessels accompanying each laden tanker monitor the vessel's actions and will radio the escorted tanker to question or alert the tanker of atypical behavior. The tanker notifies the escort vessels upon recognition of a loss of steering and/or propulsion or suspected equipment malfunction.
- The vessel stationed in the Hinchinbrook area (including Port Etches) to provide sentinel assistance to tankers in Hinchinbrook Entrance is also used as a close escort vessel for laden tankers and has open-ocean rescue capabilities.
- The two ETTs were built specifically for service in the sound and were both deployed in 1999.
- The three 140-foot, 10,000-horsepower PRTs were deployed in 2000. They have twice the horsepower and are more maneuverable than the escort/response vessels they replaced.

2.2 No-Action Alternative: Right-of-Way Not Renewed

By J.D. Norton and J. Riordan

For the purposes of this Environmental Report, the no-action alternative involves expiration of the Federal Grant and State Lease in 2004. Federal and state stipulations contain general provisions for "dismantling, removal, and restoration" (DR&R) of TAPS assets upon completion of use of the TAPS right-of-way. If the 1974 right-of-way is not renewed, federal or state agencies may assert that the provisions of Stipulation 1.10, "Completion of Use," must be performed. In that case, it would be necessary to prematurely shut in North Slope production since the pipeline would not be available for transporting crude oil.

2.2.1 Completion of Use

"Completion of use" as defined by the Federal Grant and State Lease may be appropriate if TAPS facilities can no longer operate due to the lack of a right-of-way. Upon completion of use, Stipulation 1.10 requires the removal of TAPS improvements and equipment to the satisfaction of the federal Authorized Officer (a virtually identical stipulation appears in the State Lease):

> 1.10. Completion of Use
>
> 1.10.1. Upon completion of the use of all, or a very substantial part, of the Right-of-Way or other portion of the Pipeline System, Permittees shall promptly remove all improvements and equipment, except as otherwise approved in writing by the Authorized Officer, and shall restore the land to a condition that is satisfactory to the Authorized Officer or at the option of Permittees pay the cost of such removal and restoration. The satisfaction of the Authorized Officer shall be stated in writing. Where approved in writing by the Authorized Officer, buried pipe may be left in place, provided all oil and residue are removed from the pipe and the ends are suitably capped.
>
> 1.10.2. All areas that do not constitute all, or a very substantial part of the Right-of-Way or other portion of the Pipeline System, utilized pursuant to authorizations issued in connection with the Pipeline System, shall be Put-to-Bed by Permittees upon completion of their use unless otherwise directed by the Authorized Officer. Put-to-Bed is used herein to mean that Access Roads, material sites and other areas shall be left in such stabilized condition that erosion will be minimized through the use of adequately designed and constructed waterbars, revegetation and chemical surface control; that culverts and bridges shall be removed by Permittees in a manner satisfactory to the Authorized Officer, and that such roads, sites and areas shall be closed to use. Permittees' rehabilitation plans shall be approved in writing by the Authorized Officer prior to termination of use of any such road, or any part thereof, in accordance with Stipulation 2.12.

2.2.2 Major Physical DR&R Assumptions

Guidance on the nature of DR&R is limited. However, some public-record information can be found in the assumptions for the cost estimate submitted in the proceedings held by the Federal Energy Regulatory Commission (FERC) and the Alaska Public Utilities Commission in setting tariff rates (that include DR&R) for the TAPS carriers (Fluor, 1983). Only assumptions that affect the physical assets are included in the following.

- Federal and state stipulations concerning DR&R are to be adhered to and used as a basis of the estimate.
- The existing pipeline workpad is to be maintained during dismantling operations and left in place at completion.
- Buried pipe is to be left in place, capped and void of any oil and/or residue.
- All above-ground facilities will be removed to 1 foot below grade or covered with 2 feet of fill. Below-ground facilities may be left in place with the exception of culverts, pipes in road casings and pipe adjacent to river training structures.
- All surplus and scrap materials must be removed

from Alaska except those buried or otherwise disposed of locally.

- Port locations for shipment of scrap materials will be Valdez, Whittier, and Seward. Scrap from north of Milepost 492 will generally be marshaled and consolidated in Fairbanks for rail shipment to Whittier or Seward; scrap from more southerly locations will be trucked directly to Valdez.
- Each major component of the work (e.g., pipeline and stations, terminal, cleaning and purging) will be carried out by one or more independent contractors. Overall management will be carried out by Alyeska or another Project Management Contractor.

2.2.3 Description of No Action Alternative

IMPORTANT NOTE: The following discussion of DR&R of TAPS represents one possible scenario developed based on Stipulation 1.10 of the Federal Grant and the FERC assumptions in Section 2.2.2 above. This scenario incorporates current technology and is presented for analyzing environmental impacts. The actual scope of work and sequence of events would depend on the requirements of the Authorized Officer and the State Pipeline Coordinator. Specific activities would depend on technology available at the time.

In general, DR&R activities would start at Pump Station 1 and progress south to allow for transport of cleaning products from one station to the next and finally to the VMT. Initially the pipeline would receive batches of residual oil from North Slope vessels, tanks, piping, pipelines, pump station sumps, tank bottoms, and low-point piping, followed by batches of diesel fuel to remove residual crude oil. A mixture of seawater and cleaning solution would follow the diesel (this mixture would be treated at the VMT Ballast Water Treatment Facility for discharge). Finally, air compressors would be connected by manifold to the pipe to propel a displacement pig through the pipe to remove the seawater. This sequence would be repeated at each pump station in succession from north to south. The final pipeline condition would be deemed cleaned to the satisfaction of the Authorized Officer.

Following cleaning of the pipe and other oil-wetted surfaces, improvements would be removed in accordance with plans approved by the Authorized Officer.

Scrap-loading operations would potentially occur at the North Slope, Yukon River, Fairbanks rail yard, Seward, Whittier, and Valdez construction dock. Salvage operations would remove all material for in-state or out-of-state recycling or disposal, leaving cleared land for contouring and hydroseeding. Land will be left in a stabilized condition meeting the approval of the Authorized Officer. Tank bottoms and other refinable hydrocarbon liquids will be loaded onto tankers and transported as with other crude products.

Table 2.2-1 lists the disposition of TAPS facilities. DR&R field activities are estimated to take three years.

Alyeska Pipeline Service Company

Alyeska Pipeline Service Company

Photos 2.2-1 and 2.2-2. *The photo at left shows Isabel Camp in 1976 during pipeline construction, while the photo at right shows the site following removal and restoration.*

Table 2.2-1. *Disposition of TAPS facilities for DR&R.*

TAPS Facilities to Be Removed and/or Restored (after Cleaning)			
Pipeline	• Remove above-ground pipe. • Remove remote above-ground valves, power modules, and fencing. • Cut off VSMs to 1 ft below grade and cap. • In transition sections, remove above-ground pipe to 1 ft below grade and cap below-ground pipe. • Remove above-ground river crossing structures (except Yukon River highway bridge). • Remove above-ground pipe passing through culverts and road crossings. Convert culverts to low water crossings. Remove workpad bridges. • Remove pipe adjacent to river training structures.	**Terminal**	• Drain tanks and piping to waiting tanker. • Remove above-ground piping, tanks, and concrete containment walls. • Remove power and vapor facilities including incinerators. • Remove ballast water treatment facilities including concrete tanks and above-ground structures. • Remove all buildings and cable trays. • Cut below-ground pipe below grade and cap. • Remove berths, berth piping, and mooring dolphins at mudline. • Contour terminal pad and access roads. Hydroseed and/or fertilize them to prevent erosion.
Pump Stations	• Remove station piping, equipment, buildings, & tanks. • Contour pump station gravel pads and access roads. Hydroseed and/or fertilize them to prevent erosion.	**Other**	• Purge, pig, and remove above-ground fuel-gas piping. • Purge, clean, and cap, and remove above-ground mainline refrigeration piping. • Remove mainline refrigeration equipment and buildings. • Remove microwave repeaters and equipment.
TAPS Facilities to Remain in Place			
• Gravel workpad • Pump station gravel pads • Below-ground oil and fuel gas pipe and valves • River training structures except where breached to remove pipe			
Non-TAPS Facilities to Remain in Place			
• Dalton Highway and Yukon River Bridge • Fiber-optic system • Communications sites			

2.3 Alternatives and Issues Considered But Eliminated from Detailed Analysis

The original EIS for TAPS identified a number of alternatives that were considered for moving North Slope crude oil to market (BLM, 1972). These options included pipelines from Prudhoe Bay to alternate ports in southern Alaska and on the Bering Sea, pipelines from Prudhoe through Canada to the contiguous 48 states, icebreaking tankers, submarine tankers, and rail and truck transport. The EIS also considered a number of energy and policy alternatives ranging from reduction in demand to alternative energy sources. Table 2.3-1 summarizes the options.

The alternatives considered in the original TAPS EIS were not revaluated for this Environmental Report because they are no more viable now than when initially evaluated. In addition, replacement of the existing pipeline with another pipeline on a new route is not an economic alternative to continued operation of TAPS.

Then as now, no cost-effective and practicable alternative exists to transportation of North Slope crude in the Trans Alaska Pipeline System. The fact that the pipeline is in place makes these alternatives even less attractive today from both cost and environmental standpoints. Furthermore, government policies have not changed to the extent that any of the alternative energy sources are more feasible now than at the time of the original EIS. Advances have occurred in technology for alternative energy sources, but none is yet a commercially viable replacement for energy from North Slope oil.

As a result, the alternatives in Table 2.3-1 were eliminated from further evaluation in this Environmental Report, which concentrates on the two alternatives of renewal of the TAPS ROW and no action. The alternatives discussion in the original EIS is incorporated herein by reference.

Table 2.3-1. *Alternatives considered in the original final environmental impact statement for TAPS (BLM, 1972).*

Transportation Alternatives	Energy and Policy Alternatives
• Pipeline to southern Alaska terminal with marine transportation to market: 5 routes and terminal locations considered • Marine tankers both east and west from Prudhoe Bay to markets • Pipeline to western Alaska ports on Bering Sea with marine transportation to market • Pipeline across Alaska and Canada to connect with existing pipelines in the contiguous 48 states: 5 routes considered • Railroad and/or highway to southern Alaska port with marine transportation to market • Railroad and/or highway transport through Canada to the contiguous 48 states • Other transportation schemes: ➢ Conveyors ➢ Underwater marine transportation ➢ Airlift ➢ Conversion of oil to electricity	• Reduction in demand • Increased oil imports • Additional domestic production ➢ Increased leasing on outer continental shelf ➢ Increased leasing onshore ➢ Nuclear stimulation of gas reserves • Other energy sources ➢ Increased coal production ➢ Increased nuclear energy development ➢ Synthetic sources: ⇒ Oil shale production ⇒ Tar sands ⇒ Fuel from coal ➢ Geothermal energy ➢ Hydroelectric power ➢ Experimental sources with doubtful immediate potential (9 technologies)

SECTION 3

AFFECTED ENVIRONMENT

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Introduction: Section 3

Section 3 describes the environment affected either by renewal of the Trans Alaska Pipeline System (TAPS) Right-of-Way (ROW) or by the no-action alternative. Section 3.1 covers the physical environment, Section 3.2 the biological environment, and Section 3.3 the socio-economic environment.

It is important to note that unlike most projects covered in environmental impact statements, TAPS has been in operation for over 20 years. As a result, the existing environment includes an existing, already constructed and functional pipeline system and related facilities. Consequently, current environmental conditions include the changes caused by construction and operation of TAPS.

Nearly all environmental assessments (EAs), environmental reports (ERs), and or environmental impact statements (EISs) are drafted before the project is built. This was the case for the original TAPS EIS, but for the TAPS renewal, the pipeline system has existed for over 20 years and is now part of the affected environment. The same is true for the ANS oil fields and the marine transportation link. Thus, the affected environment as discussed in Section 3 includes the following three study areas (Figure 3-1):

- Alaska North Slope,
- The pipeline route from Prudhoe Bay to Valdez, and
- The Prince William Sound/North Gulf Coast region.

Numerous EAs, ERs, and EISs have examined various portions of the study areas over the years. Relevant literature includes reports on Alpine (USACE, 1997); Northstar (USACE, 1999); NPR-A (BLM and MMS, 1998); Alaska Natural Gas Transportation System (BLM, 1976); Trans-Alaska Gas System (BLM and USACE, 1988; FERC, 1995); various Beaufort Sea oil and gas lease sale EISs, including Sale 97 (MMS, 1987a); Sale 124 (MMS, 1990); Sale 144 (MMS, 1996a); Sale 170 (MMS, 1998); various Alaska Chukchi Sea oil and gas lease sale EISs, including Sale 109 (MMS, 1987b); Sale 126 (MMS, 1991) and the original TAPS EIS prepared by the Federal Task Force on Alaskan Oil Development (BLM, 1972).

Relevant material in these and other reports is summarized and updated where appropriate and feasible, and pertinent new material is presented where appropriate.

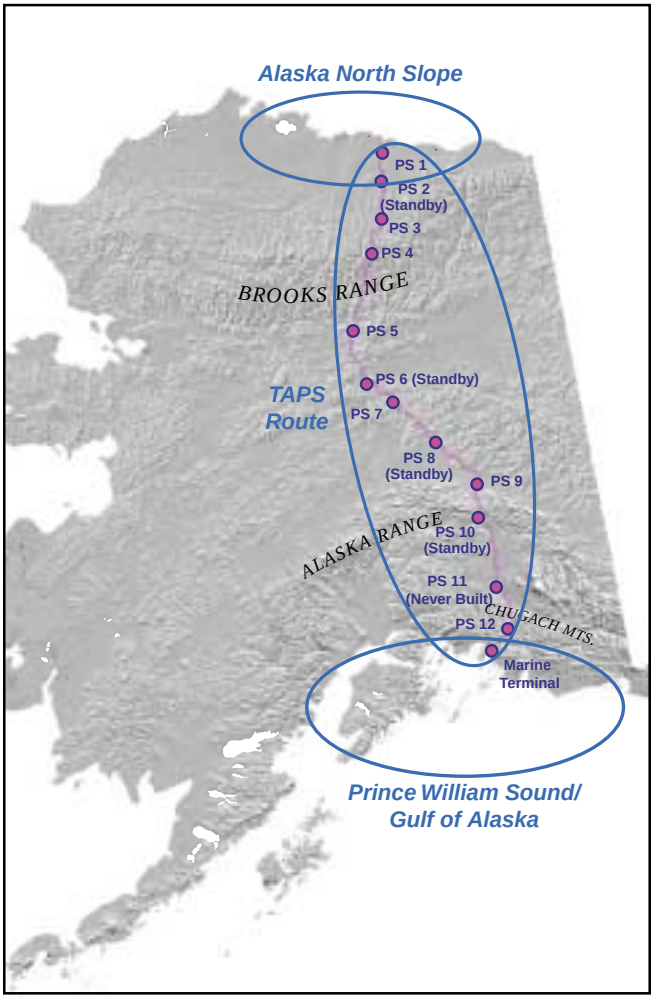


Figure 3-1. *General study areas used in preparation of this Environmental Report.*

3.1 Physical Characteristics

3.1.1 Terrestrial Environment

By R. Dugan and Golder Associates

TAPS crosses widely varying terrain including the broad Arctic Coastal Plain, three major mountain ranges, hilly uplands, hundreds of small steams, and several major rivers. The different topographic regimes are a result of the pipeline's general orientation perpendicular to the major mountain ranges. These regimes include extensive broad plains with little relief, rugged mountain passes, linear U-shaped valleys, rolling hills, and steep canyons.

More than half of the terrain has been intensely glaciated, often resulting in steep sideslopes in the mountains where the glaciers originated, and broad irregular surfaces in the lowlands where the glacially excavated materials were deposited. The highest elevation along the route occurs at Atigun Pass in the Brooks Range at 4,739 feet. Other major high points occur at Isabel Pass (3,420 feet) in the Alaska Range and at Thompson Pass (2,812 feet) in the Chugach Mountains.

3.1.1.1 Physiography and Geology

The pipeline traverses seven major physiographic units, as shown in Figure 3.1-1. These units are regions of similar geologic structure and climate and have had a unified geomorphic history (Wahrhaftig, 1965). Geomorphic processes have modified the landscape to its present configuration and character through erosion, deposition, and mass wasting by the actions of glaciers, flowing water, wind, and gravity. In general, unconsolidated surficial materials eroded from bedrock have been transported to lower elevations and deposited. The texture, moisture content, drainage characteristics, and thermal state of these unconsolidated materials affect their engineering properties. Permafrost — or perennially frozen ground — is encountered along most of the route. Each physiographic unit is described below, and Table 3.1-1 presents a summary of the principal characteristics of each unit.

North Slope

The North Slope physiographic unit includes the Arctic Coastal Plain and Arctic Foothills of the Brooks Range provinces, extending from pipeline MP 0 to MP 140. This unit is bounded to the north by the Beaufort Sea and to the south by the Brooks Range. Elevation ranges from sea level at Prudhoe Bay to approximately 3,100 feet at the northern limit of the Brooks Range. The tundra-covered coastal plain extends south from Prudhoe Bay for about 60 miles. Other than riverbanks and scattered pingos (small ice-cored hills), there is little relief. The smooth plain is poorly drained and rises gently to the south with an average gradient of about 10 feet per mile. Elongated, wind-oriented thaw-lakes and marshy thaw-lake basins cover 25 to 30 percent of the landscape. The depths of these lakes are generally limited to a few feet, and many of them are geologically short-lived features (Rawlinson, 1993).

The pipeline closely follows the northward-flowing Sagavanirktok River across a wedge of perennially frozen Quaternary sediments which become progressively thinner to the north. The Sagavanirktok is the dominant drainage in the region, with a wide, braided, and coarse-grained floodplain. Aufeis, or sheet ice from successive overflows, develops on portions of the floodplain in winter. The underlying bedrock consists of northward-dipping Tertiary and Cretaceous sedimentary rocks. The Barrow Arch, a major structural feature of uplifted lower Paleozoic rocks, underlies about 12,000 feet of post-Devonian sedimentary rocks. The Prudhoe Bay oil field is located on the crest of the arch and is a combination structural and stratigraphic trap (Mull and Adams, 1989).

South of the coastal plain, the pipeline passes between low, treeless foothills of tilted Tertiary and Cretaceous sedimentary rocks mantled with river terrace and glacial moraine deposits. This segment is characterized by broad uplands and east-west trending ridges.

The arctic coastal maritime climate is cold and dry, with the mean temperature ranging from 9° to 21°Fahrenheit (°F) and annual precipitation averaging 5.5 inches (Haugen,

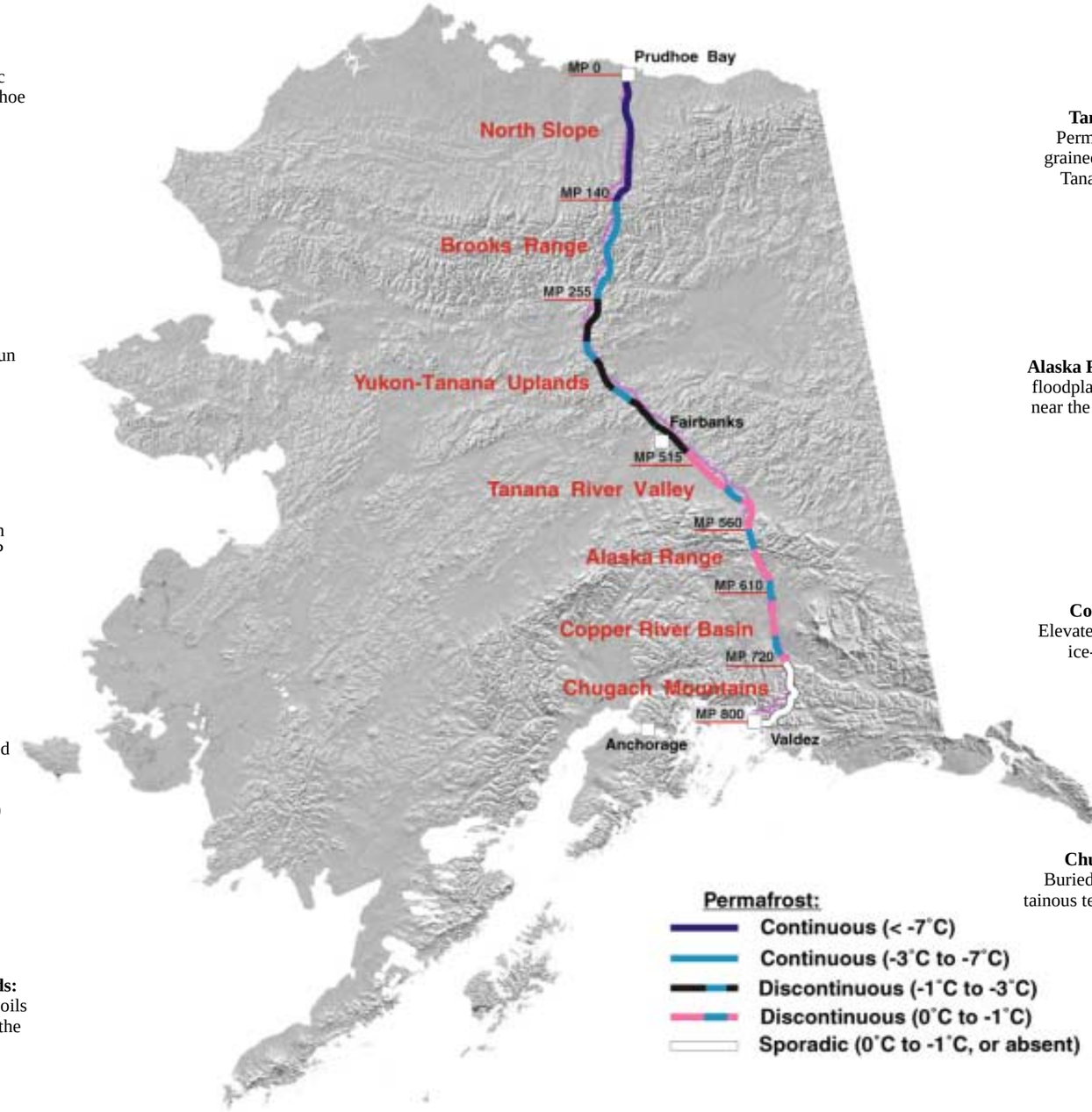
North Slope: Elevated pipeline over ice-rich permafrost on the Arctic Coastal Plain near Prudhoe Bay (MP 4)

North Slope: Elevated pipeline in the broad uplands in the Arctic Foothills between the Sagavanirktok and Atigun river valleys (MP 136)

Brooks Range: Buried pipeline below the north side of Atigun Pass (MP 165)

Brooks Range: Elevated pipeline adjacent to the Koyukuk River in a U-shaped valley (MP 200)

Yukon-Tanana Uplands: Pipeline in permafrost soils in hilly terrain south of the Yukon River (MP 400)

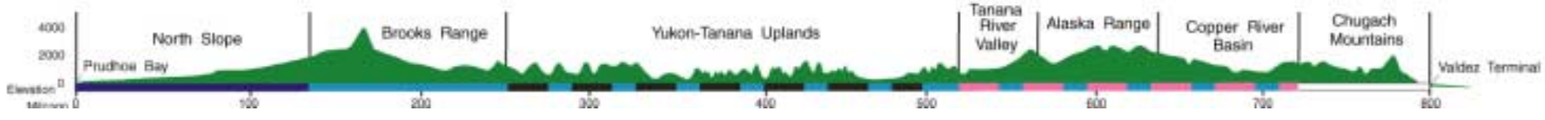


Tanana River Valley: Permafrost soils in fine-grained alluvium near the Tanana River (MP 520)

Alaska Range: Delta River floodplain and steep ridges near the crest of the Alaska Range (MP 593)

Copper River Basin: Elevated pipeline in broad ice-rich lowlands near Gulkana (MP 677)

Chugach Mountains: Buried pipeline in mountainous terrain near Thompson Pass (MP 763)



Sources: After Wahrhaftig (1965) and Brown et al. (1997).

Figure 3.1-1.
Physiographic units along the Trans Alaska Pipeline System

Table 3.1-1. *Physiographic units along the Trans Alaska Pipeline System.*

Physiographic Unit (MP Range)	Pipeline Elevation Range (ft)	Terrain	Glaciated Terrain	General Geology	Permafrost Distribution (Temp. Range)
North Slope (0 to 140)	40 to 3,100	Level plain and gentle hills	Southern portion only	Alluvial and glacial sediments overlying sedimentary bedrock	Continuous (<-7°C)
Brooks Range (140 to 255)	950 to 4,739	Steep mountain pass and U-shaped valleys	Yes	Colluvial, alluvial, and glacial sediments overlying sedimentary and metamorphic bedrock	Mostly continuous (-3°C to -7°C)
Yukon-Tanana Uplands (255 to 515)	325 to 2,300	Broad hills	No	Silt-covered metamorphic bedrock	Discontinuous (-1°C to -3°C)
Tanana River Valley (515 to 560)	900 to 2,700	Lowlands	No	Deep alluvial and glacial sediments	Discontinuous (0°C to -1°C)
Alaska Range (560 to 610)	1,900 to 3,420	Mountainous	Yes	Glacial and alluvial sediments overlying metamorphic bedrock	Discontinuous (0°C to -1°C)
Copper River Basin (610 to 720)	3,575 to 925	Gentle uplands and lowlands with deeply incised river valleys	Partially	Former lake basin filled with deep, mostly fine-grained sediments which overlie sedimentary and metamorphic bedrock	Discontinuous (0°C to -1°C)
Chugach Mountains (720 to 800)	10 to 2,812	Mountainous	Yes	Glacial and colluvial sediments overlying intensely glaciated metamorphic bedrock	Sporadic or absent (0°C to -1°C)

1982). The climate has resulted in the province being underlain by continuous, relatively cold permafrost [<-7°Centigrade (°C)] (Brown et al., 1997) that typically extends from within a few feet of the ground surface to a maximum depth of about 2,000 feet.

Brooks Range

The Brooks Range physiographic unit ranges from MP 140 to MP 255. It is bounded to the north by the mesa-like Slope Mountain and to the south by hills of the Yukon-Tanana Uplands. The Brooks Range is rugged and rises abruptly from the Arctic Foothills to elevations reaching 8,000 feet. The range trends east-west and forms the continental divide, with major drainages flowing north or south in broad valleys carved by repeated Pleistocene glaciations. Northeast-trending belts of Mesozoic and Paleozoic marine sedimentary, metamorphic, and volcanic rocks are composed primarily of limestone, shale, siltstone, schist, slate, quartzite, and basalt (Mull and Adams, 1989). The structural fabric is dominated by numerous low-angle faults resulting from northward thrusting in the Late Cretaceous and early Tertiary time (Wahrhaftig, 1965).

The pipeline crosses the continental divide at Atigun Pass, the highest point on the route (MP 166). North of the pass, the route follows the Atigun River valley, a broad, treeless, U-shaped valley with steep sideslopes rising 2,000 to 3,000 feet above the river. Bedrock is exposed in the upper slopes. Lower elevations are mantled with deep colluvial accumulations and coarse-grained floodplain deposits. Recent avalanche and slush flow deposits mantle portions of the slopes. Permafrost is continuous.

On the south side of the pass, the route descends steeply losing 1,200 feet in elevation, traverses the head of a broad valley at the head of the Chandalar River basin, and then descends abruptly another 700 feet to the headwaters of the Dietrich-Koyukuk river system. The upper Dietrich River valley is narrow, with a steep gradient and steep, coalescing fans on the sideslopes. In the middle and lower reaches, the valley widens and becomes distinctly U-shaped, and the floodplain becomes wide and braided. Permafrost is continuous. Frozen till and fan deposits blanket the valley sideslopes. Frozen alluvium and lake deposits predominate in the valley bottom (Brown and Kreig, 1983).

Yukon-Tanana Uplands

The Yukon-Tanana Uplands physiographic unit extends from MP 255 to MP 515 and encompasses the Kokrine-Hodzana Highlands, Rampart Trough, and Yukon-Tanana Uplands provinces. The elevation of the pipeline ranges from 325 to 2,300 feet.

The northernmost province is the Kokrine-Hodzana Highlands, which consists of even-topped, rounded ridges and hills reaching elevations of 2,000 to 4,000 feet. The valleys have alluviated floors to within a few miles of their heads (Wahrhaftig, 1965). This province extends from the South Fork of the Koyukuk River (MP 255) to near Hess

Creek (MP 375) and includes the irregular drainage divide between the Yukon and Koyukuk rivers. These highlands are generally underlain at depth by northeast-trending Paleozoic and Precambrian schist and gneiss. The bedrock is commonly exposed on small tors on the ridge tops. The only known mineral resource is a 4- to 5-foot coal seam which is exposed near the pipeline on a tributary to Dall Creek (Barnes, 1967).

The terrain has not been glaciated except for the very northern margin. Unconsolidated deposits generally consist of frozen colluvial silts, sands, and rock fragments; glacial sand and gravel; windblown silts; lake sediments; and stream sediments. Ice wedges, ice lenses, and ice-rich sediments occur locally, and permafrost is discontinuous but very widespread.

The Yukon River crossing is included in this unit. The Yukon is the largest river in Alaska and carries a substantial load of suspended glacial sediment during the summer. The river flows in entrenched meanders in the vicinity of the crossing, having eroded into mafic rocks of the Tozitna terrain (Mull and Adams, 1989).

The Rampart Trough province is a narrow, mostly lowland area south of the Yukon River. It has gently rolling topography 500 to 1,500 feet in elevation and extends from the north side of Hess Creek (MP 375) to the south side of Erickson Creek (MP 390). The trough was eroded into a tightly folded belt of soft continental coal-bearing rocks of Tertiary age (Wahrhaftig, 1965). The permafrost is discontinuous. The lowlands are underlain by ice-rich silt and fine-grained alluvium, while uplands are mantled with colluvium and windblown silt which overlies bedrock.

The Yukon-Tanana Uplands province, MP 390 to MP 515, is a hilly area of broad undulating divides and flat-topped spurs characterized by even-topped ridges with gentle sideslopes. The pipeline generally follows the ridge crests between the major east-west trending valleys. A belt of highly deformed Paleozoic sedimentary and volcanic rocks containing limestone units extends along the north side of the upland. The rest of the upland is underlain by Precambrian schist and gneiss with granitic intrusions. The bedrock is mineralized. Placer and lode deposits of gold and other metals have been mined for nearly a century. Windblown silt mantles the slopes. Reworked windblown silt and ice-rich organic silt cover deep stream gravels in the lowland areas. Permafrost is discontinuous.

Tanana River Valley

The Tanana River Valley physiographic unit extends from the Shaw Creek floodplain (MP 515) to Donnelly Dome (MP 560). It is a broad, lowland depression filled with sediments from the Alaska Range and drained by the Tanana River system. The elevation along the pipeline ranges from 900 to 2,700 feet. Outwash materials from the Alaska Range have pushed the Tanana River against the base of hills to the north. Most of the northern part of this region is underlain by shallow permafrost.

South of the Tanana River, permafrost is discontinuous. The terrain gently rises to the south and is mostly underlain by glacial outwash and till deposits (APSC, 1974a). Scattered low hills of granite, ultramafic rocks, and schist rise above the sediments (Wahrhaftig, 1965).

Alaska Range

The Alaska Range physiographic unit encompasses the Northern Foothills province as well as the Alaska Range mountains. It extends from Donnelly Dome (MP 560) to Isabel Pass (MP 610). The pipeline route is in or adjacent to the floodplains of the Delta River and Phelan Creek as it progresses into the mountains, reaching a maximum elevation of 3,420 feet. The crest of the range consists of rugged glaciated ridges 6,000 to 9,000 feet in elevation that trend east-west.

The Northern Foothills are underlain by Paleozoic to Precambrian schist and granitic intrusions mantled with glacial moraine. On the north side of the Alaska Range up to the Denali Fault (MP 589), the route is underlain by schist. South of the Denali Fault, bedrock consists principally of late Paleozoic marine sedimentary and volcaniclastic rocks (Péwé and Reger, 1983). No metallic minerals have been produced from lode deposits in this unit, but occurrences of copper, lead, zinc, nickel, chromium, gold, silver, asbestos, and antimony have been reported. Less than 1,000 ounces of fine placer gold have been mined from the Delta River drainage (Cobb, 1973).

Large valley glaciers radiate from the higher mountains, and some of these glaciers terminate within a mile or two of the pipeline. The Black Rapids Glacier (MP 579) made a rapid advance of about 4 miles in 1937. A 300-foot ice cliff formed at the terminus, less than a mile from the pipeline route. The glacier has since stagnated. The Castner Glacier (MP 587) has made similar advances during the Holocene epoch. Breakouts from meltwater lakes dammed by the Castner Glacier have produced brief floods on the outwash fan (Péwé and Reger, 1983).

Great longitudinal faults trend parallel to the axis of the range. The most significant fault is the Denali Fault, an active fault that is one of the longest crustal breaks in Alaska. This right-lateral, strike-slip fault is topographically expressed as an arcuate trough that can be traced without interruption from the southwestern Alaska Range through the

crest of the range into the Yukon Territory and perhaps into Chatham Strait in Southeast Alaska. Geologic evidence indicates that average rates of displacement along the Denali Fault vary from 0.04 to 1.38 inches per year. In the last 10,000 years, offsets of glacial deposits indicate that 17 to 200 feet of right-lateral movement and 20 to 33 feet of vertical movement have occurred (Péwé and Reger, 1983). Other smaller active faults include the Donnelly Dome and McGinnis faults.

A variety of glacial and glacial fluvial deposits cover most of the terrain where the slopes are not too steep. The Delta River and Phelan Creek have wide, braided floodplains and relatively steep gradients. Steep side-creeks to these streams have developed outwash fans of coarse sediments which are periodically truncated by the shifting channels of the larger streams. Talus and coarse colluvium have accumulated at the base of steep slopes. Terraces along the streams are composed of sand and gravel. Silt blown from the broad floodplain of the Delta River system has been deposited as a surficial blanket on the north flank of the range and beyond. Permafrost is discontinuous.

Copper River Basin

The Copper River Basin physiographic unit encompasses the Gulkana Uplands and the Copper River Lowlands provinces, and extends from Isabel Pass (MP 610) to Tonsina (MP 720). This intermontane basin is rimmed by 4,500- to 16,500-foot peaks of the Alaska Range and the Talkeetna, Chugach, and Wrangell mountains.

The Gulkana Uplands consist of rounded east-trending ridges separated by lowlands 2 to 10 miles wide extending from Isabel Pass to the south end of Paxson Lake (MP 635). The ridge crests — 3,500 to 5,000 feet in elevation — are 4 to 15 miles apart and have been eroded by glaciers and glacial meltwater. The lower elevations are covered by glacial deposits and esker systems. Long narrow lakes such as Summit and Paxson lakes occupy the basins. The region is underlain by Paleozoic and Mesozoic greenstone and sedimentary rocks with local granitic intrusions. No significant mineral deposits have been reported. Bedrock is mantled with glacial till and ice-contact deposits.

The Copper River Lowlands is a broad plain 1,000 to 2,500 feet in elevation that is incised by the Copper River and its tributaries. It is underlain by Paleozoic and Mesozoic metamorphic volcanic rocks to the north, and to the south by erodible Mesozoic sandstone and shale. The pipeline is several miles west of, and generally parallels, the Copper River and crosses several large tributaries including the Gulkana, Tazlina, and Klutina rivers. These rivers originate in glaciers in the surrounding mountains and generally have braided floodplains.

Ice advances in the late Pleistocene glaciations filled the lower reaches of the Copper River to form an extensive glacially dammed lake. Glaciers and streams discharging into the lake created a complex interfingering of glacial and lake deposits locally more than 500 feet thick. Following retreat of the glaciers about 9,000 years ago, permafrost began to form in the lake and glacial deposits as the streams began downcutting to their present incised valleys (Péwé and Reger, 1983). Discontinuous permafrost persists over much of the unit.

Chugach Mountains

The Chugach Mountains physiographic unit is a spectacular coastal range of intensely glaciated and rugged peaks along the Gulf of Alaska between MP 720 and the Valdez Marine Terminal (VMT) at MP 800. The higher peaks in this unit range from 7,000 to 13,000 feet, although along the pipeline route, the highest peaks are 6,000 to 7,000 feet high. The topography is characterized by U-shaped valleys, knife-edged ridges, horns, hanging glaciers, and slot canyons. The prominent drainages along the pipeline route are the Tiekel, Tsaina, and Lowe rivers, which are short, swift, and glacially fed.

The pipeline route follows the U-shaped valleys of the Little Tonsina, Tiekel, and Tsaina rivers, gradually ascending to Thompson Pass at an elevation of 2,812 feet. South of the pass, the route descends 2,000 feet in one mile and then traverses steep bedrock sideslopes parallel to the Lowe River for the remaining 20 miles to the VMT.

The area is underlain by complexly folded and faulted Cretaceous graywacke, phyllite, and greenstone. Bedrock is exposed or close to the surface over much of the route. Although no large mines have been developed near the route, gold has been mined from a few lode deposits near Port Valdez (Cobb, 1973).

Unconsolidated materials include glacial moraine and colluvium on the slopes. The terraces and floodplains along the valley bottoms typically consist of coarse sands and gravels. The steep slopes are locally subject to avalanches. The Worthington Glacier, which has been retreating for many years, terminates about half a mile from the pipeline immediately north of Thompson Pass. Permafrost is sporadic north of Thompson Pass and generally absent south of the pass.

3.1.1.2 Paleontological Resources

Considerable portions of the pipeline route are underlain by sedimentary rocks or prehistoric soils. As a result,

the corridor contains a wide array of plant and animal fossils. The North Slope and portions of the Brooks Range are underlain by several kilometers of sedimentary rocks. Most of the limestone, sandstone, siltstone, and shale is marine in origin. The earliest fossils are found in Middle Devonian rocks about 380 million years old. Most subsequent rock formations exhibit some form of fossil record (Mull and Adams, 1989).

Common fossils in these rocks include brachiopods, cephalopods, gastropods, pelecypods, sponges, bryozoans, corals, and crinoids. The first terrestrial plant fossils are found in rocks from the middle part of the Jurassic Period, roughly 160 million years ago. This is an indication of at least temporary retreat of the ancient seas that previously covered most of the region. Following this, the seas repeatedly advanced and retreated over most or all of the North Slope (Lindsey, 1986).

Late Cretaceous vertebrate fossils dating to about 70 million years ago and Tertiary fossils represented primarily by invertebrates are also common. Dinosaur fossils have been discovered recently along the Colville River several miles west of the TAPS ROW.

South of the Brooks Range, the older metamorphic, igneous, or rapidly deposited sedimentary rocks predominate, and pre-Quaternary fossils are either absent or less common.

Pleistocene fossils are present in many locations along the pipeline and are generally preserved in gravel or retransported silt. Fossil land mollusks are abundant in the Copper River Basin. Freshwater mollusks, insects, and vertebrates are common in the Fairbanks area. Large extinct mammals including mammoth, mastodon, bison, Siberian steppe antelope, horse, muskox, and others have also been found in placer mining operations in the Fairbanks vicinity. Pleistocene birds have been found on the Arctic Coastal Plain and near Fairbanks (Péwé, 1975).

Discoveries of paleontological resources are reported to the Alaska Department of Natural Resources (ADNR). During construction of TAPS, Pleistocene vertebrate remains were uncovered in gravel deposits north of the Yukon River. These typically consisted of isolated bones or tusks. No major bone beds have been encountered. Since construction, there have been no significant discoveries or impacts to paleontological resources on the TAPS ROW (Kunz, 2000, pers. comm.).

3.1.1.3 Soils and Permafrost

Permafrost is the primary factor influencing the pipeline's construction modes and distinguishing it from conventional pipelines. Permafrost is widespread in Alaska and is present along most of the route (Figure 3.1-1). Major engineering problems can arise where warming of permafrost occurs in poorly drained, fine-grained sediments. These materials generally contain large amounts of ice, which takes the form of coatings, lenses, wedges, and veins that may vary in thickness from fractions of an inch to several feet. If this material thaws, significant consolidation and loss of pipeline support could occur. Thawing of permafrost in well-drained, granular soils or in bedrock is not a technical problem, because loss of support would not normally occur.

The "active layer" is a thin, seasonally-thawed layer overlying the permafrost. It begins at the ground surface and ranges to a depth of one to approximately 15 feet depending on the climate, organic surface cover, soil moisture content, depth of snow cover, and other factors (Shur, 1997). This layer freezes in winter and thaws in summer. The thickness of the active layer can change dramatically when the surface is disturbed, thus affecting the thermal condition of the underlying soils. In the continuous permafrost zone north of Atigun Pass and in portions of the discontinuous zone throughout Alaska's Interior, the active layer annually freezes to the top of permafrost. In the more southerly portions, particularly south of the Klutina River (MP 697) and in the areas affected by previous development in the discontinuous permafrost zone, the top of permafrost is fairly deep — as much as 25 feet below the surface. Seasonal freezing does not reach the permafrost table, leaving a continuously thawed zone above the top of the permafrost. The thickness of the permafrost layer is controlled by the mean annual air temperature and the geothermal gradient (Péwé, 1982), as shown in Figure 3.1-2. The base of the permafrost is stable when the heat lost to the atmosphere is equal to geothermal heating from the earth's interior.

Permafrost Characteristics of Physiographic Units

The permafrost on Alaska's North Slope is relatively cold (<-7°C), continuous, and typically encountered within a couple feet of the ground surface in disturbed areas (Brown et al., 1997). The permafrost is up to 2,000 feet thick, while the active layer is generally less than 1.5 feet thick. Unfrozen zones are shallow and usually limited to deep river channels and the deeper lakes (Rawlinson, 1993). Massive ground ice is widespread and occurs as vertical ice wedges, films, lenses, pore-fillings, and other small segregated masses. Most basin floors display the polygonal pattern of cellular ice-wedge networks. The polygons are bordered by sod dikes, and in the more poorly-

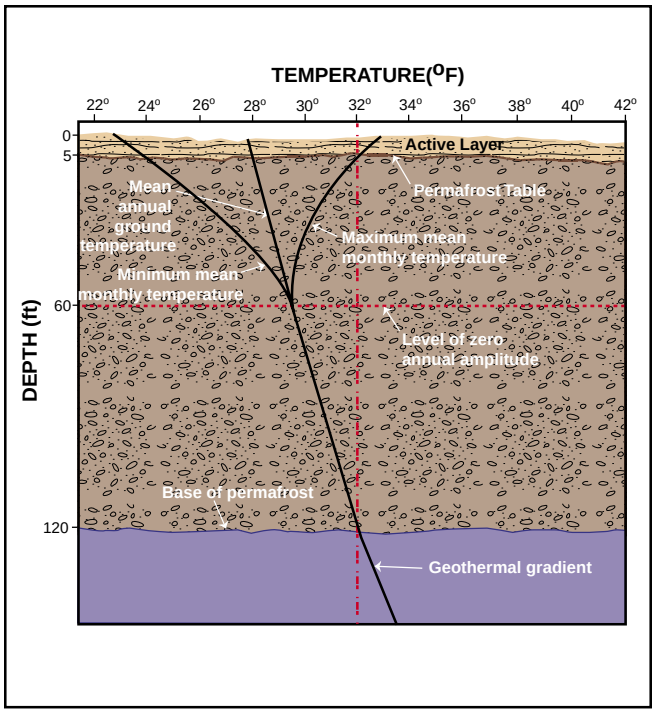


Figure 3.1-2. *Hypothetical example of typical temperature profile and thickness of permafrost in central Alaska (after Péwé, 1982)*

drained areas, they have shallow, saturated depressions in the center. The sod dikes overlie ice wedges. Shallow troughs along the crests of the dikes indicate actively growing ice wedges (Brown and Kreig, 1983). Surficial soils typically consist of several feet of ice-rich organic silt overlying coarse sands and gravels. Ice wedges are the most sensitive to disturbance because, once disturbed, the ice can rapidly melt causing significant settlement.

Permafrost in the Brooks Range is relatively cold (-3 to -7°C), mostly continuous, and up to several hundred feet thick (Brown et al., 1997). Segregated ice is present in a variety of landforms including talus cones and bedrock fractures. Permafrost transitions from continuous to discontinuous south of Atigun Pass, and the amount of ground ice is widely variable. Solifluction — the slow, downslope flow of shallow, unfrozen earth materials on a frozen substrate — is evident on many slopes due to the high silt and moisture content in the near-surface soils (Brown and Kreig, 1983).

In the Yukon-Tanana Uplands, the permafrost is discontinuous and relatively warm (-1°C to -3°C) (Brown et al., 1997). It is widespread north of Fairbanks and can be more than 175 feet thick. Massive ice in the form of wedges and lenses several feet thick occurs in lowlands (Péwé, 1982). South of Fairbanks, the ground is warmer and generally thawed, but permafrost is locally present. The permafrost is susceptible to thawing if the surface is disturbed. Permafrost in the Tanana Valley is discontinuous and warm (0°C to -1°C) (Brown et al., 1997). Interstitial ice includes massive lenses in the silts that typically overlie deep deposits of coarse alluvial sands and gravels.

Permafrost in the Alaska Range and Copper River Basin is discontinuous, relatively warm (0°C to -1°C) (Brown et al., 1997), and locally ice-rich. The Copper River Basin locally contains ice wedges (Péwé and Reger, 1983). Most of the pipeline route is underlain by hundreds of feet of glacial-lacustrine clay, silt, and sand. Fluvial silt, sand, gravel, colluvium, and swamp deposits underlie a small portion. Permafrost is commonly within 5 feet of the ground surface and may be as thick as 250 feet (Nichols, 1956). The ground ice is typically segregated in veins and veinlets in the mostly fine-grained soil matrix.

Permafrost is sporadic and warm (0°C to -1°C) in the Chugach Mountains and occurs mostly in the very northern portion of the unit in the Tonsina River valley. It is generally absent south of the upper Tiekel River, except under glaciers, because of the influence of the maritime climate.

3.1.1.4 Sand, Gravel, and Rock

Alyeska has contracts to purchase granular materials from 69 sites on public land along the ROW (Table C-1 in Appendix C). These materials consist of sand and gravel, or bedrock used to build and maintain TAPS earthwork structures. The sand and gravel sites are typically situated on alluvial fan and floodplain deposits near the ROW. Bedrock sites are located at bedrock outcrops. The size of the sites varies from a few acres to more than 40 acres.

Most of the sites were established during TAPS construction. Many are still used jointly with the Alaska Department of Transportation and Public Facilities for highway maintenance (Table C-1).

3.1.1.5 Hazardous Materials

Hazardous materials include chemicals, explosives, corrosives, and wastes that could cause harm to human health or the environment. TAPS was originally routed to avoid areas such as landfills, gunnery ranges, or contaminated sites that might contain potentially hazardous materials.

Currently, there are 58 contaminated sites on the TAPS ROW that are under the jurisdiction of the Alaska Department of Environmental Conservation. All of the sites have been contaminated by spills or leaks of petroleum hydrocarbons. The status of the sites and the number of sites in each category is as follows (Willson, 2000, pers. comm.):

- Closed (no further action required): 14 sites.

- Active (actively being either investigated, monitored, or remediated): 19 sites.
- Pending closure (application submitted for closure): 16 sites.
- Inactive (investigations and interim cleanups have been performed but concerns for safety or damage to existing structures currently prevent complete remediation): 9 sites.

A special program has been carried out since 1990 to examine and address 31 sites along the pipeline that were contaminated, or had the potential to be contaminated, by past spills. These sites had been considered clean under regulations previously in place but were re-examined in light of new public uses and current cleanup standards. Five of the sites were found to contain contamination and are included in the list of 58 contaminated sites described above (Willson, 2000, pers. comm.).

3.1.1.6 Hydrology/River Characteristics

By W. Veldman

Overview of Crossings

The pipeline crosses more than 800 identified creeks and rivers ranging in size from the Yukon River to creeks only several feet wide. In addition to the river crossings, extensive sections of the pipeline are located within or parallel and proximate to the active channels or floodplains of the Sagavanirktok, Atigun, Chandalar, Dietrich, Middle Fork Koyukuk, and Delta rivers and Phelan Creek.

Table C-2 in Appendix C provides a summary of the major and minor river and creek crossings and instream and floodplain segments for which detailed design drawings were prepared. These constitute about 12.4 percent of the total length of the pipeline.

River Types and Characteristics

The primary river and creek types crossed are:

- **Braided:** Wide, steep, high-bedload, multi-channeled systems such as the Sagavanirktok and Delta rivers and Phelan Creek (Figures 3.1-3, 3.1-4).
- **Split channels:** such as the lower parts of the Middle Fork Koyukuk (Figure 3.1-5).
- **Single channels with wide floodplains:** South Fork Koyukuk, Chena, and Salcha rivers, and Moose Creek — or deeply incised channels with no floodplain — Sulphide Gulch (Figure 3.1-6).
- **Alluvial fans:** the majority of the creeks that flow into the Delta River in the Pump Station 10 area and Sheep, Brown, and Unnamed creeks flowing into the Lowe River (Figure 3.1-7).

The behavior of the rivers and creeks is a function of the river type, magnitude of flow and size of crossing, and presence or absence of debris, permafrost, and aufeis.

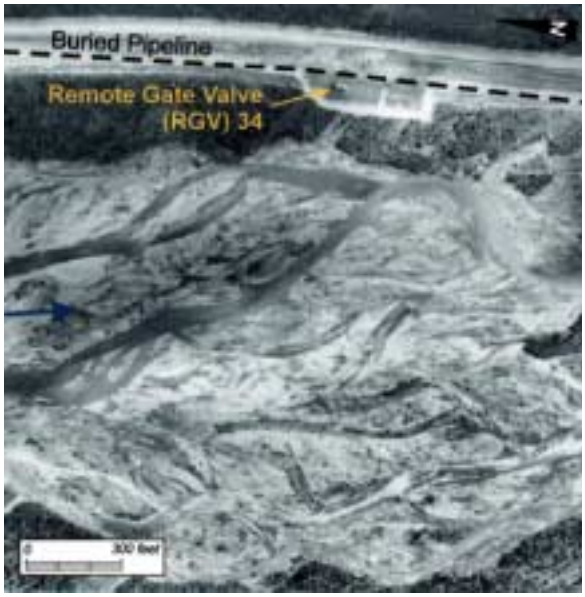
Flow Characteristics

The hydrologic characteristics along the pipeline route are varied, and stream flows are highly variable with time of year. For the purposes of a regional flood-frequency analysis, a recent report by the U.S. Geological Survey (Jones and Fahl, 1994) essentially used one hydrologic region for the entire pipeline route. (Large regions are required to generate regional relationships because smaller hydrologically unique regions — the Atigun River valley, for example — do not have sufficient flow-data measurement locations to generate a regional relationship of flow versus drainage area. The adequacy of the flow data is addressed in Section 4.) For purposes of describing hydrologic characteristics for this report, five hydrologic regions are identified:

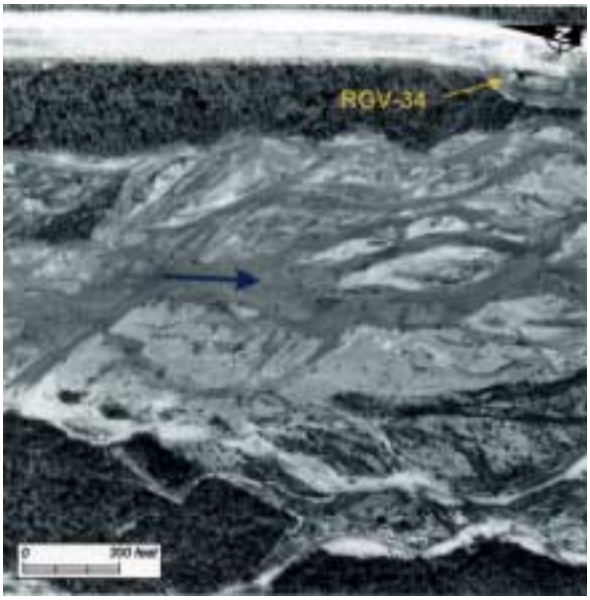
North of the Brooks Range in the Sagavanirktok and Atigun Rivers: Winter flows are minimal to nil. For example, during the mainline replacement of the 8-mile-long Atigun River pipeline section in 1991, there was no surficial flow in the Atigun River south of about MP 160. Low winter flows in the Sagavanirktok River result in significant accumulations of groundfast ice or aufeis. The flows in the winter may occur either as surface or subsurface flow from place to place or from time to time. Breakup on the Sagavanirktok River is triggered by warm temperatures and snowmelt runoff from the Atigun River and the Brooks Range. Breakup flows are over the groundfast ice resulting generally in maximum water levels. High flows on the Atigun and Sagavanirktok rivers (August 1992, for example) are usually triggered by heavy sustained rains in the Brooks Range. Flows increase and decrease rapidly in response to rainfall magnitude because the Brooks Range and permafrost conditions of the slope have a low capacity for retaining precipitation.

South Side of the Brooks Range: The Dietrich River is also characterized by severe winter aufeis formations, especially from MP 195 to 200, where small tributaries from the west supply the flow to generate the ice on the wide Dietrich River. The Middle Fork Koyukuk River has less aufeis buildup because its deeper channels result in less formation of groundfast ice. As on the north side of the Brooks Range, maximum flows are usually triggered by intense rain. One such event occurred in August 1994.

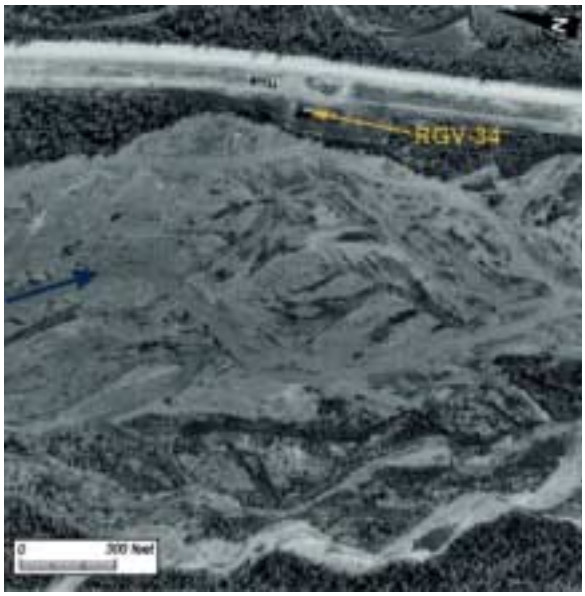
Interior: Flows in the Interior from the Jim River to the Yukon River to Big Delta are highly variable and depend largely on watershed and thus runoff characteristics.



1982 air photo



1989 air photo



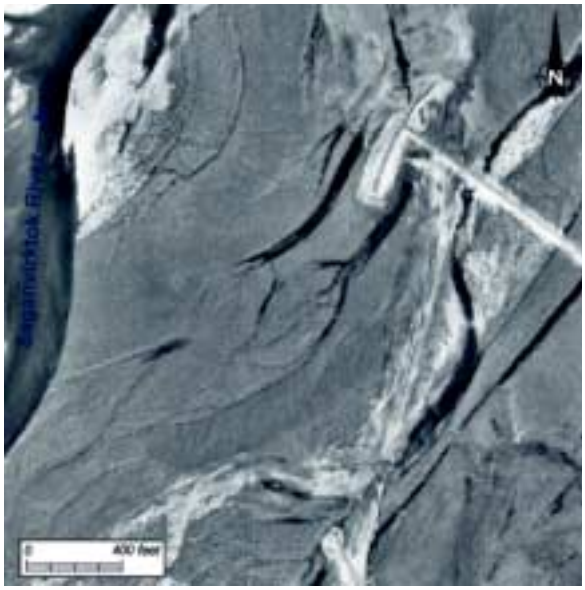
1996 air photo

June 30, 1998, site photo

Braided rivers have multiple channels that are highly mobile, especially during high flows. Their mobility is caused by the deposition or erosion of bedload and gravel bars. The magnitude and location of bank erosion are difficult to predict because sudden channel changes may cause the flow to deflect away from the riverbank or cause it to attack the riverbank.

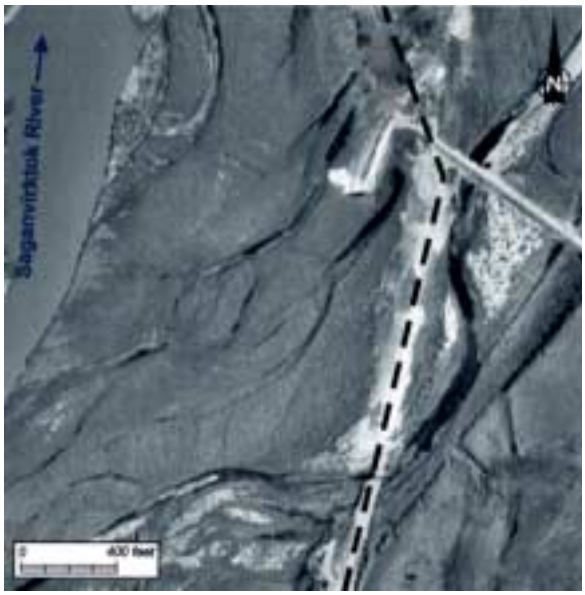
Note the numerous subchannels within the active width of the river. Erosion of the main vegetated banks can be significant during a flood.

Figure 3.1-3. *Braided river — Dietrich River, MP 185.8. Characteristics and changes over time.*



1980 air photo

1989 air photo

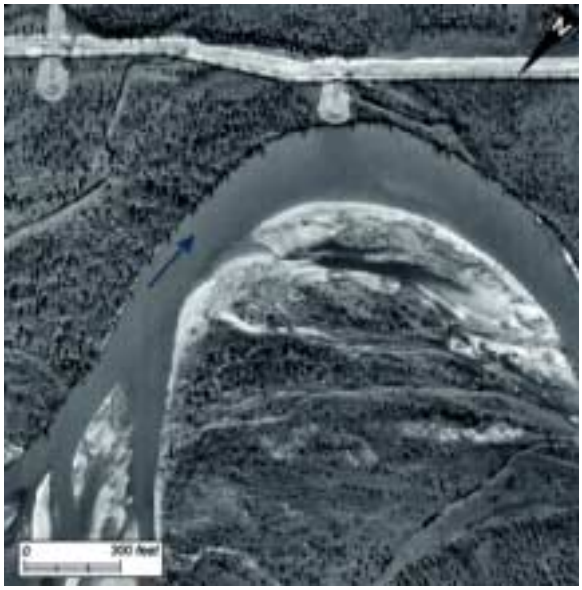


1996 air photo

Spring 1994 site photo (D.O.F. = direction of flow)

Extensive floodplain overflow occurs during spring breakup as a result of flow over groundfast icings. With the floodplain and its subchannels frozen during breakup, the overflow causes little if any change in the channels. Late summer floods, such as occurred in 1992, can cause channels to enlarge or deepen or new channels to form.

Figure 3.1-4. *Floodplain in a braided North Slope river — Sagavanirktok River, MP 63.0. Characteristics and changes over time.*



1983 air photo

1989 air photo

1996 air photo

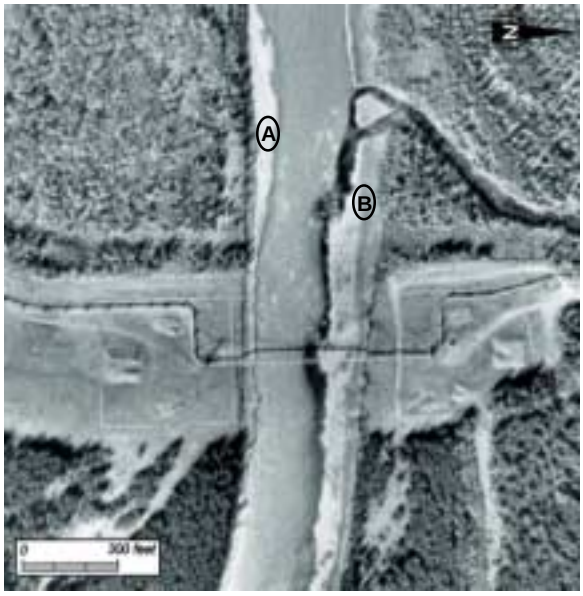
June 30, 1998, site photo

The future behavior of sharp bends in rivers such as the example shown are relatively easy to predict (at least compared to braided rivers as shown on Figure 3.1-4). Whereas the precise location of maximum velocities and thus potential bank erosion can change depending on flow patterns upstream, the bend is a constant area of bank erosion unless a cutoff channel forms across the bend. If the cutoff (1996 photo) were to form, velocities and the potential for bank erosion at the pipeline would be significantly reduced.

Figure 3.1-5. *Split channel and sharp bend — Middle Fork Koyukuk River, MP 218.5. Characteristics and changes over time.*

1974 air photo (before construction)

1985 air photo



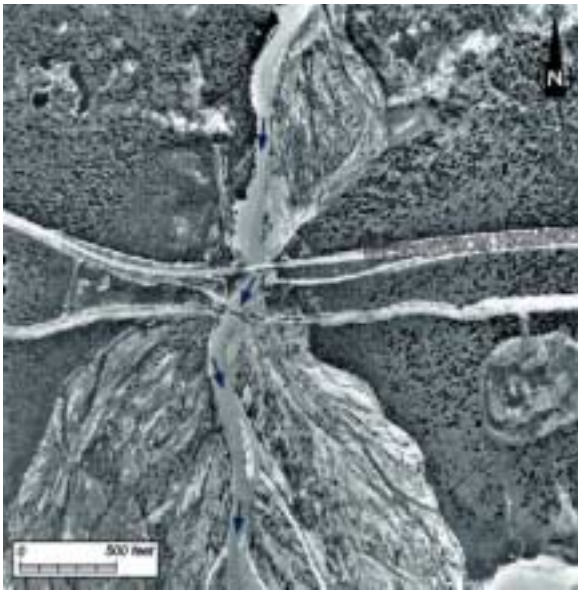
1996 air photo

May 1998 site photo

River changes (depth of channel and bank erosion) are the least in straight channels with high banks that do not overtop, even during extreme floods. However, minor changes upstream, like the formation of the bar on the south bank upstream of the crossing (A in the 1996 photo), can result in a change in the direction of flow into the opposite bank (B in the 1996 photo) and erosion, as shown on the site photo.

Figure 3.1-6. *Single incised channel — Tazlina River, MP 687.0. Characteristics and changes over time.*

1982 air photo



1989 air photo

September 1999 site photo

Alluvial fans, by their very nature, are zones of sediment deposition and rapid channel changes during high flows. Generally, the channels move within the width of the active fan, as illustrated by the photos. At times, the flow may attack the vegetated borders of the fan, thus widening the active part of the fan. Depending on the movement of the receiving stream (the Delta River in this case), fans may experience general deposition or downcutting. If the stream erodes into the nose of the fan, the channel's slope and scour depth on the fan increase, resulting generally in less bank erosion. On the other hand, if the receiving stream moves away from the mouth of the alluvial fan, the slope of the fan decreases, scour depth decreases, and bank erosion increases. (Brown Creek at MP 784 has undergone several cycles of changes.)

The Richardson Highway bridge located immediately upstream tends to restrict or limit the movement of the creek at the elevated pipeline crossing. However, even minor works constructed at the highway bridge, such as the addition of riprap to protect its abutments, can affect bank erosion and/or bed scour at the pipeline.

Figure 3.1-7. *Alluvial fan — Miller Creek, MP 599.6. Characteristics and changes over time.*

Breakup in the region can produce significant flows due to the snowfall accumulations and rapid temperature increases in the spring in this area.

Alaska Range: The Delta River and Phelan Creek are characterized by low winter flows and significant aufeis development in their wide, braided systems. Summer flows on the glacier-fed streams are dependent on temperatures and rainfall. Intense rainfall produces high flows, particularly if concurrent with a high snowmelt/glacier-induced flow. Glacier-dammed lakes occur in the Miller Creek area near Pump Station 10. When they release, very high flows can be produced.

Glennallen to Valdez: Maximum flows on the Tazlina River, Tsina River, and Sheep Creek are generally triggered by releases from glacier-dammed lakes. These releases, which occur when the head built up in the lakes is sufficient to burst through the glacier via a tunnel, can be relatively regular (e.g., the Tsina River) to less regular (e.g., the Tazlina) to infrequent (e.g., Sheep Creek). In 1997, heavy and prolonged rains following a summer snowmelt period resulted in record flows on the Tazlina River (at least for the period of recorded flow) as the lakes upstream burst simultaneously. In the Valdez area, heavy rains can produce high flows on the Lowe River and particularly on its major tributaries such as Brown Creek.

Flow Data

Peak annual flows for streams crossed by TAPS are summarized on Table 3.1-2, which highlights the maximum recorded flows both before and after pipeline startup. The relative magnitude of recent high flows along the pipeline (such as the 1992 Sagavanirktok River flood, the 1994 Middle Fork Koyukuk River flood and the 1997 flows on the Tazlina River) are observable from this listing. The relative magnitude of flows during operation of the pipeline is important in assessing its potential impact and integrity (discussed in Section 4.3.1).

Figure 3.1-8 shows the mean, maximum and minimum monthly flows for a representative number of rivers or creeks crossed by the pipeline. The dramatic breakup and summer flows compared to the low winter flows are well illustrated on this graphic. It should be noted that for systems such as the Sagavanirktok and Atigun, winter flows are estimated from late-fall flow measurements and are not based on actual field data. Therefore, they may not be representative of the actual flows at a specific time at a specific location. Because of aufeis formations, flows at a specific time and location may vary dramatically from one location to the next as flow is “lost” to ice formation or “gained” by the inflow of a local tributary. Flow at times may go subsurface at one location and then surface again downstream.

Figure 3.1-9 illustrates the maximum flows for a number of representative stations since TAPS startup. The figure shows the rapid rise in flow that can occur even in the larger watersheds. The steep terrain of the Brooks Range, little or no vegetation, and frozen ground conditions are all factors leading to minimal rainfall retention and thus high runoff coefficients and rapid increases and decreases in flow as a result of a high rainfall event.

Bed Scour and Bank Erosion

The potential for riverbed scour and bank erosion depends on the magnitude, duration, and time of the flow, as well as the bedload material transported. The majority of scour and erosion occurs during high-flow-magnitude runoff events, which may range in duration from several days to several weeks for small and large watersheds, respectively. River characteristics such as size, slope and bed material also have a significant influence on potential stream changes, as illustrated on Figures 3.1-3 to 3.1-7. The river and hydrologic characteristics that influence bed scour and bank erosion are described below.

Floodplain overflow during spring breakup, when the ground is still frozen, results in few channel changes or the formation of new channels. For example, frequent and almost annual overflows occur along and across the Dalton Highway in certain sections along the Sagavanirktok River, with little impact on the floodplain. On the other hand, dramatic scour, bank erosion, enlargement of subchannels, and development of new channels can occur if the ground is thawed during major late-summer floods — such as the record floods on the Sagavanirktok River in August 1992 and the very high summer flows on the Dietrich/Middle Fork Koyukuk River systems in 1994.

Melt from glaciers during long warm periods can result in relatively high, sustained flow that can produce bed and bank scour and erosion. The sudden release of multiple glacier-dammed lakes, as occurred on the Tazlina River in 1997, in combination with antecedent high rains, can produce extremely high flows and dramatic river changes necessitating remedial measures. Other streams with single glacier-dammed lakes, such as the Tsina River, release the stored water more frequently and almost regularly, with resultant annual moderately high flows.

Alluvial fans are areas of high potential bedload deposition, bank erosion, and development of new channels as a result of high flows. The location of the pipeline on the fan greatly determines the nature and magnitude of potential channel changes. At the upstream end, or apex, of the fan, changes will be less than at the mouth of the fan.

Table 3.1-2. *Flow data record for streams crossed by the pipeline.*

USGS Flow Station		Drainage Area (mi^2)	Period of Flow Record						Peak Annual Flow in cfs		
Name	Number		40s	1950-59	1960-69	1970-79	1980-89	1990-99	Pre-Pipeline Operation	Post Pipeline Operation	Average over Period of Record
Sagavanirktok River near Sagwon/Pump Station 3	15910000/15908000	2208/1860							34900	42900	19300
Atigun River near Pump Station 4	15904800	48.7									
Atigun River Tributary near Pump Station 4	15904900	32.6							1000	1650	642
Nutirwik Creek near Wiseman	15564866	29.2									
Snowden Creek near Wiseman	15564868	16.7							1200	600	405
Nugget Creek near Wiseman	15564872	9.47							132	540	193
Middle Fork Koyukuk River near Wiseman	15564875	1200							17100	42700	14400
Slate Creek at Coldfoot	15564879	73.4								3900	1530
Jim River near Bettles	15564885	465							21000	12800	10100
Prospect Creek near Prospect Camp	15564884	110							6800	4500	1920
Bonanza Ck. Tributary near Prospect Camp	15564887	11.7							220	290	164
Yukon River near Stevens Village	15453500	196300								827000	476000
Hess Creek near Livengood	15457800	662							10000	6480	5310
Erickson Creek near Livengood	15457700	26.3							660	860	315
Globe Creek near Livengood	15541600	23							1240	1230	379
Washington Creek near Fox	15541800	46.7									
Goldstream Creek near Nenana	15540070	41.8							1490	483	335
Chena River at Fairbanks	15514000	1995							74400	11400	10300
Salcha River near Salchaket	15484000	2170							97000	37100	18800
Tanana River at Big Delta	15478000	13500									
Ruby Creek near Donnelly/above Richardson Hwy	15478500/15478499	5.32/4.89							250	1660	274
Suzy Q Creek near Pump Station 10	15478093	1.29								1070	227
Boulder Creek near Central	15439800	31.3							1150	1460	368
Phelan Creek near Paxson	15478040	12.2							2320	1560	998
Fish Creek near Cantwell	15516010	18.2									
Gulkana River at Sourdough	15200280	1770							8840	12700	7830
Tazlina River near Glennallen	15202000	2670							60700	120400	33500
Klutina River at Copper Center	15206000	880							9040	8600	7080
Rock Creek near Tonsina	15208200	14.3							110	225	68
Squirrel Creek at Tonsina	15208100	70.5							1200	460	371
Tonsina River at Tonsina	15208000	420							8490	7000	4860
Little Tonsina River at Tonsina	15207800	22.7									
Tiekel River neart Tiekel	15212600	115									
Stuart Creek near Tiekel	15213400	37.4							1800	2690	1260
Solomon Gulch near Valdez	15226000	19.7							2420	2270	1550
Allison Creek above mouth near Valdez	15225945	7.5									

1. According to annual "Water Resources Data, Alaska" reports published by the U.S. Geological Survey, Department of the Interior, in cooperation with the State of Alaska. 1999 status (whether or not the stations are still operating) according to the USGS Internet site and/or personal communication with USGS staff in Alaska.
2. 1999 Atigun River Tributary data are preliminary. 1997 Tazlina River data are estimated by Alyeska.

Years for which data are available Pipeline startup Data available and peak flows recorded

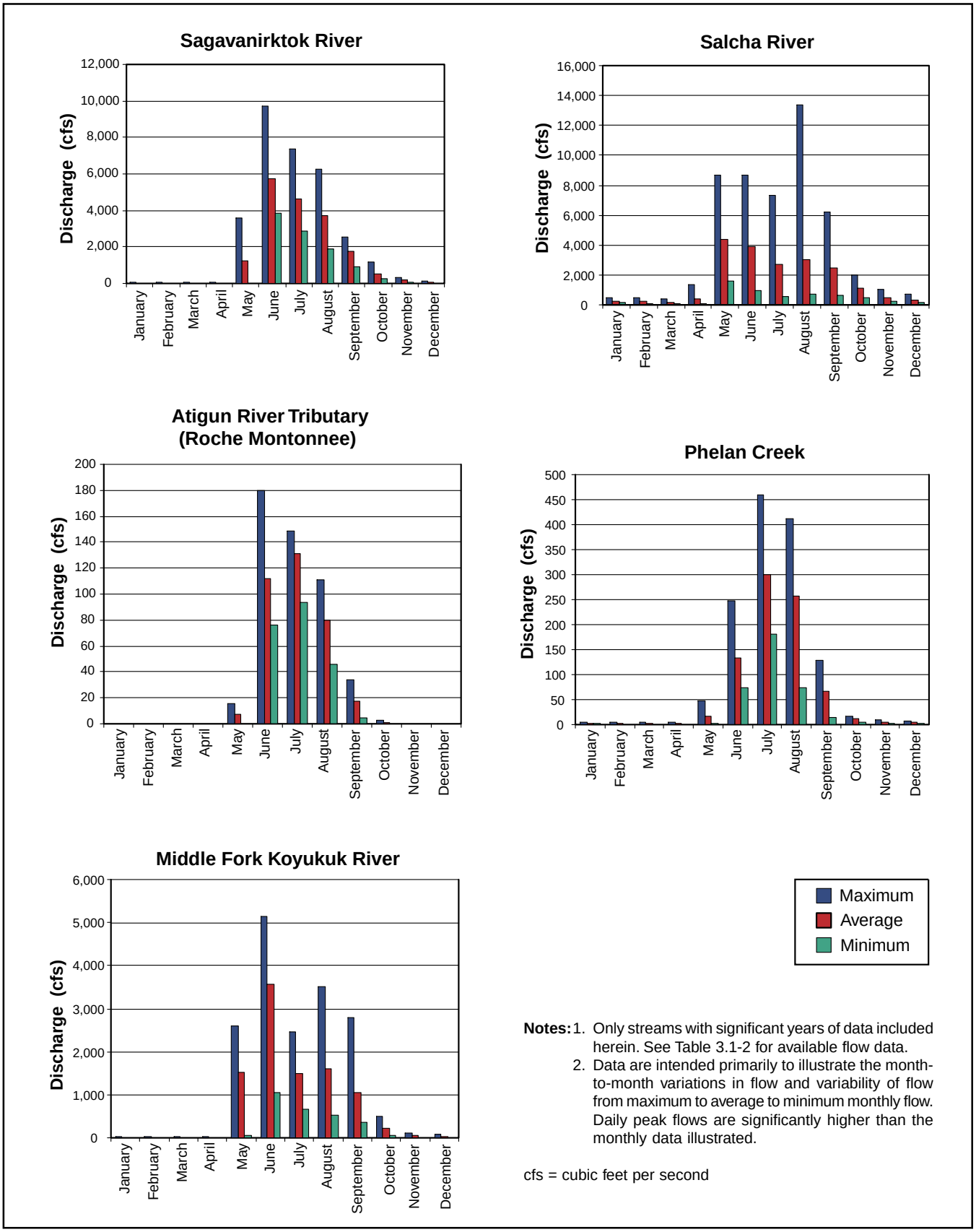
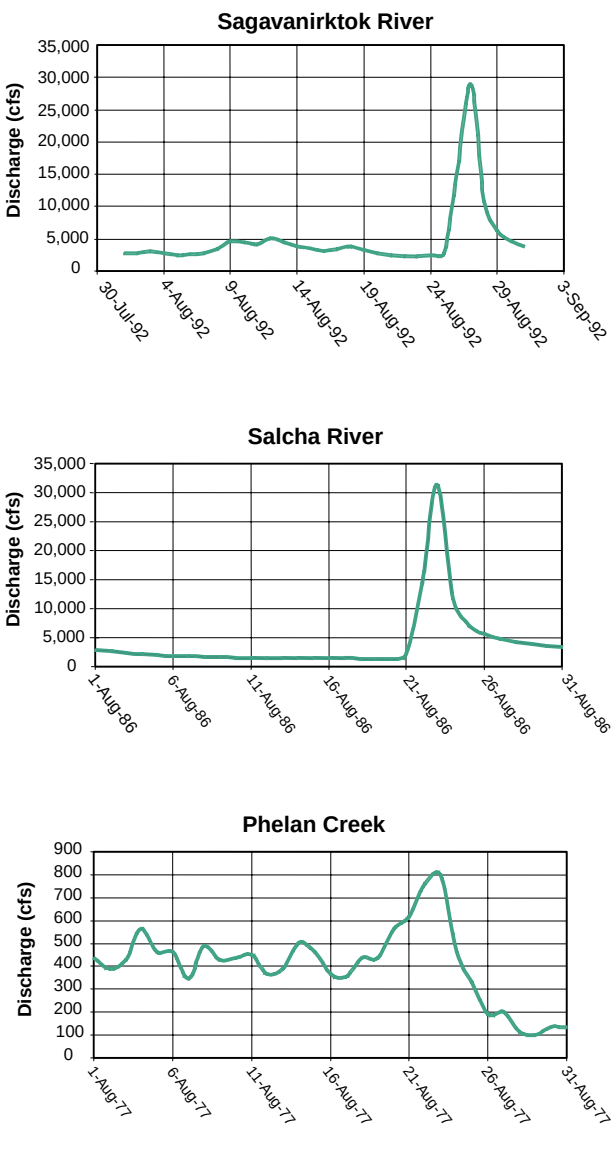


Figure 3.1-8. *Monthly flow data for streams crossed by the trans-Alaska pipeline.*



Hydrographs illustrate the rate of rise and fall of flow during high flood events. Even for large watersheds such as the Sagavanirktok River, the total duration of the flood flows is less than a week — an important consideration in regard to the duration of high flows that could affect crossings, floodplains, or instream pipe alignments.

Figure 3.1-9. *Peak flow hydrographs for representative streams crossed by the pipeline.*

Changes in the stream that the fan empties into may also have a significant influence on the behavior of the fan. For example Brown Creek, which empties into the Lowe River, has alternated between scour with little bank erosion and deposition with bank erosion as changes in the Lowe River respectively shortened and lengthened the alluvial fan.

Debris accumulations in small streams can result in dramatic local bank erosion or bed scour. Even in large river systems such as the Dietrich River or Middle Fork Koyukuk River, debris can produce significant changes in flow patterns. Major rivers north of the Brooks Range, such as the Atigun and Sagavanirktok, have no trees and thus are not affected by debris. However, as evidenced by the 1992 and 1999 rainfall-induced floods on the Sagavanirktok and Atigun rivers, respectively, high runoff rates from the steep permafrost watersheds can produce sudden and dramatic increases in flow, with resultant channel changes.

Channel Icings (Aufeis)

In wide, braided streams which have low winter flow, development of groundfast ice or aufeis is common. If the streambed is also frozen, the flow is forced to surface and freezes as a succession of shallow overflows. The location of overflows — and thus icings — varies spatially and temporally.

In some locations, such as the Dietrich River, most of the aufeis appears to be generated from inflow from the western tributaries. When the inflow freezes as it empties from the west into the wide Dietrich River, the resultant ice can have a significant slope from the west down to the east side of the river. Consequently, the initial breakup flow is concentrated along the lower east side of the river where the pipeline is located. MP 194 to 198 is one such area where dikes were added during TAPS construction to reduce the potential for overflows across the pad and VSMs.

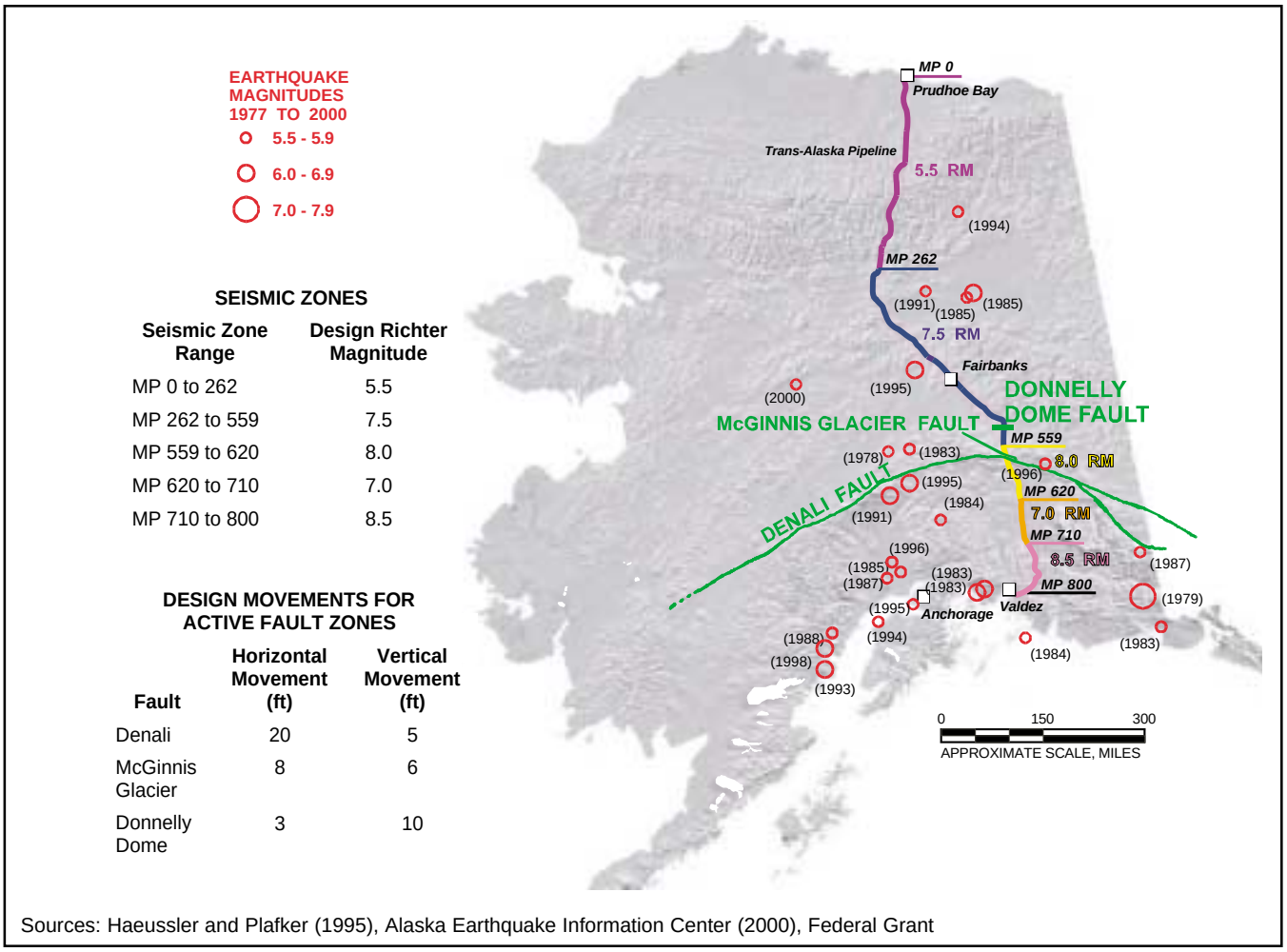
Maximum water levels are often generated by the initial spring breakup flow over the aufeis. After several days to a week of overflow, the aufeis deteriorates, lifts, and moves downstream or becomes stranded on bars and islands.

Aufeis was a significant consideration in the design of river training structures, bridges, and elevated pipeline sections.

3.1.1.7 Seismicity

By D. Nyman

The pipeline route begins in a region of low seismicity on the North Slope and terminates in one of the most seismically active regions in the world. Locations of large earthquakes and major faults are shown in Figure 3.1-10



Sources: Haeussler and Plafker (1995), Alaska Earthquake Information Center (2000), Federal Grant

Figure 3.1-10. *Map showing seismic zones and fault crossings along TAPS and earthquakes greater than magnitude 5.5 that have occurred near TAPS since startup.*

(Haeussler and Plafker, 1995).

The northern part of the TAPS route has low seismic activity. Seventy-six earthquakes greater than Richter magnitude 4.0 were recorded between the Arctic Coast and the Brooks Range from Point Barrow to the Canadian border between 1898 and 1999. Most of these earthquakes were located in the Camden Bay region approximately 80 miles east of Prudhoe Bay. Magnitudes ranged up to 5.3 on the Richter Scale (Alaska Earthquake Information Center, 2000). No known damage has resulted from these events. Earthquake activity is also low in the Brooks Range and the uplands north of the Yukon River.

The southern two-thirds of the pipeline route is seismically active and has experienced large earthquakes. Three earthquakes of magnitude 7 or greater have occurred within 50 miles of Fairbanks in the last 90 years — all before construction of TAPS. Strong shaking caused minor damage in the Fairbanks area, but there were no fault ruptures at the ground surface.

The most significant fault crossed by the pipeline is the Denali Fault, which runs along the Alaska Range for hundreds of miles. This fault is considered active and appears to have moved at least 20 feet in the past 10,000 years, although it has not moved in historical times. An earthquake of magnitude 7 has been recorded in the Alaska Range (Péwé, 1982).

The seismicity of the Chugach Mountains is very high. The epicenter of the 1964 earthquake, which had a moment magnitude of 9.2 (Richter magnitude 8.4), was about 40 miles west of the Valdez Marine Terminal. The primary tectonic displacement occurred on a subduction zone fault. The city of Valdez and associated harbor facilities, located at that time at the eastern end of Valdez Arm, were severely damaged by wave run-up caused by a massive submarine landslide. After the 1964 earthquake, the city was relocated to a site on the north shore of Valdez Arm that offers natural protection against a similar occurrence. The Valdez Marine Terminal is located on high ground on the south shore

of Valdez Arm. The site is naturally protected by bedrock ridges at Jackson Point and Saw Island, and all onshore facilities (except the small boat dock) are located at elevations higher than the estimated 30-foot run-up that occurred during the 1964 Alaska earthquake (Marine Advisers, Inc., 1969; Plafker and Mayo, 1965).

Since construction, there have been no large earthquakes in the TAPS vicinity and no reports of earthquake damage to TAPS facilities (Simmons, 2000, pers. comm.). The epicentral locations of earthquakes greater than moment magnitude 5.5 occurring in general proximity to TAPS are shown in Figure 3.1-10. The largest earthquake within 50 miles of the TAPS ROW was a magnitude 6.4 event in 1983 west of Valdez.

3.1.2 Water Resources

By B. Jokela, V. Gates, and D. Gryder-Boutet

3.1.2.1 Fresh Water Quality

Water quality data for the pipeline route are sparse. State of Alaska Water Quality Standards (18 AAC 70) describe 13 categories of water quality criteria and four major categories of uses for which to apply the criteria. Few data exist which allow comparison to water quality standards. Existing data do not provide adequate documentation of variability through the seasons of the year, nor over the course of time. Data are not sufficient to identify differences in background water quality between watersheds nor differences subject to hydrologic influence, (e.g., high versus low flow levels in streams).

Although a database of current water-quality conditions does not exist, few concerns have been expressed about water quality along TAPS. According to the Alaska Department of Fish and Game, “The planning effort prior to construction of the TAPS really shows. There have not been many fish and game habitat ‘problems,’ only ‘incidents,’ and these have been resolved quickly” (Webber-Scannell, 2000, pers. comm.). Furthermore, of nearly 800 stream crossings, only Goldstream Creek (TAPS MP 448) and the Chena River (MP 460), both near Fairbanks, are listed as impaired waters by the Alaska Department of Environmental Conservation, which maintains a list of impaired waters in accordance with Section 303(d) of the Clean Water Act. Neither of these waterbodies is impaired due to TAPS operations. Placer mining is reported to be a cause of turbidity increases in Goldstream Creek, while runoff from urban and military lands may be introducing sediment and petroleum compounds into the Chena River.

Several partnerships among stakeholders have developed in watersheds where interested parties support monitoring and management efforts for maintenance of pristine conditions in specific waterways. These groups include the Yukon River Intertribal Watershed Council, the Copper River Watershed Council, and the Tanacross Village Watershed Council. These groups are non-profit corporations and are receiving grants from EPA for certain activities envisioned as promoting watershed health. While these groups are relatively new, none has identified any specific degradation of water quality or habitat that is attributable to TAPS operations (Kellogg, 2000, pers. comm.).

Some field surveys were performed by state and federal agency staff before pipeline construction (Childers, 1975; Childers et al., 1978). Nauman and Kernodle (1973) measured and reported water-quality characteristics at 69 stations along the pipeline from 1970 to 1972. Representative data from this study are presented in Figure 3.1-11. No comprehensive follow-up has been done for comparison to current conditions.

A 1969 study focusing on North Slope streams provided a series of comparable measurements along the length of the Sagavanirktok River from high in the Brooks Range to the delta near Prudhoe Bay (Figure 3.1-12). Water sampling was performed in June and August of that year. Mineral data — particularly principal cation data — show strong similarities between June and August sampling for the watershed. Turbidity, color, and fixed suspended solids values, however, were significantly higher in June than in August, reflecting the change in principal runoff source from snow-

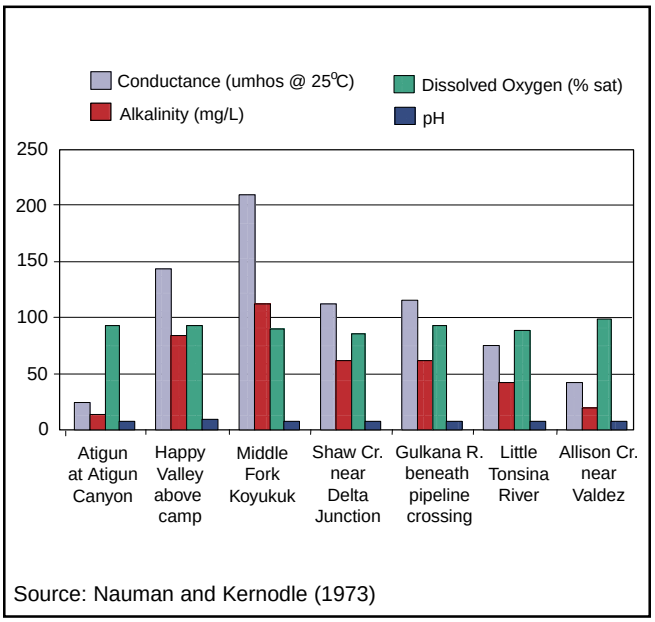


Figure 3.1-11. *Field water-quality data from selected TAPS route locations (May-September 1972).*

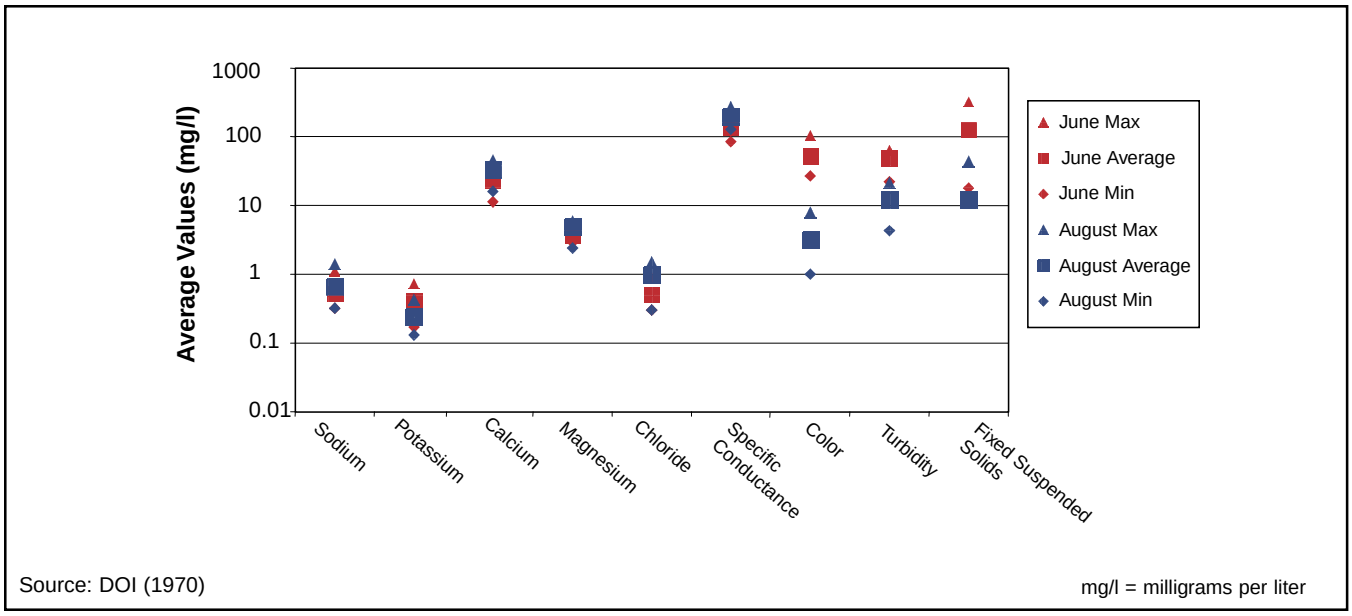


Figure 3.1-12. *Water quality in Sagavanirktok River basin, average values along watercourse, June and August 1969.*

melt to rainfall runoff and discharge from active-layer meltwater.

Although few water-quality data exist from the TAPS corridor, some general trends may be extrapolated from literature on water resources in cold regions (e.g., Jokela, 1990). Such generalizations include:

- Glacial streams have high turbidity in summer, with productivity often limited by light penetration rather than nutrient loading.
- Ice cover on streams and lakes can prevent or retard reaeration, leading to hypoxic or anoxic conditions in the water underneath the ice. This is particularly true in shallow lakes and tundra ponds with high sediment oxygen demand.
- Breakup stream flows tend to be relatively low in dissolved solids because of the high proportion of snowmelt compared to the groundwater contribution of stream flows.
- Groundwater-fed streams tend to have higher dissolved-solids and nutrient concentrations than glacial streams.

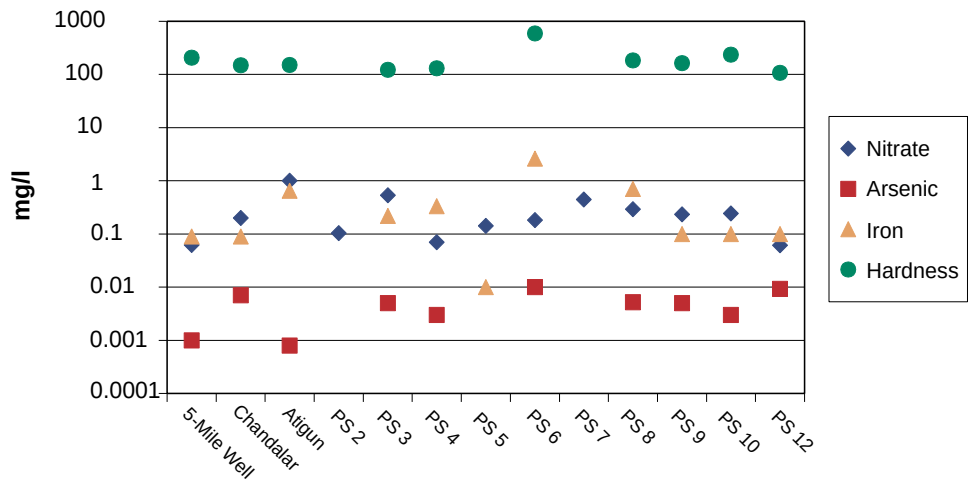
Groundwater resources are limited in permafrost areas. Near flowing water or large bodies of surface water, a thaw bulb is created by continuous heat input from the water body to the surrounding soils. The pipeline can also create a thaw bulb. DenBeste and McCart (1984a) reported "irregularities" in records of stream temperatures in several Brooks Range province streams. They suggested that the irregularities are the result of warming of the river bed by the buried pipeline. Their findings are not known to have been corroborated by subsequent research.

Water wells provide much of the potable water used by the pipeline facilities. Regular water-quality monitoring is required for public water-supply systems, such as at each pump station. Groundwater quality values from water supply monitoring at Alyeska facilities are shown in Figure 3.1-13. Nitrate data shown are from the 1990s and represent annual monitoring in accordance with state regulations (18 AAC 80). Other data are limited and may reflect only a few samples. Hardness data, for example, date back to the 1970s.

3.1.2.2 Port Valdez Marine Waters

The Valdez Marine Terminal is on Port Valdez, a fjord approximately 5 kilometers (km) wide by 18 km long, with a mean depth of 180 meters (m). It is separated from Valdez Arm of Prince William Sound by Valdez Narrows, where the minimum depth is approximately 138 m. The east-west trending Port Valdez has steep sideslopes and a relatively flat bottom, with a typical depth of 240 m over three-quarters of its length. The fjord bottom is composed principally of silts and clay-sized minerals derived from glacial river sediment loads (Naidu and Klein, 1988). Typical organic carbon content of the bottom averages 4.7 milligrams per gram (mg/g).

Surface temperature of Port Valdez ranges from -1.2°C in winter to a typical maximum of 16°C in the summer. There is a large seasonal variation in runoff from snowfields and glaciers into Port Valdez. As a result, density stratification due to temperature differences and freshwater inflow is quite strong in the summer. This stratification



Source: Alyeska Drinking Water Database

mg/l = milligrams per liter

Figure 3.1-13. *Groundwater quality at Alyeska Pipeline Service Company facilities.*

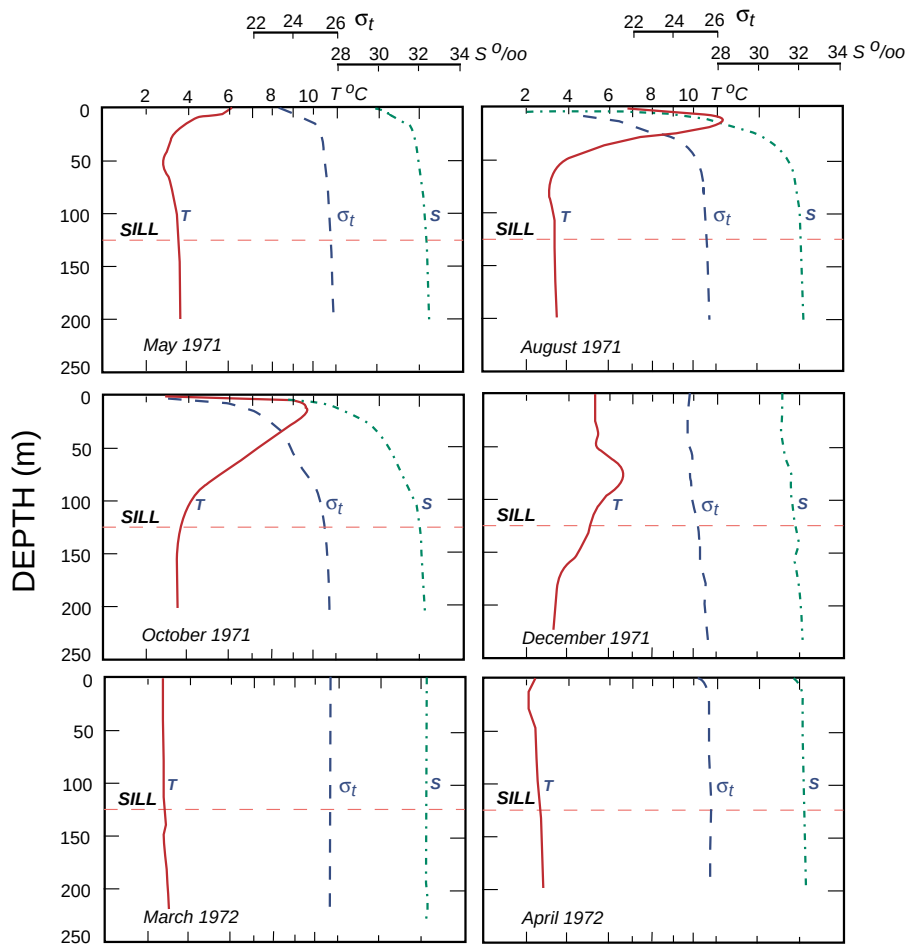
gives way to nearly complete mixing of the water column during the winter. Seasonal changes in density structure are illustrated in Figure 3.1-14.

The mean amplitude of tides in Port Valdez is about 3 meters; thus, the tidal prism corresponds to about 1.6 percent of the total volume of water contained in Port Valdez. During well-mixed winter conditions, this provides for refreshment of half the volume of Port Valdez about every 22 days. In the summer and early autumn, cold, dense marine water from the continental shelf pours into Prince William Sound and Port Valdez. This water is subsequently mixed with surface waters and ongoing inflow to provide for a hydraulic residence time for these deep waters of approximately 40 days.

During certain weather conditions, however, large volumes of surface water are introduced into Port Valdez from Prince William Sound, displacing much of the deeper waters of the fjord relatively quickly. Current measurements in the Valdez Narrows by Colonell (1980) suggest that residence times for deep waters during passage of weather systems could be reduced to a few days. Thus, climatological influence may be more important in promoting deep-water exchange than either tides or mixing with surface waters.

Hydrocarbons and trace metals were measured in the water column in Port Valdez between 1976 and 1978. Before VMT operation began, hydrocarbons included pristane, heptadecane, alkane chains, and squalene. In 1978, following initiation of ballast water treatment and disposal, samples from the area near the diffuser showed additional hydrocarbons, including xylenes, alkyl benzenes, naphthalenes, and phytane in addition to the pristane and alkanes previously documented. Total hydrocarbon concentration was in the range of 44 to 104 nanograms/gram. At sampling locations as close as 700 m to the discharge point, this array of hydrocarbons was undetectable, indicating a dilution of at least 100-fold (Colonell, 1980, p. 328).

Eight elements (aluminum, arsenic, chromium, cadmium, copper, mercury, nickel, and selenium) were surveyed in Port Valdez between 1976 and 1978. Researchers found concentrations of these elements to be typically in the normal range for clean systems. Exceptions were found in 1978, including aluminum and copper concentrations in ballast water treatment effluent from an unknown source (Gosink, 1980). Plant operations were modified to address aluminum discharges, while the occurrence of copper is considered an isolated event (Gosink, 1980). None of the trace elements mentioned is considered a pollutant of concern today. Regulatory requirements for wastewater discharges from the VMT do not include effluent limitations or water quality monitoring for these trace metals (EPA, 1997). No further water-quality data have been collected for comparison to pre-pipeline conditions, although various monitoring efforts have been designed and implemented to ensure that the most likely occurrences of water quality degradation are identified and resolved. See Section 4.2.2.2 for a discussion of monitoring efforts.



Source: After Muench and Nebert (1973)

Figure 3.1-14. *Vertical distribution of temperature (T), salinity (S), and density (σ) in Port Valdez.*

3.1.3 Atmospheric Environment

By E. Haas

TAPS spans all three major climate zones of Alaska: the Arctic Region north of the Brooks Range, the Subarctic Region south of the Brooks Range to the northern slope of the Alaska Range, and the climatically milder Maritime Region south of the Alaska Range including Prince William Sound and the Gulf of Alaska.

The climate recordings from six National Weather Service (NWS) stations were used to describe the three climatic regions. The following discussions include representative monthly average climatological data for these stations, including ambient temperature normals, precipitation, snowfall, number of clear days, and the average number of daylight hours (Figures 3.1-15 through 3.1-19). Wind roses for four stations and Prudhoe Bay are provided (Figure 3.1-20).

3.1.3.1 North of Brooks Range

Data from the Point Barrow NWS station approximately 200 miles west of Prudhoe Bay are representative of the region north of the Brooks Range. While far from Prudhoe Bay, Point Barrow is in the same climate zone, and because of the absence of physical terrain obstructions, the data from Barrow can be considered representative of Prudhoe. Meteorological data also have been collected at several monitoring sites in the North Slope exploration and production areas (SECOR, 1995). A wind-rose data summary was prepared from the data collected at the Prudhoe Bay Pad A station from 1987 to 1992 (Figure 3.1-20). A comparison of

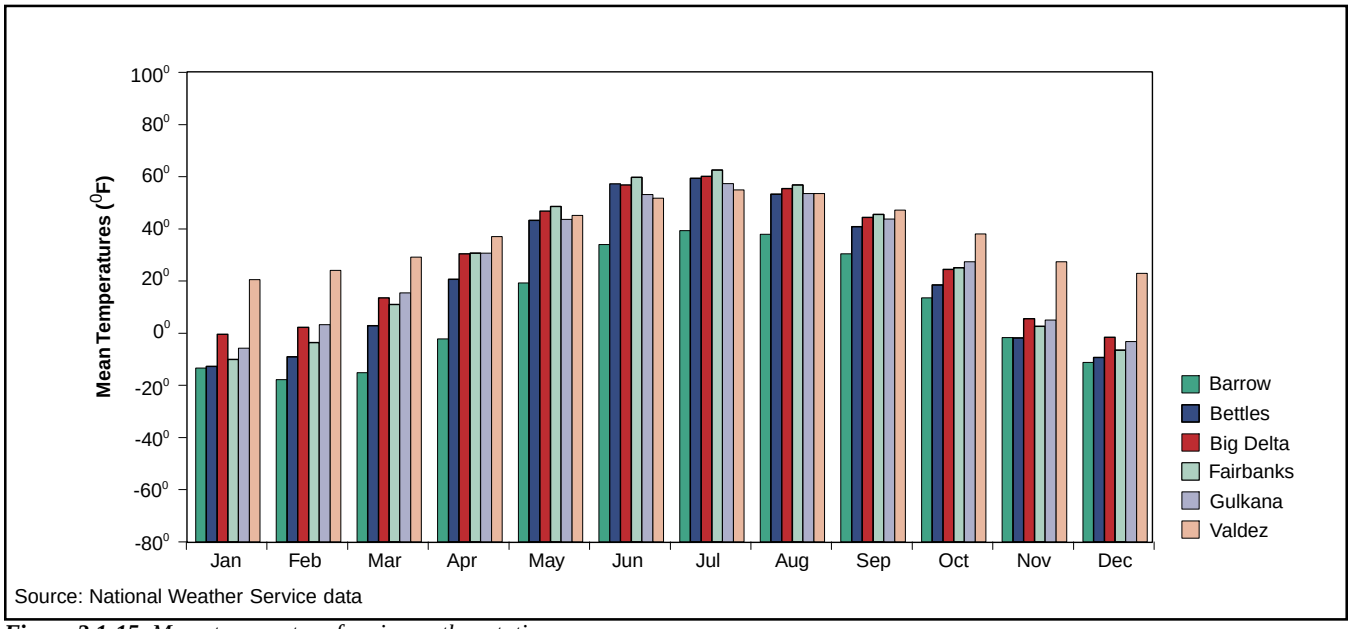


Figure 3.1-15. *Mean temperature for six weather stations.*

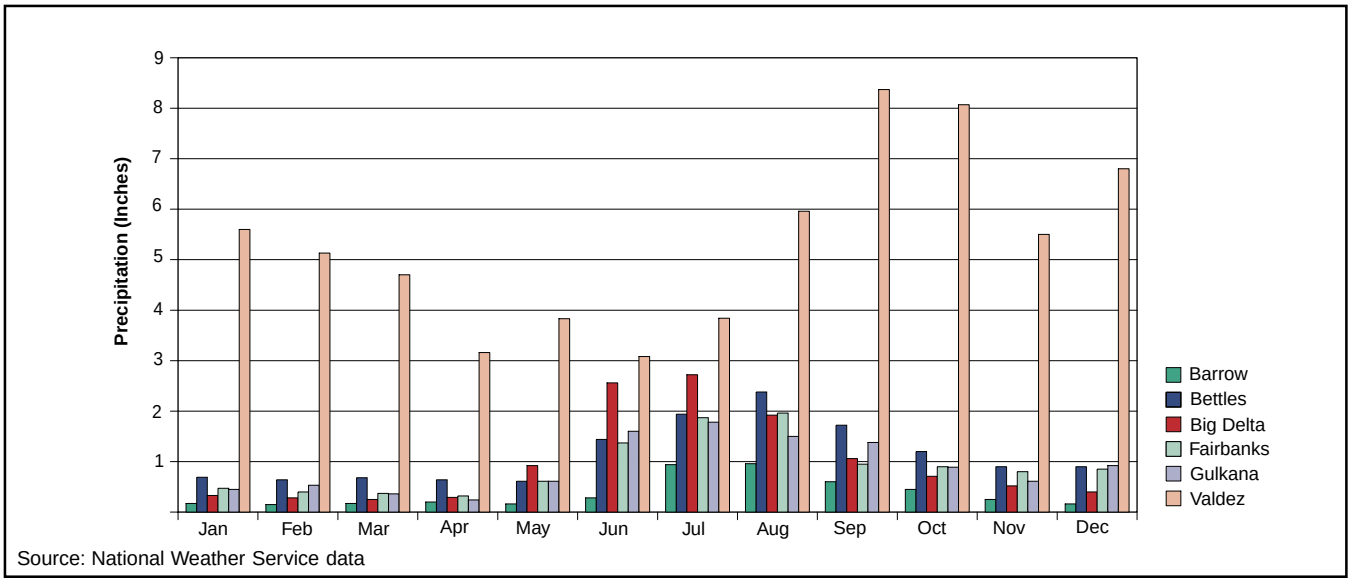


Figure 3.1-16. *Normal monthly accumulation of precipitation for six weather stations.*

the Prudhoe Bay and Barrow wind roses shows a strong similarity in wind speed and direction.

In winter, the Barrow station generally records one of the lowest mean temperatures for the state, even though the lowest temperatures do not occur there (WRRC, 1999). The Arctic Ocean to the north and level tundra stretching 100+ miles to the south create a persistent wind regime that reduces cooling by radiation and prevents cool air from pooling in low-lying areas. The temperatures in this region remain below freezing through most of the year, with the daily maximum reaching higher than 32°F only 109 days a year on average. Freezing temperatures have been observed every month of the year. January, February, and March are generally the coldest months. In April, temperatures begin to warm, and May is the transitional period from winter to summer. July and August are the warmest months, even though the possibility still exists that temperature lows may drop below freezing. During late July or early August, the Arctic Ocean is usually ice-free near shore. The end of the short summer is reached in September, and in November about half of the daily mean temperatures are zero or below. The variation of wind speeds during the year is small, with the fall months the windiest. Consequently, temperature inversions in the lower levels of the atmosphere are not

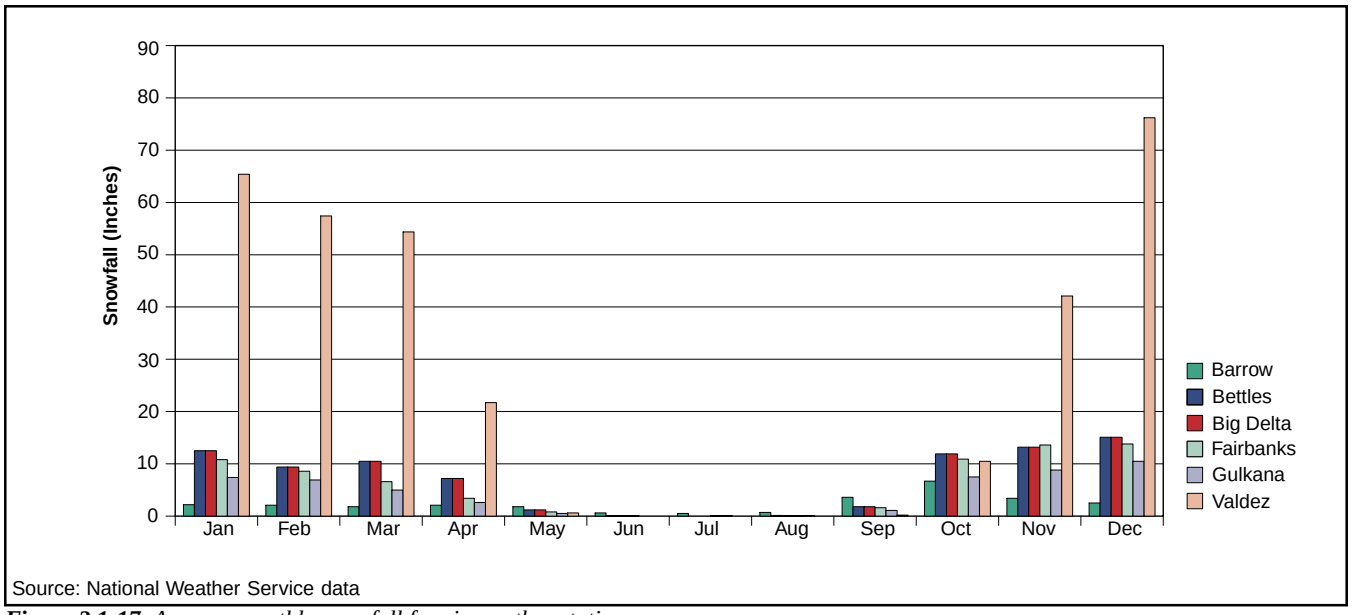


Figure 3.1-17. *Average monthly snowfall for six weather stations.*

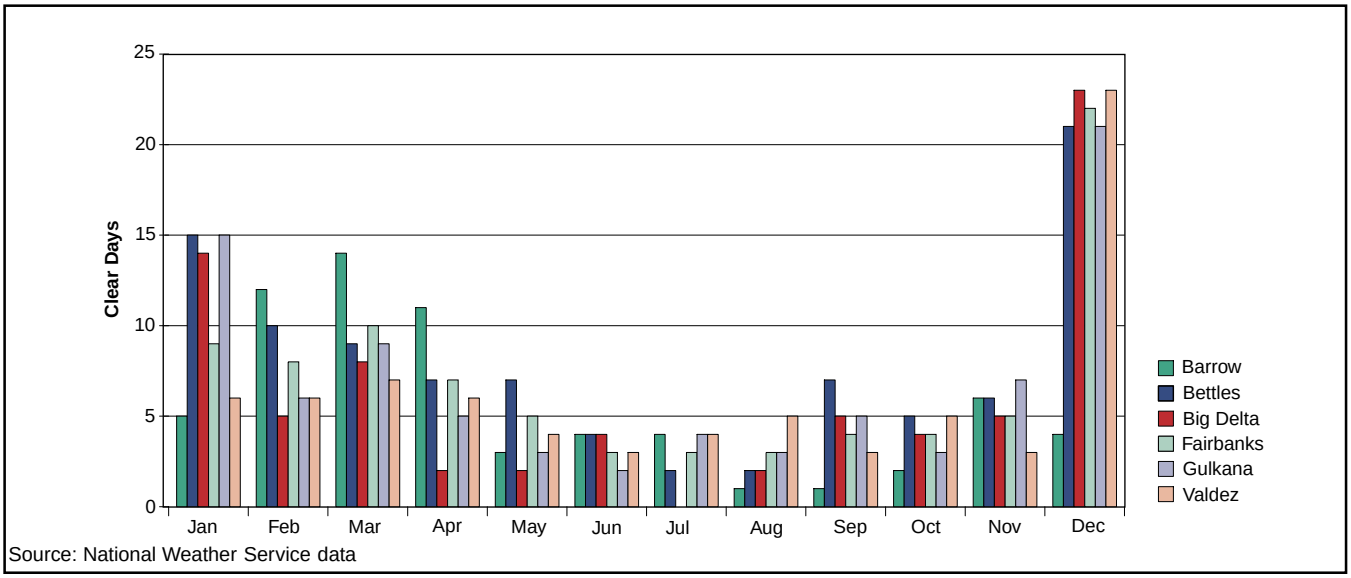


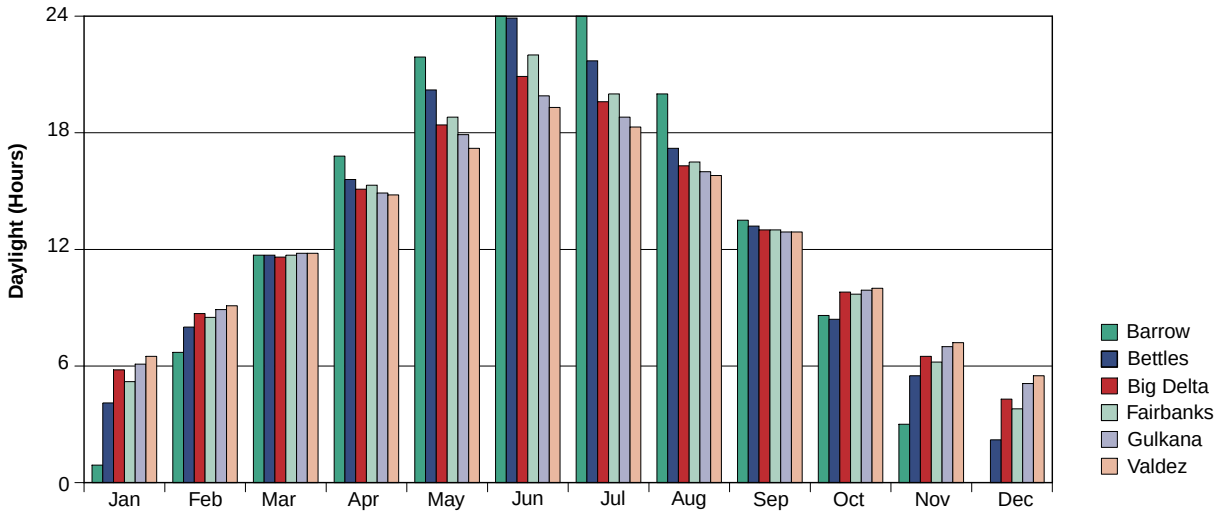
Figure 3.1-18. *Mean number of clear days for six weather stations.*

as marked as those observed at stations in the central Interior. All of the above effects reduce the likelihood of extreme winter lows; however, periodic high winds create extremely low wind chills.

At Barrow, the sun dips below the horizon at 12:50 p.m. on November 18 and does not reappear until January 24. By that time, the amount of daylight increases by at least 9 minutes per day until May 10, when daylight reaches 24 hours per day. The sun does not set from that time to August 2, when it again sets for 1 hour and 25 minutes. The decrease in hours of daylight is as rapid as the increase. The level of cloudiness, precipitation, and coastal fog tracks closely with the number of daylight hours. All three build to a maximum along with the hours of daylight. Maximum cloudiness continues into the fall. Since accurate cloud observations can be made only during daylight, records of cloudiness are not available for winter. The annual average precipitation is less than 8 inches [200 millimeters (mm)]. The layer of snow covering the tundra during the winter months is usually thin.

3.1.3.2 South of Brooks Range to North of Alaska Range

This region covering all of central Alaska can be best described with observations from the Bettles and Fairbanks



Source: National Weather Service data

Figure 3.1-19. *Average hours of daylight for six weather stations.*

stations. Bettles airport is located on the south side of the Koyukuk River and is one of four NWS stations north of the Arctic Circle. The climate in this zone is typical of a continental regime. Temperatures in this region during the long summer days are mild, with maximums mostly in the high 60s and low 70s, and occasionally in the 80s and even 90s for Fairbanks (WRRC, 1999).

In Bettles the sun does not set from June 2 to July 9. The freeze-free period averages 89 days, from May to late August. Minimum temperatures average below zero from November through March. The average January temperature is about -9°F, and lows can reach -60°F or colder. Cold winter temperatures are often amplified by terrain-induced temperature inversions in the lower atmosphere.

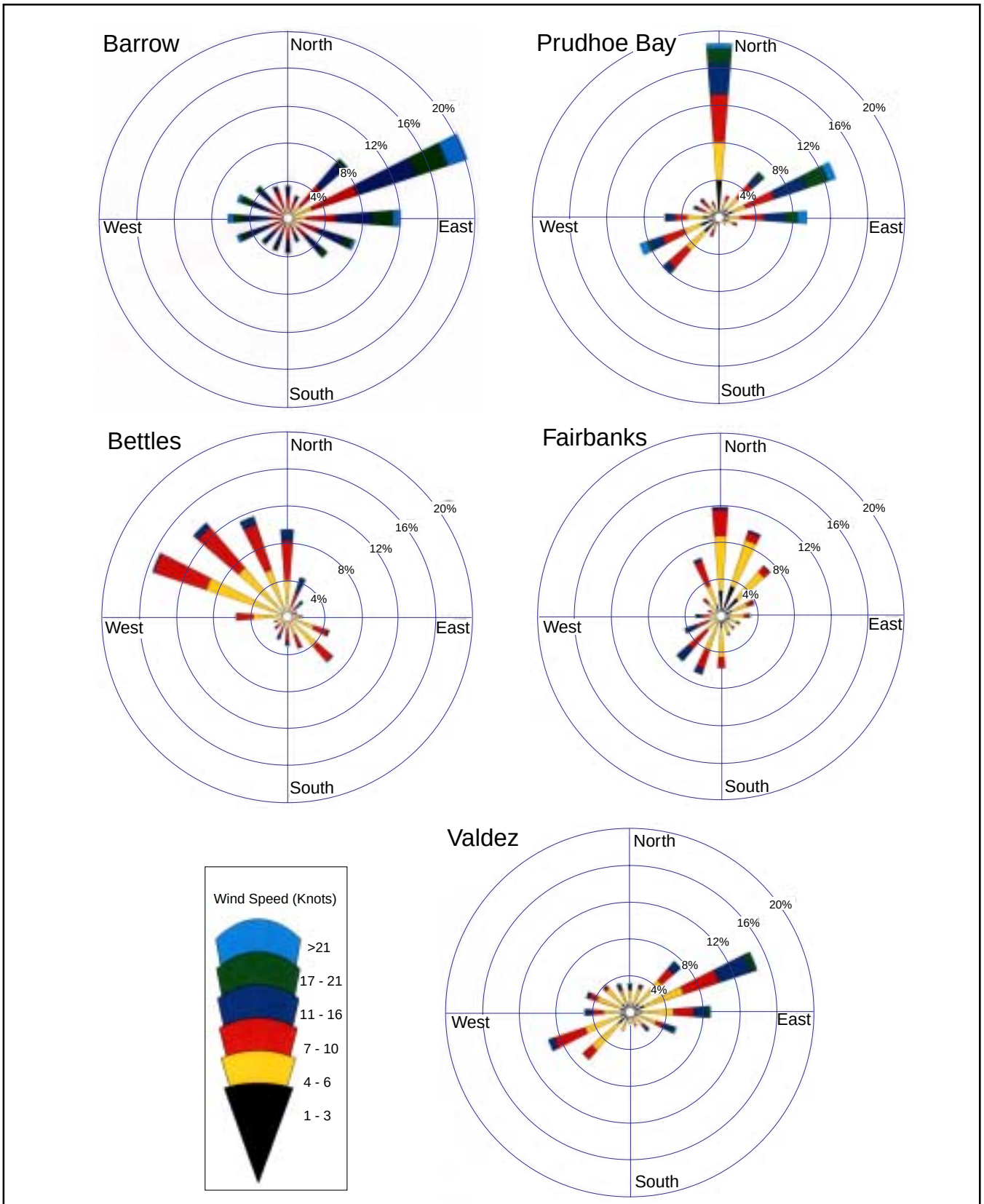
Fairbanks, located in the Tanana Valley, is surrounded by rolling hills reaching elevations up to 2,000 feet to the north and east of the city. Frequently during winter, a pool of cold air settles into the valley, while the uplands are often warmer by more than 10 degrees. Low-lying areas nearby, such as the community of North Pole, are often noticeably colder than Fairbanks. For most of the Interior, the transitions from summer to winter and vice versa are rapid, resulting in short spring and fall seasons. For Fairbanks the temperature range is larger in the winter, from about -65° to +45°F. This large range reflects the great difference between frigid weather associated with dry northerly air flow from the Arctic and mild temperatures associated with southerly air flow from the Gulf of Alaska, accompanied by chinook winds off the Alaska Range, 80 miles to the south.

Annual precipitation amounts in this region fall well within what is expected for a continental climate. They also follow the pattern of nearly all Alaskan stations, with precipitation amounts building up to a maximum during late summer and fall. The average annual precipitation is about 24 inches. During summer, thunderstorms are frequent but generally without damaging hail or winds. Snow has occurred during all months except July. The total seasonal snowfall has ranged from less than 40 inches to more than 130 inches. From October through April, the ground is covered with powdery snow that accumulates to depths of several feet. Snowfalls of 4 inches or more in a day are common; however, blizzard conditions are almost never seen.

Surface winds in this region are seldom strong during any season of the year, nor do they show much seasonal variation. Wind directions prevail from the north 10 months of the year. Winds in Fairbanks are above 20 miles an hour less than 1 percent of the time.

Water vapor generated by domestic combustion sources in urban areas frequently forms dense ice fog during winter at temperatures of -20°F or colder. In Fairbanks, cold snaps accompanied by ice fog generally last from about a week up to three weeks. The fog is usually about 300 feet deep, so that the surrounding uplands are usually in the clear, with warmer temperatures. Visibility in the ice fog is sometimes quite low, and this can hinder aircraft operations for as much as several days in severe cases.

Freezing of local rivers normally begins in the first week



Source: National Weather Service data, except Secor (1995) for Prudhoe Bay

Figure 3.1-20. *Windroses for five weather stations.*

of October. By the end of October, the ice will normally support a person's weight. Breakup of the river ice usually occurs in the first week of May. The growing season is very short and limited to the warm summer months. Hardy vegetables and grains can be grown mainly in the southern parts of this region.

3.1.3.3 South of the Alaska Range

The Alaska Range arches from the Lake Iliamna area northward through Denali National Park and Preserve, and then eastward to Tok and the Wrangell-St. Elias Mountains. Given the general wind pattern that brings moist maritime air from the Gulf of Alaska north toward the Interior, the Alaska Range creates a formidable climatic barrier. The coastal region south of the range includes the Panhandle and the coast of the Gulf of Alaska. This area is greatly affected by the relatively warm Japan Current and by the proximity of the Gulf of Alaska. Cloudy skies, successive wet days, dampness, fogginess, and occasional gale winds are typical. Annual precipitation is heavy in most of the area and varies from 20 inches at Cook Inlet to as much as 200+ inches at some areas in the Panhandle (WRRC, 1999). The abundant snowfall feeds the many glaciers. Summers are cool here, and winters, relatively mild.

NWS stations are located at Gulkana and Valdez. Gulkana is in the Copper River Basin approximately 150 air miles northeast of Anchorage and about 75 miles south of the Alaska Range. The Gulkana weather station represents nearly 100 miles of the pipeline in the Copper River drainage from the south slope of Isabel Pass in the Alaska Range to the foot of Thompson Pass in the Chugach Mountains. Even though Gulkana is south of the Alaska Range, its climate clearly cannot be classified as coastal. The mountains surrounding the Gulkana area capture a large portion of the moisture that might otherwise reach the valley, particularly from the Gulf of Alaska. Sixty inches or more are deposited each year on the windward slopes of the Chugach Mountains (WRRC, 1999). The average length of the growing season is 78 days. The heaviest precipitation occurs during the summer, and maximum cloudiness occurs during these months. Prevailing surface wind directions are from the southeast during spring, summer, and early fall, and from the north during late fall and winter.

The terrain surrounding Valdez exerts a pronounced influence on practically all aspects of the local weather and climate. The sheltering and channeling effects of the surrounding mountains produce two distinct wind regimes. From October through April, the prevailing direction is from the northeast, and from May through September the prevailing direction is from the southwest (WRRC, 1999). During winter, high pressure in the Interior and low pressure in the Gulf of Alaska occasionally cause east to north winds of about 100 knots to flow out of passes and river canyons. The high mountain ridges to the north provide a considerable barrier to the flow of cold continental air from the Interior, and temperatures rarely dip below zero. However, there is a definite offsetting factor with the downslope drainage of colder air from higher elevations, snowfields and glaciers on the southern slopes of these mountains. The coldest temperatures at Valdez appear to be related to this phenomenon. Valdez has average daily minimum temperatures below 15°F in December, January, and February (WRRC, 1999). The extreme minimum recorded between 1909 and 1967 was -28°F in February 1947. The nearby snowfields and icefields, combined with the ocean areas, provide a moderating effect on the summer high temperatures, which have seldom reached the middle 80s. Considerable variations occur in practically all weather elements within relatively short distances.

Precipitation is abundant in Valdez year-round, but builds up noticeably during late summer and fall. The heaviest precipitation usually occurs in September and October, when almost one-third of the total annual rainfall of 64 inches occurs. Snowfall during winter is very heavy, averaging about 250 inches a year. There is considerable cloudiness during the entire year. Cloudy conditions (eight-tenths cloud cover or more) occur between 60 and 70 percent of the time.

The growing season in Valdez averages slightly over 100 days, extending from May 26 to September 12. In addition, the glacial nature of the plain, the ruggedness of other surrounding terrain, and the cold water runoff from glacier melt tend to keep most available agricultural soil at temperatures too cool for desirable vegetation development during the growing season.

3.2 Biological Resources

This section describes the biological resources along the TAPS ROW. The ecosystem structure and vegetation of each ecoregion in the ROW are described, as well as the life history and population-level characteristics of the animals in those systems. For each region along TAPS, the distribution of the prominent plants and animals and the environmental factors that determine these patterns are detailed. Information describing the resources before TAPS construction and since TAPS activity started in 1978 is reviewed. The type and amount of information vary depending on species. Written information specific to the TAPS ROW has been augmented with authors' first-hand experience and interviews of people who have worked with the management and regulation of TAPS.

3.2.1 Special Areas, Special Management Zones, and Zones of Restricted Activity

By H. Whitlaw, R. Ritchie, and J. McKendrick

Special areas and special management zones include zones of restricted activity (ZRAs), areas of critical ecological concern (ACECs), long-term vegetation monitoring and restoration sites, existing and potential research sites, selected fish streams, and critical/sensitive wildlife habitats near TAPS (Table 3.2-1; ADF&G, 1986a, b; ADNR, 1986; APSC, 1993; BLM, 1987a, b, 1989, 1991; BLM and USACE, 1988; Zasada et al., 1981).

All fish streams and peregrine falcon use areas within the TAPS ROW are defined as ZRAs (APSC, 1993) based on Stipulation 2.5.3.1 of the Federal Agreement and Grant of Right-of-Way. In these areas, activities are restricted during all fish spawning and migration periods, and falcon breeding, nesting, and migration periods (BLM, 1987b).

ACECs were proposed in the federal Bureau of Land Management's (BLM's) *Utility Corridor Proposed Resource Management Plan and Final EIS* (BLM, 1989) and established with the management plan's record of decision (BLM, 1991). Non-implemented ACECs are shown as "potential" uses (Table 3.2-1). As with ZRAs, activities are restricted in ACECs to meet protection and management objectives for designated sensitive habitats (e.g., lambing areas, mineral licks, rare plants, nesting habitat, fish habitat, and migration routes).

Historical vegetation-monitoring sites have provided baseline ecological data (these sites are not currently being monitored). Revegetation/restoration sites are used to study the responses of vegetation to construction-related disturbances and oil spills.

Most special areas and special management zones along the TAPS ROW occur north of Fairbanks, primarily north of the Brooks Range. National parks, national wildlife refuges, national wild and scenic rivers, and state recreation areas are addressed in Section 3.3.6.

3.2.2 Vegetation and Wetlands

By D. Funk, J. McKendrick, T. Jorgenson, and J. Kidd

The TAPS ROW traverses a variety of ecological regions, ecosystems, and community types ranging from coastal arctic tundra to coastal Western Hemlock-Sitka Spruce forests along its 800-mile (1,288-km) length and from sea level to alpine tundra over a 1,444-m elevation change. This section describes the vegetation and wetland types crossed by the TAPS ROW. Descriptions are organized by ecoregions (Gallant et al., 1995) except that Interior forested lowlands and uplands, Interior highlands, and Interior bottomlands are grouped into a single "Interior Forests" ecoregion for simplicity (Figure 3.2-1). Within each ecoregion, the distribution of the dominant plant communities and the environmental factors that determine these patterns are described.

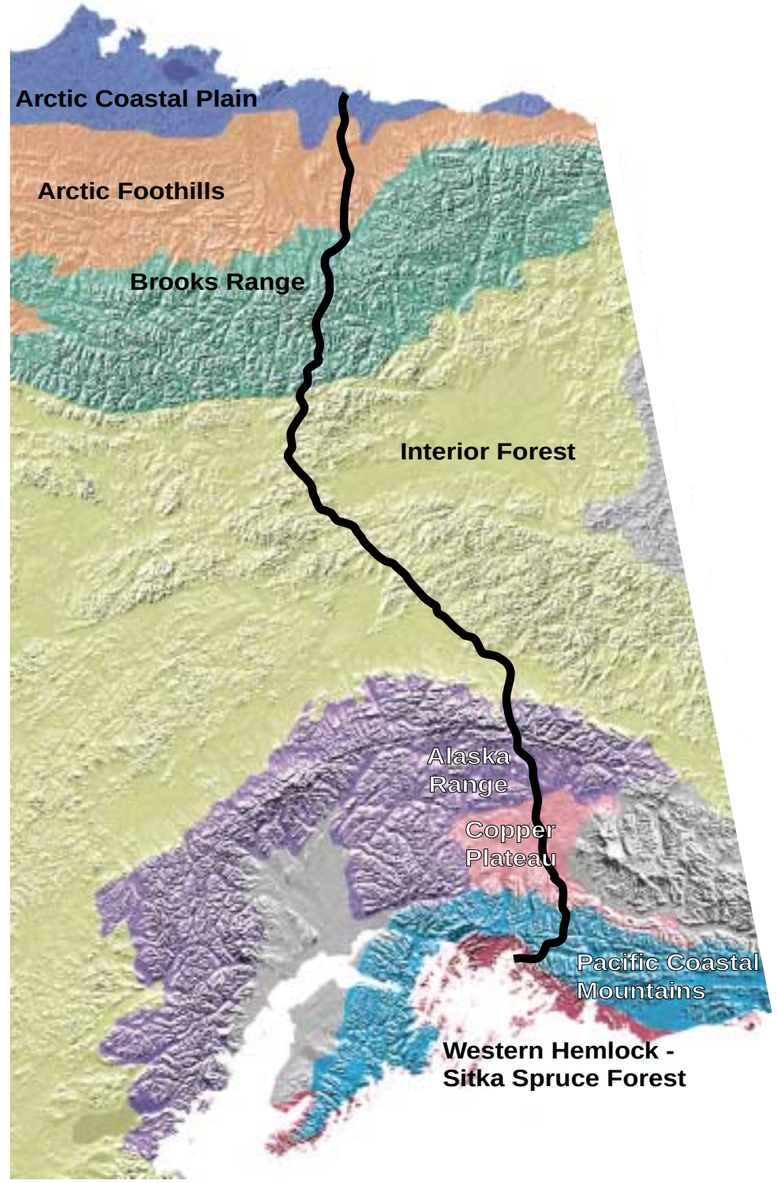
Vegetation types are classified as wetlands when the soil physical characteristics, hydrology, and dominant plant species composition (as described from the literature) meet the wetland criteria in the *Corps of Engineers Wetlands Delineation Manual* (USACE, 1987a). The status of the dominant species in each vegetation type was assessed us-

Arctic Coastal Plain: Nearly level plain underlain by continuous thick permafrost. Wet grass and sedge communities dominate. Dwarf scrub communities occur in drier sites where microtopography provides a deeper rooting zone.

Arctic Foothills: Ridges, mesas, and plateaus underlain by thick permafrost. Grass and sedge communities dominate with dwarf scrub on well-drained sites. Open low scrub communities along drainages.

Brooks Range: Steep rugged mountains mostly barren of vegetation and underlain by thick permafrost. Dwarf scrub communities on drier sites and grass and sedge communities on wet and moist sites in lower valleys.

Interior Forest: Rolling lowlands with plateaus and low to high hills, steep rounded ridges and flat to nearly flat bottomlands underlain by discontinuous permafrost. Needleleaf, broadleaf and mixed forest communities dominate with tall scrub communities, low scrub bogs, and scrub-graminoid communities in wettest areas.



Alaska Range: Steep rugged mountains and broad valleys underlain by discontinuous permafrost. Dwarf scrub communities on dry windswept sites, low scrub and tall scrub communities on moist to mesic sites. Needleleaf forests and woodlands in valleys and lower slopes.

Copper Plateau: Level to gently rolling plain with thin to moderately thick permafrost. Broadleaf forests, tall scrub communities and needleleaf forests on better drained sites. Low scrub bogs and wet graminoid communities in wettest areas.

Pacific Coastal Mountains: Steep rugged mountains with isolated masses of permafrost. Low and dwarf scrub communities where vegetation occurs. Needleleaf forests in some lower drainages.

Western Hemlock - Sitka Spruce Forest: Level to irregular terrain to steep foothills of coastal mountains. Needleleaf broadleaf and mixed forests with tall scrub swamps, low scrub bogs, and wet graminoid herbaceous communities and wet forb herbaceous communities in wet sites.

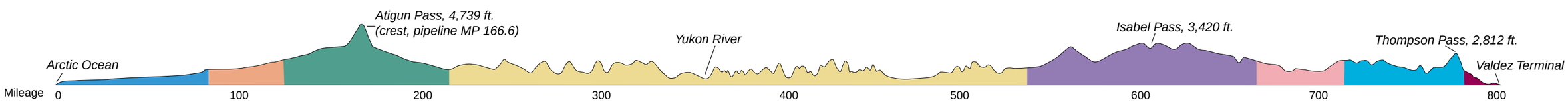


Figure 3.2-1.
Major vegetational zones along TAPS (adapted from Gallant et al., 1995).

Table 3.2-1. *Active and historical special areas, special management zones, and zones of restricted activity (APSC, 1993).*

	Special Areas and Management Zones	Description	TAPS Milepost	Map*
1	Franklin Bluffs Peregrine Falcon ZRA	Concentrated nesting habitat	15-36	1, 2
2	Sagwon Bluffs Peregrine Falcon ZRA	Concentrated nesting habitat	57-61, 59-68	3
3	Vegetation Monitoring Sites**	Long-term monitoring value due to the vegetation database on willows collected by Zasada et al. (1981)	90, 94	4
4	Vegetation Monitoring Site**	Long-term monitoring of vegetation recovery from 7/19/77 oil spill	26	2
5	Slope Mountain Peregrine Falcon ZRA	Concentrated nesting habitat	113-116	5
6	Vegetation Monitoring Site**	Long-term monitoring of vegetation recovery from 1/1/81 spill	115	5
7	Vegetation Monitoring Site**	Long-term monitoring of vegetation response to pipeline construction from a snow pad	120-124	5
8	Toolik Lake Research Natural Area	Research station	122-140	5
9	Galbraith Lake ACEC	Crucial lambing areas and mineral licks for Dall sheep; possible rare and sensitive plants	136-145	5, 6
10	Vegetation Monitoring Site**	Long-term monitoring value due to the vegetation database on willows collected by Zasada et al. (1981)	146	6
11	Revegetation/Restoration Monitoring Site	Long-term monitoring value for revegetation/restoration studies	157	6
12	Sten Creek Restoration	Long-term monitoring value for revegetation/restoration practices	164	6
13	Vegetation Monitoring Site**	Long-term monitoring of vegetation recovery from 6/10/79 spill	166	6
14	West Fork Atigun ACEC	Dall sheep lambing habitat and mineral licks	156-163	6
15	Snowden Mountain ACEC	Dall sheep habitat and mineral lick area	190-200	7
16	Sukakpak Mountain ACEC	Rare or sensitive plants may exist; long-term revegetation monitoring	207-211	7, 8
17	Nugget Creek ACEC	Dall sheep lambing habitat and mineral licks	216-221	8
18	Poss Mountain ACEC	Dall sheep habitat and mineral lick areas	217-219	8
19	Jim River ACEC	Chum and king salmon spawning areas; overwintering habitat for resident and anadromous fish species; raptor habitat	257-280	9, 10
20	Yukon River Peregrine Falcon ZRA	Concentrated nesting habitat for falcons and other raptors	350-355	12
21	Grapefruit Rocks Peregrine Falcon ZRA	Concentrated nesting habitat for Peregrine Falcons and other raptors	417-418	14
22	Vegetation Monitoring Site**	Long-term monitoring of vegetation response to pipeline construction from a snow pad	418	14
23	Vegetation Monitoring Site**	Long-term monitoring of vegetation recovery from 10/11/78 spill	432	15
24	Vegetation Monitoring Site**	Long-term monitoring of vegetation recovery from 2/15/87 sabotage-caused spill	458	15
25	Wildlife Protection	ADNR designation to protect wildlife	490-500	16, 17
26	Delta River (proposed)	Chum salmon spawning area	531-534	18
27	Sandhill Crane Migration Habitat	Potential BLM/DOD designation to protect Sandhill Crane migration habitat	543-559	18
28	Fish Creek	ADNR mineral withdrawal area to protect fish habitat and water supply to hatcheries in the vicinity	612-614	20
29	Mud Lake ACEC (potential)	BLM designation for additional protection of eagle, caribou, moose, bear, sensitive plant, and fish spawning habitat	615-623	20
30	State Fish Hatcheries	Fish Hatcheries No. 1 and 2	615, 618	20
31	Spring Creek	ADNR mineral withdrawal area to protect fish habitat	636-647	21
32	Trumpeter Swan Critical Habitat (potential)	ADNR designation for Trumpeter Swan critical habitat	642-668	21, 22

*TAPS Environmental Atlas (APSC, 1993).
**Most vegetation monitoring sites were established by the University of Alaska Fairbanks.

ing Reed's (1988) *The National List of Plant Species That Occur in Wetlands: Alaska (Region A)*. Table 3.2-2 lists vegetation types, species typical of each type, and the landforms with which types are usually associated. Type names follow Viereck et al.'s (1992) *Alaska Vegetation Classification*. Table 3.2-3 lists the taxonomic names of the plant species. Nomenclature follows Hultén (1968) for vascular plants and Vitt et al. (1988) for nonvascular plants.

3.2.2.1 Arctic Coastal Plain

The northernmost portion of the TAPS ROW lies in the Arctic Coastal Plain ecoregion (Figure 3.2-1). The entire Arctic Coastal Plain is underlain by thick permafrost that impedes drainage and creates saturated soils in most areas. Wetland plant communities of sedges, grasses, and mosses dominate this region. Where changes in relief occur, communities contain dwarf shrubs, cushion plants, lichens and graminoids that are adapted to the better-drained soils (Walker, 1985). Coastal plain soils are mostly fine-grained and extremely ice-rich (Brown, 1968; Brown and Sellman, 1973; Rawlinson, 1993; Shur and Jorgenson, 1998). Large- and small-scale permafrost-related landscape features are important in creating the relief that determines wet, moist, and dry tundra.

Geomorphic and fluvial processes are responsible for opening habitats for colonization and succession on the coastal plain (Billings, 1987). Wind-oriented thaw-lakes cover 20 to 50 percent of the land surface across the region (Gallant et al., 1995). These shallow thaw-lakes (typically 1 to 7 m in depth) follow a cyclic pattern of formation and drainage in response to the degradation and subsequent reforming of ice-rich permafrost (Britton, 1957; Carson and Hussey, 1961; Billings and Peterson, 1980). Following drainage, the wet basins are colonized within a few years by pioneer graminoid plant and moss species (Ovendon, 1986). Vegetation types that commonly establish in drained thaw-lake basins include Sedge-Willow Tundra, Wet Sedge-Herb Meadow Tundra, Wet Sedge Meadow Tundra, and Wet Sedge Grass Meadow Tundra. Wet Sedge-Grass Meadow communities often dominate young thaw-lake basins (Billings and Peterson, 1980; Bliss and Peterson, 1992). Through time, the floristic composition of the basins changes gradually to Wet Sedge Meadow Tundra communities that are typical of older basins (Billings and Peterson, 1980; Funk et al., 1991; Bliss and Peterson, 1992). Plant species composition and successional sequences vary depending on the volume of ice in underlying permafrost, age of the thaw lake when it drains (Billings and Peterson, 1980), and the basin substrate characteristics (Funk et al., 1991). Near the Sagavanirktok River, where the TAPS ROW is located, the deposition of alkaline loess (wind-blown silt) derived from the river channel tends to maintain plant species composition typical of early- and mid-successional communities when compared to more acidic areas (Walker, 1985; Walker and Everett, 1991).

Vegetation patterns are also influenced by microtopographic variation including strangmoor ridges, frost scars, the development of ice-wedge polygons, and naturally induced thermokarst (Peterson and Billings, 1978; Webber, 1978; Walker et al., 1980). These smaller-scale disturbances alter vegetation patterns and create complex plant-community structure (Walker, 1983). Ice wedges are particularly sensitive to disturbance because they form directly below the active layer, which has little capacity to adjust to changes in energy balance at the surface. Once disturbed, ice wedges easily melt, resulting in deep troughs and high-centered polygons (Lawson, 1986; Walker, Cate et al., 1987).

Wet tundra microsites are common, and many of the plant communities along the TAPS ROW in this ecoregion are classified as wetlands (Table 3.2-2). These sites primarily support Wet Sedge Meadow Tundra and Wet Sedge-Grass Meadow (Walker et al., 1980; Walker and Acevedo, 1987). Fresh Grass Marsh communities of pendant grass dominate sites with deeper water (up to 1 m). Moist microsites include polygon rims, tops of poorly developed high-centered polygons, low hummocks, strangmoor ridges, and well-drained terrain along streams. Moist sites drain soon after spring runoff and are dominated by Sedge-Willow Tundra and Sedge-*Dryas* Tundra. Dry sites occur on gravelly soils formed from stream deposits and on margins of old lake-basins and rivers. Soils on dry sites usually have thin to no organic surface horizon and support dwarf scrub communities, particularly Sedge-*Dryas* and *Dryas* Tundra (Walker, 1985).

On the Arctic Coastal Plain outside of the TAPS ROW, there are large gravel bars and sandbars (Bliss and Cantlon, 1957; Bliss and Peterson, 1992) and sand dunes (Peterson and Billings, 1978, 1980) along rivers. Active dunes are largely restricted to river margins (Tedrow and Brown, 1967) and coastal areas, but also occur on the leeward shores of some thaw-lakes (Walker, 1973) and support Dunegrass communities. Open and Closed Low Willow Shrub communities are found on active and inactive floodplains. Seral Herb communities are present in active floodplain sites, riverbanks, and eroding bluffs. Halophytic Sedge Wet Meadow and Halophytic Grass Wet Meadow communities dominate extensive areas of coastal salt marsh (Meyers, 1985; Noel and Funk, 1999). The vegetation of

Table 3.2-2. *Vegetation types and associated landforms found in each ecoregion crossed by the TAPS ROW. Vegetation types with an asterisk are also classified as wetlands.*

Ecoregion (1)	Landform, Landscape Position (2,3)	Vegetation Type (3)	Dominant Species
Arctic Coastal Plain	Active and inactive floodplains	Open and Closed Low Willow Shrub*	Richardson, Diamondleaf, and Grayleaf Willows, Alpine Milk Vetch, Dwarf Fireweed
	Low-centered polygons, nonpatterned ground	Open Low Willow-Sedge Shrub Tundra*	Diamondleaf Willow, Water Sedge, Arctic Sweet Coltsfoot, Polar Grass
	Active floodplain	Seral Herbs	Dwarf Fireweed, Wormwood, Dwarf Hawk's Beard, Northern Sweetvetch
	Low-centered polygon rims, high-centered polygons, pingos	Sedge-Dryas Tundra (4)	Water Sedge, Bigelow Sedge, Entire-leaf Mountain-avens, White Mountain-avens
	Active sand dunes	Dunegrass	Dunegrass, Dupontia, *Senecio pseudo-amica*
	Thaw lakes and ponds	Fresh Grass Marsh*	Arctic Pendant Grass, Water Sedge
	Drained thaw lakes, nonpatterned ground	Wet Sedge Meadow Tundra*	Tall Cottongrass, Water Sedge, Mosses
Arctic Foothills	Silty colluvium	Open Low Mesic Shrub Birch-Ericaceous Shrub*	Resin Birch, Bog Blueberrry, Mountain-Cranberry, Labroador Tea, Feathermoss
	Silty colluvium	Open Low Willow Shrub*	Richardson, Diamondleaf, and Grayleaf Willows, Alpine Milk Vetch, Dwarf Fireweed
	Alpine sandstone and till slopes and ridges	Dryas and Dryas-Lichen Dwarf	White Mountain-avens, Arctic Willow, Bog Blueberry, *Stereocaulon tomentosum*, Cladonia spp.
	Silt-capped valleys and gentle slopes	Tussock Tundra*	Tussock Cottongrass, Diamondleaf Willow, Bigelow Sedge
	Drained lake basins, valley depressions; lacustrine or fine-grained silts	Wet Sedge Meadow Tundra*	Tall Cottongrass, Water Sedge, Mosses
Brooks Range	Pond margins, streambanks; silt loam over gravel	Open Low Willow-Sedge Shrub Tundra*	Diamondleaf Willow, Water Sedge, Bigelow Sedge, Arctic Sweet Coltsfoot
	Alpine drainages and gelifluction lobes	Willow Dwarf Shrub Tundra	Least and Netleaf Willows, Crowberry Sedges, Lichens
	Flood plain terraces; silt loam over gravel	Open Low Alder-Willow Shrub*	American Green Alder, Diamondleaf Willow, Sedges, Mosses
	Till slopes and ridges	Dryas Dwarf Shrub Tundra	White Mountain-avens, Arctic Willow, Bog Blueberry, Bearberry
	Mid-slope; thin, stony soil	Dryas-Sedge Dwarf Shrub Tundra	White Mountain-avens, Northern Single-spike Sedge and other Sedges, Mosses and Lichens
	Rocky ridges and upper slopes	Ericaceous Dwarf Shrub Tundra	Alpine Bearberry, Mountain-Cranberry, Bog Blueberry, Bigelow Sedge, Alpine Azalea, Lichens
	Drained lake basins, valley depressions	Wet Sedge Meadow Tundra*	Tall Cottongrass, Water Sedge, Mosses
Interior Forests	Well-drained hillsides, treeline, young river terraces	Open and Closed White Spruce Forest	White Spruce, alder, Highbush Cranberry, Twinflower, Prickly Rose, Buffaloberry, Bluejoint, Horsetail
	Well-drained slopes of shallow bedrock, or poorly-drained silts on floodplain terraces or north-facing slopes	Open and Closed Black Spruce Forest (4)	Black Spruce, Resin Birch, Labrador Tea, Bush Cinquefoil, Mountain-Cranberry, Horsetail
	Near treeline or poorly-drained silts on floodplain terraces	Open and Closed Black Spruce-White Spruce Forest (4)	Black Spruce, White Spruce, Labrador Tea, Willows, Feathermosses
	Wet lowlands, shallow permafrost	Open Black Spruce-Tamarack Forest*	Black Spruce, Tamarack, Resin Birch, Labrador Tea, Mosses

(1) Gallant et al. (1995).
(2) Walker (1985).
(3) Viereck et al. (1992).
(4) Can be classified as upland or wetland, depending on soil and hydrologic conditions.

Table 3.2-2 (cont'd). *Vegetation types and associated landforms found in each ecoregion crossed by the TAPS ROW. Vegetation types with an asterisk are also classified as wetlands.*

Ecoregion (1)	Landform, Landscape Position (2,3)	Vegetation Type (3)	Dominant Species
Interior Forests (Cont'd)	Well-drained slopes of shallow bedrock or very poorly drained silts	Black Spruce Woodland*	Black Spruce, Cottongrass, Willows, Sphagnum moss
	Floodplain terraces	Closed Balsam Poplar Forest	Balsam Poplar, Thinleaf Alder, Willows, Prickly Rose
	Upland loess soils	Closed Paper Birch Forest	Paper Birch, Willows, Alder, Labrador Tea
	Well-drained slopes upland slopes, commonly south-facing	Closed Quaking Aspen Forest	Quaking Aspen, Highbush Cranberry, Twinflower
	Very poorly drained lowlands, shallow permafrost	Open Black Spruce Dwarf Tree Scrub*	Black Spruce, Labrador Tea, Tussock Cottongrass, Sphagnum Moss
	Active and young floodplains	Open and Closed Tall Willow Shrub (4)	Feltleaf, Grayleaf, Diamondleaf, Littletree Willows, Bluejoint, Dwarf Fireweed, Meadow Horsetail
	Upland drainageways, seepages	Open Tall Shrub Swamp*	Thinleaf, American Green Alders, Bluejoint
	Non-patterned wetlands with thick organic mat	Open Low Shrub Birch-Ericaceous Shrub Bog*	Resin Birch, Mountain-Cranberrry, Bog Blueberry, Labrador Tea, Sedges, Sphagnum Moss
	Poorly drained silty lowlands to well-drained upland slopes	Bluejoint (4)	Bluejoint
	Lake and pond margins, sloughs; silty or organic soils	Subarctic Lowland Sedge Wet Meadow	Water Sedge, *Carex saxatilis*, Meadow Horsetail
	Sloughs, oxbow lakes, lake margins, silty or organic soils	Fresh Herb Marsh	Swamp Horsetail, Bluckbean, Water Smartweed
Alaska Range	Treeline; inactive floodplains; silts over coarse gravels	Open White Spruce Forest	White Spruce, Alder, Highbush Cranberry, Twinflower, Prickly Rose, Buffaloberry, Bluejoint, Horsetail
	North-facing slopes at treeline	Open Black Spruce-Willow Shrub	Black Spruce, White Spruce, Labrador Tea, Willows, Feathermosses
	Steep to moderate slopes at treeline; silt loams	Open Tall Shrub Birch Willow Shrub	Resin Birch, Diamondleaf, Barratt, and Richardson Willows, Fescue Grass
	Moderately well drained slopes; stony silt loams	Open Mesic Shrub Birch-Ericaceous	Resin Birch, Labrador Tea, Mountain-Cranberry, Bog Blueberry, Crowberry, Fescue Grass
	Steep to moderate slopes at treeline, drainageways	Closed Tall Alder-Willow Shrub*	American Green Alder, Diamondleaf Willow, Sedges, Moss
	Alpine drainages and gelifluction lobes	Willow Dwarf Shrub Tundra	Least and Netleaf Willows, Crowberry, Sedges, Lichens
Copper Plateau	Inactive floodplains; silts over coarse gravels	Open White Spruce Forest	White Spruce, alder, Highbush Cranberry, Twinflower, Prickly Rose, Buffaloberry, Bluejoint, Horsetail
	Poorly-drained lowlands, shallow permafrost	Open Black Spruce Forest (4)	Black Spruce, Resin Birch, Labrador Tea, Bush Cinquefoil, Mountain-Cranberry, Horsetail
	Floodplain terraces	Closed Balsam Poplar Forest	Balsam Poplar, Thinleaf Alder, Willows, Prickly Rose
	Moderately to well-drained upland soils	Closed Paper Birch Forest	Paper Birch, Willows, Alder, Labrador Tea
	Poorly drained lowlands, shallow permafrost	Open Black Spruce Dwarf Tree Scrub*	Black Spruce, Labrador Tea, Tussock Cottongrass, Sphagnum Moss
	Seeps, streambanks; silts with interbedded organics	Close Tall Shrub Swamp*	Thinleaf Alder, Diamondleaf Willow, Water Sedge, Bluejoint
	Non-patterned wetlands with thick organic mat	Open Low Shrub Birch-Ericaceous Shrub Bog*	Resin Birch, Mountain-Cranberry, Bog Blueberry, Labrador Tea, Sedges, Sphagnum Moss

(1) Gallant et al. (1995).
(2) Walker (1985).
(3) Viereck et al. (1992).
(4) Can be classified as upland or wetland, depending on soil and hydrologic conditions.

Table 3.2-2 (cont'd). *Vegetation types and associated landforms found in each ecoregion crossed by the TAPS ROW. Vegetation types with an asterisk are also classified as wetlands.*

Ecoregion (1)	Landform, Landscape Position (2,3)	Vegetation Type (3)	Dominant Species
Copper Plateau (Cont'd)	Lake and pond margins, sloughs; silty or organic soils	Subarctic Lowland Sedge Wet Meadow*	Water Sedge, *Carex saxatilis*, Meadow Horsetail
	Sloughs, oxbow lakes, lake margins; silty or organic soils	Fresh Herb Marsh*	Swamp Horsetail, Buckbean, Water Smartweed
Pacific Coastal Mountains	Upper mountain slopes; shallow, poor to well drained soils	Closed Mountain Hemlock Forest (4)	Mountain Hemlock, Bog and Dwarf Blueberry, Lace Flower, Ferns
	Subalpine slopes, drainages, floodplains; moderately well-drained loams (often stony)	Closed Tall Alder Shrub (4)	American Green Alder, Diamondleaf and Grayleaf Willows, Fescue Grass, Polargrass
	Slope depressions, snowbed communities; thin, stony soils	Closed Low Ericaceous Shrub	Aleutian Mountain Heath, Starry Cassiope, Bog and Dwarf Blueberry
	Alpine slopes, snowbeds; thin, stony soils	Mountain-heath Dwarf Shrub Tundra	Mertens Cassiope, Aleutian Mountain Heath, Bog and Dwarf Blueberry, Crowberry
	Alpine slopes; commonly north-facing; thin, stony soils	Cassiope Dwarf Shrub Tundra	Meadow Horsetail, Variegated Scouring-rush, Yellow Marsh-marigold
	Seepage areas, pond and marsh margins; saturated or semi-permanently flooded silts or sands; shallow organic horizon	Subarctic Lowland Herb Wet Meadow*	Sitka Spruce, Sitka Alder, Bluejoint
Coastal Western Hemlock-Sitka Spruce Forests	Active alluvial fans and floodplains	Open Sitka Spruce Forest	Western Hemlock, Sitka Spruce, Devilsclub, Rusty Menziesia, Salmonberry
	Footslopes, benches, poorly drained soils with relatively thick organic surface layer	Open Western Hemlock - Sitka Spruce Forest	Black Spruce, Resin Birch, Labrador Tea, Bush Cinquefoil, Mountain-Cranberry, Horsetail
	Poorly-drained lowlands on shallow soils, permafrost is absent	Open Black Spruce Forest*	Black Cottonwood, Thinleaf Alder, Salmonberry, Tall Fireweed, Devilsclub
	Floodplains, thin silt loam overlying glacial outwash	Open Black Cottonwood4	Feltleaf, Grayleaf, Diamondleaf, and Littletree Willows, Bluejoint
	Active floodplains	Open and Closed Tall Willow Shrub (4)	Dwarf Fireweed, Meadow Horsetail

(1) Gallant et al. (1995).
(2) Walker (1985).
(3) Viereck et al. (1992).
(4) Can be classified as upland or wetland, depending on soil and hydrologic conditions.

the coastal plain has been thoroughly described in a number of documents including Tieszen (1978); Brown et al. (1980); Walker et al. (1980); Walker (1985); BLM and MMS (1998); USACE (1999, 1997, 1990, 1987, 1984, 1980); and others.

3.2.2.2 Arctic Foothills

The rolling hills and plateaus of the Arctic Foothills are similar to the Arctic Coastal Plain — treeless and underlain by thick permafrost. However, the foothills have more defined drainage patterns and fewer lakes. The most common vegetation type is Tussock Tundra, which dominates old glacial moraines. Dwarf shrub communities occur on the younger rocky moraine ridges, and willow and alder shrub communities occupy active floodplains and small drainages. Inactive floodplains in the region are covered with wet sedge meadows. Plant distribution is largely controlled by drainage patterns and the processes of weathering and deposition (frost creep, gelifluction, erosion, eolian deposition, ice aggradation and thermokarst), which alter surface characteristics in the landscape (Jorgenson, 1984).

In upland areas where ice-rich permafrost has formed in glacial till and colluvium, thermokarst and periglacial features are less common than on the Arctic Coastal Plain. Mass wasting of the gentle slopes is thought to reduce the microtopographic patterns caused by development of polygonal ice wedges (Kreig and Reger, 1982). Additionally, the well-integrated drainage network on the upland slopes creates water tracks from the movement of surface water and groundwater that is above the permafrost (Jorgenson, 1984; Walker, D.A. et al., 1989; Giblin et al., 1991). This

Table 3.2-3. *Scientific and common names of dominant plant species found along the TAPS ROW (taxonomy after Hultén, 1968).*

Common Name	Scientific Name	Common Name	Scientific Name
Alder	*Alnus spp.*	Lace flower	*Tiarella trifoliata*
Aleutian mountain heath	*Phyllodoce aleutica*	Least willows	*Salix rotundifolia*
Alpine azalea	*Azalea procumbens*	Littletree willow	*Salix arbusculoides*
Alpine bearberry	*Arctostaphylos alpina*	Lyngbye sedge	*Carex lyngbyaei*
Alpine foxtail	*Alopecurus alpinus*	Meadow horsetail	*Equisetum arvense*
Alpine milk vetch	*Astragalus alpinus*	Mertens cassiope	*Cassiope mertensiana*
American green alder	*Alnus crispa*	Mountain hemlock	*Tsuga mertensiana*
Arctic pendant grass	*Arctophila fulva*	Mountain-cranberry	*Vaccinium vitis-idaea*
Arctic sweet coltsfoot	*Petasites frigidus*	Netleaf willow	*Salix reticulata*
Arctic willow	*Salix arctica*	Northern single-spike sedge	*Carex scirpoidea*
Balsam poplar	*Populus balsamifera*	Northern sweetvetch	*Hedysarum alpinum*
Barratt willow	*Salix scouleriana*	Paper birch	*Betula papyrifera*
Bearberry, kinnikinnik	*Arctostaphylos uva-ursi*	Polar grass	*Arctagrostis latifolia*
Bigelow sedge	*Carex bigelowii*	Prickly rose	*Rosa acicularis*
Black cottonwood	*Populus trichocarpa*	Quaking aspen	*Populus tremuloides*
Black spruce	*Picea mariana*	Red fescue	*Festuca rubra*
Bluejoint	*Calamagrostis canadensis*	Resin birch	*Betula glandulosa*
Bog blueberry	*Vaccinium uliginosum*	Richardson willow	*Salix lanata*
Bog rosemary	*Andromeda polifolia*	Rusty menziesia	*Menziesia ferruginea*
Buckbean	*Menyanthes trifoliata*	Salmonberry	*Rubus spectabilis*
Buffaloberry	*Shepherdia canadensis*	Senecio pseudo-arnica	*Senecio pseudo-arnica*
Bush cinquefoil	*Potentilla fruiticosa*	Sitka alder	*Alnus sinuata*
Carex saxatilis	*Carex saxatilis*	Sitka spruce	*Picea sitchensis*
Cladonia spp.	*Cladonia spp.*	Sphagnum moss	*Sphagnum spp.*
Copperbush	*Cladothamnus pyrolaeflorus*	Starry cassiope	*Cassiope stelleriana*
Cow parsnip	*Heracleum lanatum*	Stereocaulon tomentosum	*Stereocaulon tomentosum*
Crowberry	*Empetrum nigrum*	Swamp horsetail	*Equisetum fluviatile*
Devilsclub	*Oplopanax horridus*	Sweetgale	*Myrica gale*
Diamondleaf willow	*Salix planifolia*	Tall Cottongrass	*Eriophorum angustifolium*
Dunegrass	*Elymus arenarius*	Tall fireweed	*Epilobium angustifolium*
Dupontia, tundra grass	*Dupontia fischeri*	Tamarack	*Larix laricina*
Dwarf blueberry	*Vaccinium caespitosum*	Thinleaf alder	*Alnus tenuifolia*
Dwarf dogwood	*Cornus canadensis*	Tussock cottongrass	*Eriophorum vaginatum*
Dwarf fireweed	*Epilobium latifolium*	Twinflower	*Linnaea borealis*
Dwarf hawk's beard	*Crepis nana*	Variegated scouring-rush	*Equisetum variegatum*
Entire-leaf mountain-avens	*Dryas integrifolia*	Water sedge	*Carex aquatilis*
Feltleaf willow	*Salix alexensis*	Water smartweed	*Polygonum amphibium*
Fescue grass	*Festuca altaicia*	Western hemlock	*Tsuga heterophylla*
Grayleaf willow	*Salix glauca*	White mountain-avens	*Dryas octopetala*
Highbush cranberry	*Viburnum edule*	White spruce	*Picea glauca*
Horsetail	*Equisetum spp.*	Wormwood	*Artemisia arctica*
Labrador tea	*Ledum groenlandicum*	Yellow marsh-marigold	*Caltha palustris*

drainage reduces the impoundment of surface water and decreases the potential for ice-wedge melting and thermokarst. The gravelly floodplain of the Sagavanirktok River has soils that are relatively thaw-stable and have little massive ice (Kreig and Reger, 1982).

Most soils are poorly drained, fine-textured silt loams and silty-clay loams (Brown, 1980). However, in areas where glacial till is at or near the surface, coarser rocky mineral substrates are present (Walker, M.D. et al., 1989). Poorly drained soils occur on gentle slopes of loess-covered glacial moraines and support Tussock Tundra (Walker et al., 1994). Moderately well-drained and well-drained gravelly soils occur on ridges and terraces adjacent to the major rivers (Brown, 1980). Either *Dryas*-Lichen or *Dryas* Tundra occurs in these drier, more exposed sites on the upper slopes and ridges (Walker et al., 1994). Along drainages and on active floodplains, Open Low Willow Shrub communities occur, and Wet Sedge Meadow Tundra dominates drained lake basins, valley depressions, and abandoned floodplains.

As on the Arctic Coastal Plain, wetlands dominate much of the terrain adjacent to the TAPS ROW in the Arctic Foothills. The valley bottoms and hill slopes have poorly drained organic silts or clay loam soils with organic horizons 5 to 40 centimeters (cm) thick (Walker, M.D. et al., 1989). In some habitats (usually on upper slopes), the silts overlay till and are thick enough to impede drainage and remain saturated. Upland soils can be found on south-facing sandstone outcrops and on exposed till. Wetland plant communities include Tussock Tundra, Open Low Mixed Shrub-Sedge Tussock Tundra, Open Low Mesic Shrub Birch Ericaceous Shrub, Open Low Willow Shrub, and Wet Sedge Meadow Tundra.

3.2.2.3 Brooks Range

The rugged, deeply dissected mountains of the Brooks Range support sparse vegetation cover because of the steep, easily eroded slopes; shallow soils; high winds; and arctic climate. Vegetation is generally limited to valleys and lower hillsides. There is little soil development on slopes, and valley soils are primarily developed from glacial till. Soils are usually gravelly and may be covered with silty colluvial and residual material from fine-grained sedimentary rocks. Thick permafrost creates shallow thaw depth and poor soil drainage, but the soils are generally thaw-stable (Kreig and Reger, 1982). Steep slopes and high moisture content in the active soil layer cause slope failures that expose large patches of bare rocks and soil (Brown and Kreig, 1983). Frost mounds and heaving, and river channel migration also influence vegetation patterns (Brown et al., 1983). Wildfires are common, ranging in size from less than 1 hectare (ha) to 109,265 ha, (Gabriel and Tande, 1983), and alter vegetation patterns on the south side of the Brooks Range.

Vaccinium and Bearberry Dwarf Shrub Tundra, *Dryas*-Sedge, and *Dryas* Dwarf Shrub Tundra are the most common plant communities (Table 3.2-2) on the upper slopes and ridges of the Brooks Range. Open Low Willow Sedge Shrub Tundra occupies pond margins and stream banks at higher elevations. Drained lake basins and valley depressions support Wet Sedge Meadow Tundra (Cooper, 1986). The TAPS ROW in this region is located primarily in floodplain and in forested valleys. Floodplains support Open Low Alder-Willow Shrub communities on river terraces where silt loams have formed over gravel. Forested sites are described more completely in Section 3.2.2.4.

Wetlands in the Brooks Range are confined to lower slopes where sufficient fine-grained sediments have accumulated along rivers and drainageways. The lowland soils have a relatively thick fibric to hemic organic horizon overlaying a mucky silt loam. Shallow permafrost in these soils restricts drainage. The riparian wetland soils are also poorly drained and typically include a thin organic horizon over a silty or sandy loam, with gravelly sand or coarse cobbles at depth (Rieger et al., 1979). Lowland sites support Wet Sedge Meadow Tundra and Open Low Willow-Sedge Shrub Tundra, while Open Low Alder-Willow Shrub communities dominate riparian wetlands (Cooper, 1986).

3.2.2.4 Interior Forests

The Interior Forests region crossed by the TAPS ROW is a mosaic of forest, grassland, shrubs, bog, and tundra types (Van Cleve et al., 1991). Local vegetation types form primarily in response to slope, aspect, elevation, parent material, and succession after wildfire (Viereck et al., 1986). The dry continental climate and low sun angle create sharp contrasts in the vegetation of north- and south-facing slopes. The presence or absence of permafrost is often correlated with site slope and aspect and is also important in determining vegetation distribution (Viereck et al., 1986). In lowlands, thermokarst features such as high-centered polygons, thaw lakes, and collapse-scar bogs and fens are common in the landscape (Drury, 1956; Racine et al., 1998; Jorgenson et al., 1999). The high ice content of lowland permafrost makes these areas particularly sensitive to disturbance. Fire (Viereck, 1973; Dyrness et al., 1986), climatic warming (Osterkamp et al., 1998; Osterkamp and Romanovsky, 1999), and human-caused disturbance can cause large changes in hydrology, soils, and vegetation.

In Interior Alaska, highly productive Closed Quaking Aspen Forest, Closed Paper Birch Forest, and Closed White Spruce Forest stands occupy south-facing, well-drained slopes (Viereck, 1979; Viereck, 1975). Treeline forests occur at about 750 m in elevation on surrounding hills and are composed of Open and Closed Black Spruce-White Spruce stands. Broadleaf Closed Balsam Poplar Forests and Quaking Aspen Forest dominate mid-successional communities leading to Open or Closed White Spruce Forests on river floodplains where permafrost is absent (Viereck et al., 1986; Adams and Viereck, 1992; Adams 1999). Black Spruce forests are found primarily on north-facing slopes and in wet lowlands where permafrost is near the surface (Viereck, 1975). The soils are saturated and composed of a moderately thick organic layer over a silt loam (Rieger et al., 1979). Open Black Spruce-Tamarack Forest also may occur in lowlands with a shallow active layer. Viereck et al. (1986) divide the forest sites into (1) cold, wet, black spruce sites usually underlain by permafrost and (2) mesic white spruce sites and successional stages leading to white spruce on warm, well-drained, permafrost-free soils.

Frequent fires maintain most forest stands in successional stages limiting mature and climax forest types (Dyrness et al., 1986). Wildfires are common and range in size from 1 ha to more than 300,000 ha (Gabriel and Tande, 1983). The fire season usually lasts from June through early August. Estimates of the natural fire cycle in Alaskan taiga range from 50 to 200 years (Heinselman, 1978; Yarie, 1981; Dyrness et al., 1986). Recently burned areas support early successional herbaceous forb communities dominated by fireweed. Graminoid communities dominated by bluejoint and willow scrub communities follow in succession. Broadleaf forests succeed the willow stage in uplands, on south-facing slopes, or on well-drained river terraces. However, paper birch stands succeed willow on east-, west- and some north-facing slopes and in flat areas. Mixed forest stands occur when spruce becomes established in the broadleaf stands. Forests dominated by spruce eventually replace the mixed stands on many sites (Viereck, 1975; Viereck et al., 1986; Adams and Viereck, 1997).

Open and Closed Black Spruce forests are the most dominant wetland types in the Interior Forests ecoregion along the TAPS ROW, although the floodplain of the Tanana River and smaller streams also support a variety of riparian shrub and graminoid-dominated wetlands (Table 3.2-2). Riparian shrub communities include Open and Closed Tall Willow Shrub and Open Tall Shrub Swamp. Old floodplain terraces with shallow permafrost are occupied by Black Spruce Woodland and several types of open low mesic shrub and bog communities composed of Resin Birch and ericaceous shrubs (Luken and Billings, 1983; Luken, 1984). Wetland graminoid communities include Subarctic Lowland Sedge and Sedge-Shrub Wet Meadows, Fresh Herb Marsh, and Bluejoint and Bluejoint-Herb meadows. Soils in these wet meadow and marsh communities range from very poorly drained histosols to poorly drained silt loams.

3.2.2.5 The Alaska Range

The Alaska Range consists of high, steep mountains separated by broad valleys. Rocky slopes, icefields, and glaciers cover most of the land surface in the region. Slope and aspect largely determine plant community distribution. The windswept upper hillsides and ridgetops have shallow, well-drained, gravelly soils that support alpine dwarf shrub communities. Protected slopes and drainageways support dwarf and tall shrubs, while lower slopes and valleys have open needleleaf forests and woodlands.

Wildfires in the region are infrequent and small (Gabriel and Tande, 1983), with most open habitat created by slope failures, avalanches, and river channel migration. The occurrence of thermokarst landscape features that influence vegetation patterns is limited because permafrost is generally restricted to relatively thaw-stable, coarse-grained alluvial fan, glacial till, glaciofluvial outwash, and thick loess deposits (Kreig and Reger, 1982).

Open Mesic Shrub Birch-Ericaceous Shrub communities occupy moderately drained slopes with stony silt loam soils. Willow Dwarf Shrub Tundra is typical of moist to mesic sites in alpine drainages and on gelifluction lobes. Open Tall Birch-Willow Shrub communities occur on silt loam soils of steep to moderate slopes at treeline. Closed Tall Alder-Willow Shrub communities occur at treeline on steep to moderate slopes, along streambanks, and in drainages. Needleleaf forests and woodlands in the Alaska Range are dominated by Open White Spruce Forest or Open Black Spruce-White Spruce Forest. Open White Spruce Forest occurs at treeline and on inactive floodplains, while Open Black Spruce-White Spruce Forest is generally restricted to treeline stands on north-facing slopes (Viereck et al., 1992).

Wetlands in the Alaska Range along the TAPS ROW are restricted primarily to valley bottoms and lower slopes, although patches of alpine wet meadows are also present. Soils are poorly drained, loamy colluvium over gravelly and stony glacial drift (Rieger et al., 1979). Predominant wetlands include Open and Closed Low Willow and Open Low Alder-Willow Shrub, Open Low Mixed Shrub-Sedge Tussock Tundra, and Mesic Sedge-Grass Meadow Tundra.

3.2.2.6 Copper Plateau

The Copper Plateau is a level to rolling plain in Southcentral Alaska that was the site of a large lake during glacial times (Gallant et al., 1995). Black Spruce Forests are the most common plant communities on the Copper Plateau and are interspersed with shrub-dominated wetlands. Permafrost is discontinuous, warm, and relatively ice-rich. Soils have formed primarily from the glacial deposits and lacustrine sediments that dominate the region (Péwé, 1975; Ferrians et al., 1969; Ferrians et al., 1989). Shallow permafrost creates poorly drained soils. Collapse-scar bogs and thaw lakes are common landscape features, forming in abandoned meltwater channels and depressions associated with glacial morainal deposits. Well-drained soils occur in uplands following wildfires or in gravelly deposits where permafrost is either deep or absent.

Open Black Spruce Forest is typical of poorly drained lowlands that have a shallow permafrost table. In wetter areas these communities give way to Open Black Spruce Dwarf Tree Scrub communities, which include *Sphagnum* moss species and tussock cottongrass. Wetlands also support Open Low Shrub Birch-Ericaceous Shrub bogs that form non-patterned wetlands and develop a thick organic mat. Mosses (particularly *Sphagnum* spp.) are abundant in these sites. Wet graminoid herbaceous communities including Subarctic Lowland Sedge Wet Meadow and Fresh Herb Marsh occupy sloughs, oxbow lakes, and lake and pond margins. Open White Spruce Forests are found on inactive floodplains where silts overlay coarse gravels. Floodplain terraces support Closed Balsam Poplar Forest stands, and moderately to well-drained upland soils support Closed Paper Birch Forest.

The distribution and types of wetlands in the Copper Plateau are comparable to those in the Interior Forests ecoregion, except the wetlands of the Copper Plateau have formed in soils from glacial deposits and lacustrine sediments, rather than from loess and alluvial deposits. Open Black Spruce Forest and woodland dwarf Black Spruce communities are the dominant wetlands along the TAPS ROW, although Open Low Mixed Shrub-Sedge Tussock Bog and Open Low Mesic Shrub Birch-Ericaceous Shrub communities also are common. Soils in these wetlands are poorly drained and frequently underlain by permafrost.

3.2.2.7 Pacific Coastal Mountains

Alpine barrens, glaciers, and icefields cover most of the Pacific Coastal Mountains in Southcentral Alaska. As in the Alaska Range and Interior Forests, aspect and slope influence the distribution of local plant communities. Soils have developed in gravelly glacial till and colluvium. Permafrost is limited to isolated patches in the lowlands, and there are few thermokarst features (Kreig and Reger, 1982). Alpine dwarf and low shrub communities are the most common vegetation types at higher elevations. Tall shrub and forest communities occur at lower elevations in valleys and drainageways.

Mountain-Heath Dwarf Shrub Tundra and Cassiope Dwarf Shrub Tundra occupy the thin, stony alpine soils. Heath communities develop on south-facing slopes and in snowbeds, while Cassiope communities are common on north-facing alpine slopes. Closed Low Ericaceous Shrub communities dominated by copperbush form dense thickets at lower elevations in sites where snowcover persists until late spring. Subalpine slopes, drainages, and floodplains with stony, moderately well-drained, loam soils support Closed Tall Alder Shrub communities. Closed Mountain Hemlock Forests from lower elevations colonize upper mesic sites in protected drainageways.

Wetlands in the Pacific Coastal Mountains are restricted to low mountain passes and valleys. Hydric soils are poorly drained and occur on slopes affected by seepage and drainages. Very poorly drained histosols develop in morainal depressions and outwash plains (Rieger et al., 1979). Wetlands in the seeps and drainageways include Open Tall Alder Shrub and Open Tall Alder-Willow Shrub. Subarctic Lowland Sedge-Shrub Wet Meadow and Subarctic Lowland Herb Wet Meadow wetlands occupy depressions.

3.2.2.8 Coastal Western Hemlock-Sitka Spruce Forests

Coastal Western Hemlock-Sitka Spruce Forests dominate a region of Southcentral and Southeast Alaska consisting of steep footslopes, alluvial fans, floodplains, outwash plains, scattered moraines, river terraces, and river deltas of the Pacific Coastal Mountains (Gallant et al., 1995). The relatively long growing season, high annual precipitation, and mild temperatures of this region support a variety of coastal forest, scrub, and wetland plant communities. Soils near the mountains have formed in gravelly and stony moraine deposits or in volcanic ash over moraine deposits. River delta soils, terraces, alluvial fans, and floodplains have formed in silts and clays subject to flooding and tidal inundation (Crow, 1977; Thilenius, 1995; Boggs, 1997).

Forests are the characteristic plant communities in the region and may be dominated by needleleaf species, broadleaf species, or a mixture of the two. Open Western Hemlock-Sitka Spruce Forest is the most common forest type

growing on footslopes, benches, and poorly drained soils with relatively thick organic surface layers. Mountain hemlock is also common in the northern coastal forests near Valdez (Cooper, 1942) and may dominate stands near treeline (Viereck et al., 1992). Open Sitka Spruce Forest is prevalent on active alluvial fans and floodplains in the region, while Open Black Spruce Forest dominates poorly-drained lowlands with shallow soils. Broadleaf stands of Open Black Cottonwood occupy floodplain sites where thin silt loam soils overlay glacial outwash.

Wetland plant communities along the TAPS ROW establish on hydric soils that have formed in glacial outwash and are rarely influenced by permafrost. These soils typically have a coarse base layer capped with a silt or silt loam of varying thickness (Rieger et al., 1979). In morainal or outwash plain depressions, histosols composed of a thick *Sphagnum* peat over a silty or sandy loam may be present. In glacial outwash areas, seasonal and persistent flooding, respectively, favor open and closed stands of Black Cottonwood forested wetlands, Open and Closed Tall Willow Shrub, and Open Tall Alder-Willow Shrub (Table 3.2-2). Gentle slopes and lowlands having saturated soils support Open Western Hemlock-Sitka Spruce Forest and Sitka Spruce Woodland, and Open Black Spruce and Open Low Shrub Ericaceous Shrub Bog, respectively. Bogs have the highest plant species diversity in the region and include Subarctic Lowland Sedge-Bog Meadow and Subarctic Sedge-Herb Wet Meadow community types.

The islands and mainland of PWS occur in this ecosystem. Crow (1977), Thilenius (1995), and Boggs (1997) have described coastal plant communities of Prince William Sound. In particular, Halophytic Sedge and Halophytic Grass Wet Meadow communities dominate in coastal areas.

3.2.3 Fish

By R. Fechhelm and L. Moulton

The primary sources used in compiling the following descriptions of fish habitat and usage along TAPS are ADF&G (1986a, b, c; 1999a, b, c); BLM (1987a, b); APSC (1993); and the Alyeska Fish Stream Database (APSC, n.d.), which includes information on fish species present in many of the streams along the ROW. Under Alaska Statute 16.05.870(a), ADF&G (1986a, b, c) defines “anadromous fish waterbodies” as those important for spawning, rearing, or migration of anadromous fishes. Anadromous fishes are those species that spawn in fresh water but spend part of their life cycle at sea. They include Arctic cisco, Bering cisco, least cisco, Dolly Varden, rainbow (steelhead) trout, chum salmon, chinook (king) salmon, pink salmon, and coho (silver) salmon

The official federal Authorized Officer’s list of key fish and wildlife areas along TAPS on federally administered lands is found in BLM (1987b). Sensitive habitat in BLM (1987b) is identified based on listings described in BLM (1987a), *Open File Report - TAPS Fish Streams*. This document classifies waterbodies along the pipeline route as either not sensitive, sensitive, or critically sensitive to fish species inhabiting those waterbodies during all or part of the year. These definitions were originally established by BLM based on an overview of the spawning, migration, and rearing activities of important fish species and assemblages along the pipeline route. This classification was also used in the *Environmental Atlas of the Trans Alaska Pipeline System* (APSC, 1993), Appendix C of this Environmental Report can be referred to for stream names and pipeline mileposts.

3.2.3.1 Arctic Slope Drainage

The Arctic Slope Drainage portion (MP 0 to 170) of the pipeline route consists primarily of the Sagavanirktok River and its side channels and tributaries (Figure 3.2-2). The pipeline crosses the headwaters of the Kuparuk River at MP 124 and 126. Thirteen species of fish (plus two incidentals) have been reported in the Sagavanirktok River drainage (Table 3.2-4), the most important of which are Dolly Varden, broad whitefish, Arctic cisco, and grayling. The presence of chum salmon, least cisco, and humpback whitefish is incidental, and these species do not represent large spawning stocks (Craig, 1984). Sport fishing is minimal and largely limited to oil field workers who fish for Dolly Varden and grayling. There is no subsistence or commercial fishery along the river itself. However, juvenile Arctic cisco that overwinter in the lower reaches and delta may eventually be recruited to the Colville River, where they join stocks harvested by both commercial and subsistence fisheries. Far-ranging adult Dolly Varden may also be taken in subsistence fisheries along the coast during summer (Craig, 1989a).

Pump Station 1 (MP 0) is adjacent to the Putuligayuk River, which is classified as an anadromous fish stream in its lower reaches because of the summer presence of Arctic cisco, broad whitefish, and least cisco. The pipeline ROW then parallels the Sagavanirktok River, crossing 48 of its side channels from MP 18 (Low Life Creek) to MP 93. The river and smaller channels are classified as anadromous fish habitat along this entire length primarily because of the presence of Dolly Varden. Side channels also contain

Figure 3.2-2. *Major drainages along the TAPS ROW.*

Table 3.2-4. *Fish species by major drainages along TAPS route.*

Order	Family	Species	Drainages		
			Arctic Slope	Yukon River	Copper River
Petromyzontiformes	Petromyzontidae	Arctic lamprey (*Lampetra japonica*)	No	Yes	No
Cypriniformes	Cyprinidae	Lake chub (*Couesius plumbeus*)	No	Yes	No
	Catostomidae	Longnose sucker (*Catostomus catostomus*)	Yes	Yes	Yes
Salmoniformes	Esocidae	Northern pike (*Esox lucius*)	No	Yes	No
	Umbridae	Alaska blackfish (*Dallia pectoralis*)	No	Yes	No
	Osmeridae	Pond smelt (*Hypomesus olidus*)	No	No	Yes
	Salmonidae	Arctic cisco (*Coregonus autumnalis*)*	Yes	No	No
		Arctic grayling (*Thymallus arcticus*)	Yes	Yes	Yes
		Bering cisco (*Coregonus laurettae*)*	No	Yes	No
		Broad whitefish (*Coregonus nasus*)	Yes	Yes	No
		Chinook (king) salmon (*Oncorhynchus tshawytscha*)*	Incidental	Yes	Yes
		Chum (dog) salmon (*Oncorhynchus keta*)*	Incidental	Yes	Yes
		Coho (silver) salmon (*Oncorhynchus kisutch*)*	No	Yes	Yes
		Dolly Varden** (*Salvelinus malma*)*	Yes	Yes	Yes
		Inconnu (*Stenodus leucichthys*)	No	Yes	No
		Humpback whitefish (*Coregonus pidschian*)	Yes	Yes	No
		Lake trout (*Salvelinus namaycush*)	Yes	No	Yes
		Lake whitefish (*Coregonus clupeaformis*)	No	No	Yes
		Least cisco (*Coregonus sardinella*)*	Yes	Yes	No
		Pygmy whitefish (*Prosopium coulteri*)	No	No	Yes
		Pink (humpback) salmon (*Oncorhynchus gorbuscha*)*	Yes	No	Yes
		Rainbow (steelhead) trout (*Oncorhynchus mykiss*)*	No	No	Yes
		Round whitefish (*Prosopium cylindraceum*)	Yes	Yes	Yes
		Sockeye (red) salmon (*Oncorhynchus nerka*)*	No	Yes	Yes
Gadiformes	Gadidae	Burbot (*Lota lota*)	Yes	Yes	Yes
Scorpaeniformes	Cottidae	Slimy sculpin (*Cottus cognatus*)	Yes	Yes	Yes
Gasterosteiformes	Gasterosteidae	Ninespine stickleback (*Pungitius pungitius*)	Yes	No	Yes

* Denote anadromous species.

**Fish of the genus *Salvelinus* caught in North Slope drainages and along the Beaufort Sea coast before the mid-1980s were identified as the western Arctic Bering Sea form of the Arctic char (*S. alpinus*). Morrow (1980) and Behnke (1980, 1984) contended that these fish are northern forms of Dolly Varden (*S. malma*), and current consensus conforms to this taxonomic designation. Thus, no Arctic char are listed along TAPS.

grayling, ninespine stickleback, round whitefish, and slimy sculpin and are considered sensitive during the May-to-October open-water season. The main channel is considered sensitive year-round since it may provide rearing and overwintering areas for all species. The main river is critically sensitive from May through June because of grayling spawning and from August through October because of Dolly Varden migration and spawning.

None of the streams or rivers from MP 93 to the Brooks Range (MP 170) is classified as anadromous fish habitat. TAPS crosses numerous tributary creeks from Spoiled Mary Creek (MP 75) to Oksrukuyik Creek (MP 103), all of which are classified as sensitive from May to October because they provide summer foraging habitat for a number of species including grayling and Dolly Varden. They are also critically sensitive in spring and fall because of grayling and Dolly Varden spawning. As in the lower reaches, the main channel of the Sagavanirktok River into which these tributaries empty is sensitive year-round and critically sensitive in spring (May-June) and fall (August-October).

Several creeks along the pipeline ROW from Thieles Trickle (MP 113) to Galbraith Lake Tributary (MP 138) support grayling and non-anadromous Dolly Varden during the sensitive summer period from May through October. TAPS crosses the East Fork of the Kuparuk River at MP 124 and the Kuparuk River at MP 126. The Kuparuk River

is an anadromous fish stream downstream but not in this area of the TAPS ROW. From MP 142 to 143, the pipeline crosses the Atigun River and several access streams to Tee Lake. These waters contain Dolly Varden, grayling, burbot, lake trout, slimy sculpin, and round whitefish and are critically sensitive throughout the summer from May to October. They also provide overwintering habitat and are sensitive from November through December.

All of the streams crossed by the pipeline from Vanish Creek (MP 145) through the Atigun River floodplain (MP 157-165) are sensitive during the open-water summer, providing habitat for Dolly Varden, grayling, burbot, slimy sculpin, and round whitefish.

Fish have been studied extensively outside of the TAPS ROW on the Arctic Coastal Plain. Fish populations of the Arctic Coastal Plain and nearshore region of the Beaufort Sea provide an important subsistence resource for local residents (Craig, 1989a) and support commercial and sport harvests (BLM and MMS, 1998; Howe et al., 1998). Fish populations near existing and planned developments, and the effects of the developments on fishes and fish habitat, have been extensively investigated since the mid-1970s (Furniss, 1975; Craig and McCart, 1975; Bendock, 1979a; Craig and Haldorson, 1981; Griffiths and Gallaway, 1982; Critchlow, 1983; Gallaway et al., 1983; Griffiths et al., 1983; Woodward-Clyde Consultants, 1983; Craig, 1984; Moulton et al., 1986; Envirosphere, 1987; Fechhelm and Fissel, 1988; Hemming, 1988-1996; Hemming et al., 1989; Fechhelm and Griffiths, 1990; Fechhelm et al., 1989, 1992, 1999; LGL, 1990-1996). Summaries of these studies are included in recent reviews and EIS documents, including USACE (1980, 1984), ARCO Alaska et al. (1996), BLM and MMS (1998), and Truett and Johnson (2000).

Important fish species in the Arctic Coastal Plain and nearshore Beaufort Sea include Arctic grayling, Dolly Varden char, Arctic cisco, least cisco, and broad whitefish. Arctic grayling are a freshwater species, while the others can include both anadromous and freshwater populations. The following species descriptions are from Gallaway and Fechhelm (2000) and Moulton and George (2000).

Arctic grayling is the second most widespread freshwater fish, after ninespine stickleback, on the coastal plain, occurring in both stream systems and lakes (Moulton and George, 2000). Grayling typically spend the winters in deep areas in larger rivers such as the Colville, Kuparuk, Sagavanirktok, and Canning. During or after spring breakup, adult grayling move into tributary streams for spawning. Streams with sand or gravel substrates seem to be most heavily used. After spawning, adults disperse to summer feeding areas. Grayling embryos hatch after approximately three weeks. Young-of-the-year (age 0) grayling feed in the tributary streams until late summer, then move into the main river for wintering. Juveniles, which do not participate in the spawning migrations, move in spring from wintering areas into small streams, lakes, or shallow areas in the main river to find suitable feeding areas.

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Photo 3.2-1. *Arctic grayling.*

Dolly Varden char spawn in many of the mountain streams emptying into the Beaufort Sea between and including the Colville and Mackenzie rivers (Craig and McCart, 1974, 1975; Smith and Glesne, 1982; Craig, 1977a, b; Daum et al., 1984; Craig, 1984; Everett and Wilmot, 1987). This species is not found in coastal plain streams west of the Colville, possibly because these drainages lack perennial springs (Craig, 1984). The Sagavanirktok River is thought to contain the largest Dolly Varden population(s) on the North Slope (McCart et al., 1972). Juveniles remain in their natal streams for several years before their first seaward migration (Craig, 1977a, b; 1989b).

Dolly Varden char are powerful swimmers that migrate considerable distances along the coast during the summer. Although spawners are believed to maintain fidelity to their natal streams, non-spawners may overwinter in non-natal drainages (Glova and McCart, 1974; Craig, 1977a; DeCicco, 1985, 1990, 1992, 1997). The transitory nature of Dolly Varden in the nearshore zone during the open-water season confounds population estimates based on local catch rates or mark/recapture studies (Gallaway and Fechhelm, 2000).

Nearly all summer studies conducted in the nearshore zone report collecting substantial numbers of large Arctic cisco (Craig and Mann, 1974; Griffiths et al., 1975, 1977; West and Wiswar, 1985; Wiswar and West, 1987; Griffiths, 1983; Fruge et al., 1989; Underwood et al., 1995). Arctic cisco found in the Alaskan Beaufort Sea are believed to originate from spawning grounds in the Mackenzie River system of Canada (Gallaway et al., 1983, 1989). In spring, newly hatched young-of-the-year (age 0) are flushed downriver into ice-free coastal waters adjacent to the Mackenzie Delta. Some young-of-the-year are transported westward to Alaska by wind-driven coastal currents (Gallaway et al., 1983; Fechhelm and Fissel, 1988; Moulton, 1989; Fechhelm and Griffiths, 1990; Schmidt et al., 1991; Underwood et al., 1995; Colonell and Gallaway,

1997). In summers with strong and persistent east winds, enhanced westward transport can carry fish to Alaska's Colville River, where they take up winter residence. They remain in the Colville River until the onset of sexual maturity at about age 7, at which point they migrate back to the Mackenzie River to spawn (Gallaway et al., 1983).

The meteorologically driven recruitment process plays a major role in determining the age structure of Arctic cisco populations in Alaska. Summers of strong, persistent east winds are associated with strong year classes in the Colville/Sagavanirktok region (Cannon et al., 1987a; Moulton, 1989; Glass et al., 1990; Reub et al., 1991; LGL, 1992, 1994a; Griffiths et al., 1996). These year classes maintain a presence in the region that can be tracked as fish grow to ages harvested by the commercial and subsistence fisheries operating in the Colville River (Moulton et al., 1992, 1993; Moulton and Field, 1988, 1991, 1994; Moulton, 1994, 1995).

Least cisco have both migratory and freshwater resident populations on the Arctic Coastal Plain. The diadromous least cisco has a discontinuous distribution in the coastal Beaufort Sea (Craig and McCart, 1975; Craig, 1984, 1989b). Western populations are associated with the Colville River and smaller tundra rivers to the west, whereas eastern populations are associated mainly with the Mackenzie River. The vast distance between these freshwater systems apparently isolates the migratory populations from each other.

Little is known about westward dispersal of Colville River least cisco during summer, but adult fish that disperse eastward are known to travel considerable distances down the coast. Substantial numbers of large least cisco are typically collected in the Prudhoe Bay/Sagavanirktok Delta region. High abundance has also been reported for studies in Foggy Island Bay (Cannon et al., 1987a; Glass et al., 1990) and as far as Mikkelsen Bay (Fechhelm et al., 1996), about 120 km east of the Colville River. Relatively few large least cisco reach Camden Bay, located some 200 km east of the Colville River (Underwood et al., 1995).

The eastward dispersal of juvenile least cisco during summer appears to be a function of wind-driven coastal currents (Fechhelm et al., 1994). West winds in early summer (primarily July) create easterly flowing currents in Simpson Lagoon that enhance the eastward dispersal of small fish. In summers of substantial west winds (about one year out of every two), large numbers of juvenile least cisco are collected in the Prudhoe Bay/Sagavanirktok Delta region (Griffiths et al., 1983; Moulton et al., 1986; LGL, 1992, 1993). In years lacking substantial July west-wind events, few small least cisco reach the east end of Simpson Lagoon (Cannon et al., 1987a; Glass et al., 1990; Reub et al., 1991; Fechhelm et al., 1994; LGL, 1994b; Griffiths et al., 1995).

As with least cisco, the diadromous broad whitefish has two population centers in the Beaufort Sea region — the Colville River and westward, and the Mackenzie River drainage. Unlike the situation with least cisco and Arctic cisco, however, the Sagavanirktok River supports a spawning and overwintering population of broad whitefish.

Of the four dominant diadromous species, broad whitefish are the most restricted in terms of their summer dispersal from overwintering rivers. Young fish (age 2 and younger) from the Sagavanirktok River population tend to remain near the low-salinity waters of the delta for much of the open-water season (Gallaway and Fechhelm, 2000). There has been speculation that salinity intolerance may be the reason for this limited summer distribution. Older broad whitefish (age 3 and older) disperse farther from their natal rivers (Gallaway and Fechhelm, 2000), regularly moving between the Sagavanirktok and Colville rivers (Moulton et al., 1986; Cannon et al., 1987b; Moulton and Field, 1994) through Simpson Lagoon. Broad whitefish catches reported for the eastern Alaskan Beaufort Sea have been nominal to nil (Griffiths, 1983; West and Wiswar, 1985; Wiswar and West, 1987; Fruge et al., 1989; Underwood et al., 1995).

Broad whitefish use a variety of habitats through their life cycle. Spawning occurs in deep portions of large rivers in fall. In the Mackenzie River, they spawn in the lower river just upstream of the marine influence. The anadromous population in the Colville appears to show a similar pattern, with spawning in the main river upstream of the delta. Bendock and Burr (1986) identified a pre-spawning migration in August, but did not know if the fish were freshwater residents or part of the anadromous population. Lake-spawning populations have not been identified.

During the spring flood, age-0 and juvenile broad whitefish enter a variety of available habitats, including seasonally flooded lakes, lakes connected to stream systems, river channels, and coastal areas. Fish using perched lakes remain in the lake until they reach maturity, then return to the river in the spring of the year they will spawn. Broad whitefish that do not enter perched lakes either enter the coastal region and adjacent small drainages to feed — thus assuming an anadromous pattern — or remain in the river system and feed in low-velocity channels, tapped lakes, or drainage lakes. In fall, they leave the shallow feeding areas and return to deep wintering areas in the main river or lakes. Maturity is first reached at age 9, with most maturing at age 10 to 12 (Bendock and Burr, 1984, 1986).

3.2.3.2 Yukon Drainage

Nineteen species of fish are found in the Yukon Drainage (MP 170 to 605); of these, grayling, Dolly Varden, and chum, coho, and chinook salmon are important along TAPS (Table 3.2-4). Other common species include whitefishes, slimy sculpin, longnose sucker, northern pike, and burbot.

Commercial and subsistence fishing in the Yukon drainage is primarily for chinook, chum, and coho salmon. Along the pipeline, the heaviest fishing occurs in the Yukon River main stem and around Fairbanks. Sport fishing north of the Yukon River is largely restricted to lakes and streams accessible from the Dalton Highway (ADF&G, 1986b). Sport fishing effort is relatively light because of the region's isolation. Grayling is the most heavily harvested species, and small numbers of whitefish, lake trout, and burbot are also taken. South of the Yukon River, the area around Fairbanks supports one of the largest sport fisheries in the state, with grayling accounting for over 50 percent of the take. Additional species taken include northern pike, whitefish, burbot, lake trout, Dolly Varden, and chinook, chum, and coho salmon (ADF&G, 1986b). Some of the heaviest sport fishing occurs in the Chena, Salcha, and Delta rivers.

Grayling, slimy sculpin, and possibly Dolly Varden use the North Fork of the Chandalar River (MP 170-173), which is the first drainage crossed by the pipeline on the south slopes of the Brooks Range. It is sensitive during summer open water from May through October and critically sensitive in spring and fall because of grayling and possibly Dolly Varden spawning.

South from the Brooks Range, the pipeline follows the course of the Dietrich River and the Middle Fork of the Koyukuk River from MP 175 to 247. The Dietrich River drainage is inhabited by Dolly Varden, grayling, burbot, round whitefish, longnose sucker, and slimy sculpin. Known overwintering areas occur intermittently along the Dietrich River from MP 179 to 193 and are critically sensitive year round. The river's tributaries are sensitive habitat during open water (May-October). Although none of the water bodies within the Dietrich River system is classified as anadromous, discharge flows into the Middle Fork of the Koyukuk River, which is anadromous. The Middle Fork of the Koyukuk and several of its tributaries from MP 205 to 247 support stocks of Dolly Varden, chum and chinook salmon, grayling, and other species. The river is critically sensitive rearing habitat year-round, and most remaining tributaries and sloughs are sensitive from April through October. The pipeline crosses the mouths of two major anadromous-fish tributaries — Hammond River (MP 222) and Slade Creek (MP 238), which are sensitive during the open water period.

South of MP 247, the pipeline crosses several streams that provide habitat for chum and chinook salmon, including the South Fork of the Koyukuk River (MP 256), Jim River (MP 268, 271), Douglas Creek (MP 270), Prospect Creek (MP 277), Yukon River (MP 353), Minnie Creek (MP 226), and Marion Creek (MP 233). These streams are critically sensitive all year. Other non-anadromous streams that support grayling and numerous minor species are sensitive from April through October. Although no anadromous fish streams exist between Prospect Creek and the Yukon River, Bonanza Creek (MP 284, 286) and Fish Creek (MP 295) empty into the South Fork of the Koyukuk River, which is anadromous. The Kanuti River (MP 303) provides anadromous-fish habitat near its mouth.

There are no anadromous fish streams along the 185 miles (296 km) of TAPS between the Yukon and Chatanika (MP 438) rivers. Most streams in this region support grayling and numerous other species including whitefishes, slimy sculpin, longnose sucker, northern pike, and burbot. These water bodies are sensitive from May through October. The Tolovana River (MP 399) supports anadromous fish about 25 miles (40 km) downstream of TAPS (APSC, 1993).

From the Chatanika to Tanana rivers, the pipeline crosses several major anadromous streams including the Chatanika River (MP 438), Chena River (MP 460), Little Salcha River (MP 491), Salcha River (MP 496), Redmond Creek (MP 500), Shaw Creek (MP 520), and the Tanana River (MP 531). This region contains some of the most productive salmon spawning and rearing grounds in Interior Alaska and supports extensive commercial and subsistence fisheries. A major chum-salmon spawning area is located just downstream of the MP 531 crossing at the confluence of the Tanana and Delta rivers. The Chatanika, Chena, Salcha, and Tanana rivers and Shaw Creek provide critically sensitive year-round habitat for salmon and whitefish. Washington Creek (MP 432), Moose Creek (MP 471-473), and the Little Salcha River provide critically sensitive overwintering habitat from November through April, and sensitive habitat the rest of the year.

No anadromous fish streams are found between the Tanana River (MP 531) and Sable Pass (MP 605). Most of the creeks crossed by the pipeline ROW empty into the Delta River, which supports anadromous fish near its confluence with the Tanana River. The Delta River provides sensitive habitat for grayling and whitefish from May through October, and there is a year-round sensitive area at MP 592. The only stream emptying into the Delta River with sensitive habitat is Phelan Creek; perennial springs

provide year-round habitat for grayling and whitefish. Both the Delta River and Phelan Creek are considered critically sensitive during spring and fall.

3.2.3.3 Copper River Drainage

Seventeen species of fish are found within the Copper River Drainage portion (MP 606 to 800) of the pipeline ROW (Table 3.2-4). Although all five species of salmon are found in the drainage, sockeye and coho salmon are the most dominant species; chinook salmon comprise relatively small runs, and pink and chum salmon runs are very small (ADF&G, 1986c). The Copper River is the major producer of sockeye salmon in the Prince William Sound region. Many sockeye and coho salmon spawn in the lower portion of the Copper River drainage, below the point where the Copper River and TAPS diverge. Other important species include grayling, Dolly Varden, rainbow (steelhead) trout, whitefish, sculpin, burbot, suckers, and smelt.

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Photo 3.2-2. *Sockeye salmon.*

The Copper River commercial driftnet fisheries for sockeye and coho salmon are some of the most productive in the Prince William Sound region (ADF&G, 1986c). The fisheries occur in conjunction with the major runs: May to late July for sockeye, and early August to early September for coho. The Gulkana River Sockeye Salmon Enhancement Project, which is located along the pipeline in the upper Copper River drainage, is the only major sockeye hatchery in the region and is a dominant factor enhancing the commercial catch. Sockeye and chum salmon support recreational fisheries throughout the Copper River drainage. Recreational fisheries for grayling occur during summer in the area, particularly in the Gulkana River. Dolly Varden are taken where available along the TAPS route; however, most of the harvest is incidental to salmon fisheries (ADF&G, 1986c). There is a minor sport fishery for rainbow (steelhead) trout where available in the area, with fishing being heaviest in the Gulkana River area.

The Gulkana River (MP 655) is a major anadromous fish stream supporting a large recreational fishery. In addition to supporting stocks of chinook and sockeye salmon, grayling, and steelhead trout, the river contains at least seven other species. The Gulkana River is sensitive year-round and critically sensitive through summer feeding and spawning periods from May through October. The Gulkana River Sockeye Salmon Enhancement Project hatchery is located at MP 615 and MP 618, an area that is critically sensitive during the incubation period from midsummer through spring (APSC, 1993).

Between the Gulkana River and the Tonsina River (MP 723), a distance of 58 miles (92.8 km), the pipeline directly crosses only two anadromous fish streams: the Tazlina (MP 687) and Klutina (MP 697) rivers. Both rivers provide migratory and spawning habitat for chinook and sockeye salmon and steelhead trout, with coho salmon also occurring in the Klutina River. Other species found in both streams include grayling, Dolly Varden, burbot, and whitefish. These rivers are sensitive from spring through late fall and critically sensitive during the open-water months from May to October. Along this stretch, the pipeline crosses or runs near 11 other streams, all of which are used by grayling. Although none is classified as anadromous by ADF&G, Bear Creek (MP 672), Dry Creek (MP 680), and Squirrel Creek (MP 717) are anadromous within several miles downstream of the pipeline where they support chinook salmon stocks. These streams are sensitive for grayling during the open-water feeding season and critically sensitive in May-June when grayling are spawning.

From the initial crossing of the Tonsina River (MP 723) until the final crossing of the Little Tonsina River (MP 734), TAPS encounters a continuous series of sensitive anadromous fish habitats. The Tonsina River supports stocks of chinook, coho, and sockeye salmon; grayling; Dolly Varden; and several other species. It is classified as sensitive from April through November and critically sensitive during the open-water migration, spawning, and rearing period from June through October. The ROW passes through the Little Tonsina Flats (MP 731-732), a large wetland area that provides foraging habitat for chinook and coho salmon, Dolly Varden, grayling, and slimy sculpin; however, it is considered sensitive only in August and September. Slate Creek (MP 732) and the Little Tonsina River are anadromous fish streams that also support coho and chinook salmon, Dolly Varden, and grayling. The Little Tonsina also contains sockeye salmon, whitefish, and burbot. Both rivers are sensitive through most of the year and provide critically sensitive overwintering habitat from October through February.

No anadromous fish streams exist between the Little Tonsina River (MP 734) and MP 780, where the pipeline begins paralleling the Lowe River. The streams and creeks along this length of the ROW contain Dolly Varden and are sensitive overwintering areas from January through March and critically sensitive during the spawning and overwintering period from August through December.

From the Lowe River crossing (MP 780) to the terminus of the pipeline at Port Valdez (MP 800), nearly all tributaries, streams, and creeks are considered anadromous fish habitat. They contain pink, sockeye, coho, and occasionally chum salmon and Dolly Varden. These water bodies are the exclusive domain of these anadromous species, and secondary species are rare. All of these streams and tributaries are sensitive year round and are critically sensitive from late summer through much of the winter in conjunction with spawning and overwintering.

3.2.3.4 Prince William Sound and Tanker Routes

Prince William Sound supports major populations of marine and anadromous fish that form the basis of major commercial, subsistence, and sport fisheries. Sockeye salmon, pink salmon, coho salmon, chinook salmon, chum salmon, and Pacific herring have provided the greatest commercial harvest value in recent years (Morstad et al., 1999). Pacific halibut, sablefish, and other marine species are also harvested (Bechtol, 1995). Sockeye salmon are the most harvested species in the subsistence fishery, with the other salmon species also providing important harvests (Morstad et al., 1999). Salmon and halibut also support a large sport fishery, with an estimated 130,000 person-days fished in 1997 (Howe et al., 1998).

Rice et al. (1996) and Wells et al. (1995) have described effects to fish populations in Prince William Sound from the 1989 *Exxon Valdez* oil spill. Studies on initial effects and subsequent recovery of fish populations following the spill have not resulted in consensus on the extent of damage and recovery rate. Studies conducted by the *Exxon Valdez* Oil Spill Trustee Council indicated initial damage to Pacific herring, pink salmon, Dolly Varden char, and cutthroat trout (Rice et al., 1996). Although the level of recovery is not clear, pink salmon, Dolly Varden char, and cutthroat trout now support commercial and sport fisheries. After a record harvest in 1992, the Pacific herring population collapsed and has remained depressed, with reduced or no commercial harvest (Morstad et al., 1999). Monitoring of both Pacific herring and pink salmon continues.

Pink salmon were considered particularly vulnerable to contamination from the Valdez Marine Terminal and from oil spills in the Sound because a large portion of the wild population spawns in the intertidal region of the spawning streams (Noerenberg, 1963; Helle et al., 1964; Helle, 1970). Pink salmon are the most abundant salmon species in Prince William Sound, with the wild population averaging 6.65 million fish (range 2.20 to 14.41 million) from 1989 to 1998 (Morstad et al., 1999). During this time, four major hatcheries have added an annual average of 20.76 million fish (range 4.85 to 31.82 million). Together, these populations have supported a commercial harvest averaging 25.11 million pink salmon over the same period.

Three other species of Pacific salmon (sockeye, coho, and chum) also play an important role in the Prince William Sound ecosystem. Sockeye salmon enter a number of systems throughout the Sound, with a small run entering Robe Lake near Valdez. Other systems with historically significant runs include Eshamy and Coghill lakes in the western Sound (Morstad et al., 1999). Coho salmon also enter the Robe Lake system and are spread widely through the Sound. A hatchery run developed at the Solomon Gulch Hatchery at Valdez supports a large sport fishery in August. From 1988 to 1997, the sport coho harvest averaged 32,000 fish, with the annual average exceeding 50,000 fish since 1995 (Howe et al., 1998). Chum salmon are also spread widely through the Sound and are important to the commercial harvest. The chum salmon harvest is also bolstered by a hatchery run. They are now the second most numerous species in the salmon harvest (Morstad et al., 1999).

Dolly Varden support an important sport fishery in Prince William Sound, with an average harvest of 3,259 fish from 1988 to 1997 (Howe et al., 1998). The Dolly Varden in the Sound are considered anadromous and have a complex life cycle involving repeated annual migrations between freshwater rivers or lakes and the sea. Dolly Varden alevins emerge from spawning stream gravel in May and remain in the stream for 2 to 4 years (Armstrong, 1970). In the Sound, most smolts leave spawning streams in May and June at ages 2, 3, and 4 to feed in saltwater and are generally thought to return to overwinter in freshwater streams in the fall. Numerous variations in life history exist for fish spawned in watersheds with lakes and those without lakes (Armstrong and Morrow, 1980); however, each spring, adult and immature fish again migrate from freshwater systems to feed in saltwater. Mature fish return to their natal streams at age 7 to 9 to spawn in the fall. These migration patterns make management complex because individual stocks are difficult to recognize and each stream or lake system may contain mixed stocks of Dolly Varden originating from streams over a vast area (Armstrong, 1984). Additionally, recent analyses have shown that Dolly Varden contradict the accepted pattern of return to lakes each fall. In tagging studies throughout Southcentral Alaska, including Prince William Sound, Bernard et al. (1995) found that 14 to 58 percent may spend the entire winter at sea.

Pacific herring support a diverse commercial fishery in Prince William Sound, with five different fisheries target-

ing different aspects of the herring population through the year. Prior to spawning, a sac roe fishery harvests unspawned females. After spawning, herring roe are harvested on kelp. In the fall, a fishery harvests herring for food and bait (Morstad et al., 1999). The herring fisheries are conducted mainly along western Montague Island, with the food and bait fishery also occurring near Knowles Head and Red Head north of Port Gravina (Sharp et al., 1996). In recent years, the harvest has been highly variable, with all-time record harvests in 1991-92 and complete fishery closures in 1994-96. The stock collapsed in 1993 following an outbreak of viral hemorrhagic septicemia (VHS), and the fishery has been sporadic since (Sharp et al., 1996).

Rockfish support both commercial and sport harvests in the Sound (Bechtol, 1995; Howe et al., 1998). The annual sport harvest of rockfish averaged 13,209 fish between 1988 and 1997 (Howe et al., 1998), while the commercial harvest averaged 214,966 pounds from 1988 to 1994 (Bechtol, 1995; average weight not available to convert pounds to number of fish). The rockfish group is composed of several species, all of which are long-lived and slow to mature. These traits cause them to be especially vulnerable to over-harvest, and management strategies are constantly evolving to avoid stock depletion (Bechtol, 1995).

The sensitivities of fish resources and habitats along the tanker route to the U.S. West Coast are similar to those described for Prince William Sound, with many of the same species of salmon, herring, and other marine and anadromous fishes being important to the local economies and ecosystems. BLM and MMS (1998) described the current status of six salmon populations, one cutthroat trout, and 11 steelhead trout populations from the Columbia River Basin, Oregon and California, all of which are listed or proposed for listing as endangered or threatened species. Since that time, four additional salmon populations in Washington have been listed, and three populations of bull trout have been proposed for listing (FWS, 1998b; NOAA, 1999a). In addition, seven populations of marine fishes from Puget Sound have been proposed for listing: Pacific herring, Pacific cod, Pacific hake, walleye pollock, brown rockfish, copper rockfish, and quillback rockfish (NOAA, 1999b).

3.2.4 Birds

By B. Anderson, R. Day, S. Johnson, R. Ritchie, and D. Troy

Many birds are highly mobile and migratory, and many species that breed on the North Slope and overwinter in Prince William Sound also migrate through the TAPS ROW and adjacent areas. Consequently, the discussion of birds in this report takes a broad view.

Birds found along the TAPS ROW can be divided into five major groups: waterfowl, raptors, shorebirds, seabirds, and passerines and other birds. Most are migratory and use the ROW only during the spring and summer months, but some species occur year-round. Population estimates for most species along the TAPS ROW are generally unavailable, but are noted when possible. Quantitative assessments cannot be made on bird populations, but qualitative interpretations are possible. Scientific names for all species discussed below are provided in Table 3.2-5.

Birds are abundant in the North Gulf of Alaska Coast/ Prince William Sound region. The avifauna of this region is described by Gabrielson and Lincoln (1959), Isleib and Kessel [1973 (1979 reprinting with addendum)], Gould et al. (1982), and DeGange and Sanger (1987). Habitats used by these species are described in Isleib and Kessel (1973). At least 278 species of birds have been recorded in the tanker routes (Gabrielson and Lincoln, 1959; Isleib and Kessel, 1973; DeGange and Sanger, 1987). Agler and Kendall (1997) estimated that approximately 246,000 ± 41,000 marine-oriented birds (includes waterbirds, seabirds, and shorebirds) occurred in Prince William Sound in summer 1996 and that approximately 253,000 ± 35,000 occurred there in winter 1996. Large numbers of marine-oriented birds also occur in and around the Kenai Peninsula. Smaller numbers are associated with the Copper River Delta, although it is important to migrating shorebirds; perhaps as many as 20,000,000 shorebirds migrate through the region (Isleib, 1979).

3.2.4.1 Waterfowl

The TAPS route supports a diverse group of waterfowl, including loons, swans, geese, Sandhill Cranes, and ducks. The status, distribution, and abundance of waterfowl vary along the ROW based on species range, life history, and habitat requirements. Of the 57 species of waterfowl known to occur in Alaska, 39 species are found along the ROW and 33 of those species breed there.

Loons

Four species of loons (Yellow-billed, Pacific, Common, and Red-throated loons) breed near the TAPS ROW. North of the Chugach Mountains, loons are present only from May through October, whereas several species (Yellow-billed, Common, and Pacific loons) overwinter in the Prince William Sound area. In winter, Red-throated Loons also may be found in the coastal waters of Alaska, particularly in the Southeast. Breeding phenology for all loons is

Table 3.2-5. *Common and scientific names and status of bird species found along the TAPS ROW, on the North Slope, and in Prince William Sound. B = breeder, B? = possible breeder, M = migrant, R = resident (usually includes breeding), S = summer visitor, W = winter visitor (accidentals or vagrants were not included in the list); status along TAPS ROW varies among regions. Sources: TAPS ROW: Gabrielson and Lincoln (1959), Kessel and Gibson (1978), and sources in text; ANS: Johnson and Herter (1989): PWS: Isleib and Kessel (1973). Species names follow American Ornithologists' Union (1998, 2000).*

Common Name	Scientific Name	TAPS ROW	North Slope	PWS
WATERFOWL & WATERBIRDS				
Red-throated Loon	*Gavia stellata*	B	B	W
Pacific Loon	*Gavia pacifica*	B	B	R
Common Loon	*Gavia immer*	B	—	R
Yellow-billed Loon	*Gavia adamsii*	B	B	W
Horned Grebe	*Podiceps auritus*	B	—	R
Red-necked Grebe	*Podiceps grisegena*	B	B	R
Greater White-fronted Goose	*Anser albifrons*	B	B	M
Snow Goose	*Chen caerulescens*	M	B	M
Canada Goose	*Branta canadensis*	B	B	M
Brant	*Branta bernicla*	B	B	M
Trumpeter Swan	*Cygnus buccinator*	B	—	M
Tundra Swan	*Cygnus columbianus*	M	B	M
Gadwall	*Anas strepera*	B	M	R
American Wigeon	*Anas americana*	B	B	R
Mallard	*Anas platyrhynchos*	B	B	R
Blue-winged Teal	*Anas discors*	M	—	S
Northern Shoveler	*Anas clypeata*	B	B	M
Northern Pintail	*Anas acuta*	B	B	R
Green-winged Teal	*Anas crecca*	B	B	R
Canvasback	*Aythya valisineria*	B	M	S
Redhead	*Aythya americana*	B	—	—
Ring-necked Duck	*Aythya collaris*	B	—	S
Greater Scaup	*Aythya marila*	B	B	R
Lesser Scaup	*Aythya affinis*	B	B	—
Steller's Eider	*Polysticta stelleri*	—	B	W
Spectacled Eider	*Somateria fischeri*	—	B	—
King Eider	*Somateria spectabilis*	—	B	—
Common Eider	*Somateria mollissima*	—	B	—
Harlequin Duck	*Histrionicus histrionicus*	B	—	R
Surf Scoter	*Melanitta perspicillata*	B	—	R
White-winged Scoter	*Loxia leucoptera*	B	—	R
Black Scoter	*Melanitta nigra*	B	M	R
Long-tailed Duck (Oldsquaw)	*Clangula hyemalis*	B	B	W
Bufflehead	*Bucephala albeola*	B	—	R
Common Goldeneye	*Bucephala clangula*	B	—	R
Barrow's Goldeneye	*Bucephala islandica*	B	—	R
Common Merganser	*Mergus merganser*	B	—	R
Red-breasted Merganser	*Mergus serrator*	B	B	R
Sandhill Crane	*Grus canadensis*	B	B	M
SEABIRDS				
Northern Fulmar	*Fulmarus glacialis*	—	—	S
Sooty Shearwater	*Puffinus griseus*	—	—	M
Short-tailed Shearwater	*Puffinus tenuirostris*	—	—	M
Fork-tailed Storm-Petrel	*Oceanodroma furcata*	—	—	S
Double-crested Cormorant	*Phalacrocorax auritus*	—	—	W
Red-faced Cormorant	*Phalacrocorax urile*	—	—	W
Pelagic Cormorant	*Phalacrocorax pelagicus*	—	—	R
Pomarine Jaeger	*Stercorarius pomarinus*	B	M	M
Parasitic Jaeger	*Stercorarius parasiticus*	B	B	B
Long-tailed Jaeger	*Stercorarius longicaudus*	B	B	M
Bonaparte's Gull	*Larus philadelphia*	B	—	B
Mew Gull	*Larus canus*	B	—	R
Herring Gull	*Larus argentatus*	B	—	B
Thayer's Gull	*Larus thayeri*	—	M	W

Table 3.2-5 (cont'd). *Common and scientific names and status of bird species found along the TAPS ROW, on the North Slope, and in Prince William Sound. B = breeder, B? = possible breeder, M = migrant, R = resident (usually includes breeding), S = summer visitor, W = winter visitor (accidentals or vagrants were not included in the list); status along TAPS ROW varies among regions.*

Common Name	Scientific Name	TAPS ROW	North Slope	PWS
SEABIRDS (Cont'd)				
Slaty-backed Gull	*Larus schistisagus*	—	M	—
Glaucous-winged Gull	*Larus glaucescens*	R	—	R
Glaucous Gull	*Larus hyperboreus*	B	B	W
Sabine's Gull	*Xema sabini*	B	B	—
Black-legged Kittiwake	*Rissa tridactyla*	S	—	B
Ross's Gull	*Rhodostethia rosea*	—	M	—
Ivory Gull	*Pagophila eburnea*	—	M	—
Caspian Tern	*Sternia caspia*	—	—	B?
Arctic Tern	*Sterna paradisaea*	B	B	B
Aleutian Tern	*Sterna aleutica*	—	—	S
Common Murre	*Uria aalge*	—	—	B
Black Guillemot	*Cepphus grylle*	—	B	—
Pigeon Guillemot	*Cepphus columba*	B	—	R
Marbled Murrelet	*Brachyramphus marmoratus*	B	—	R
Kittlitz's Murrelet	*Brachyramphus brevirostris*	B	—	R
Ancient Murrelet	*Synthliboramphus antiquus*	—	—	S
Cassin's Auklet	*Ptychoramphus aleuticus*	—	—	S
Parakeet Auklet	*Aethia psittacula*	—	—	B
Rhinoceros Auklet	*Cerorhinca monocerata*	—	—	S
Horned Puffin	*Fratercula corniculata*	—	—	B
Tufted Puffin	*Fratercula cirrhata*	—	—	B
RAPTORS				
Osprey	*Pandion haliaetus*	B	—	M
Bald Eagle	*Haliaeetus leucocephalus*	B	—	R
Northern Harrier	*Circus cyaneus*	B	—	M
Sharp-shinned Hawk	*Accipiter striatus*	B	—	B
Northern Goshawk	*Accipiter gentilis*	R	—	R
Swainson's Hawk	*Buteo swainsoni*	M	—	—
Red-tailed Hawk	*Buteo jamaicensis*	B	—	B?
Rough-legged Hawk	*Buteo lagopus*	B	B	M
Golden Eagle	*Aquila chrysaetos*	B	B	B
American Kestrel	*Falco sparverius*	B	—	B
Merlin	*Falco columbarius*	B	—	—
Gyrfalcon	*Falco rusticolus*	R	R	R
Peregrine Falcon	*Falco peregrinus*	R	B	B
Great Horned Owl	*Bubo virginianus*	R	—	R
Snowy Owl	*Nyctea scandiaca*	B	B	—
Northern Hawk Owl	*Surnia ulula*	R	—	—
Great Gray Owl	*Strix nebulosa*	R	—	—
Short-eared Owl	*Asio flammeus*	R	B	M
Boreal Owl	*Aegolius funereus*	R	—	—
Northern Saw-whet Owl	*Aegolius acadicus*	R	—	R
GROUSE				
Ruffed Grouse	*Bonasa umbellus*	R	—	—
Spruce Grouse	*Falcipennis canadensis*	R	—	R
Willow Ptarmigan	*Lagopus lagopus*	R	R	W
Rock Ptarmigan	*Lagopus mutus*	R	R	W
White-tailed Ptarmigan	*Lagopus leucurus*	R	—	W
Sharp-tailed Grouse	*Tympanuchus phasianellus*	R	—	—
SHOREBIRDS				
Black-bellied Plover	*Pluvialis squatarola*	B	B	M
American Golden-Plover	*Pluvialis dominica*	—	—	M
Pacific Golden-Plover	*Pluvialis fulva*	B	B	M
Semipalmated Plover	*Charadrius semipalmatus*	B	B	B
Killdeer	*Charadrius vociferus*	B	—	—

Table 3.2-5 (cont'd). *Common and scientific names and status of bird species found along the TAPS ROW, on the North Slope, and in Prince William Sound. B = breeder, B? = possible breeder, M = migrant, R = resident (usually includes breeding), S = summer visitor, W = winter visitor (accidentals or vagrants were not included in the list); status along TAPS ROW varies among regions.*

Common Name	Scientific Name	TAPS ROW	North Slope	PWS
SHOREBIRDS (Cont'd)				
Black Oystercatcher	*Haematopus bachmani*	—	—	B
Greater Yellowlegs	*Tringa melanoleuca*	B	—	B
Lesser Yellowlegs	*Tringa flavipes*	B	—	B
Solitary Sandpiper	*Tringa solitaria*	B	—	—
Wandering Tattler	*Heteroscelus incanus*	B	—	B
Spotted Sandpiper	*Actitis macularia*	B	—	B
Upland Sandpiper	*Bartramia longicauda*	B	—	—
Whimbrel	*Numenius phaeopus*	B	—	M
Hudsonian Godwit	*Limosa haemastica*	B	M	—
Bar-tailed Godwit	*Limosa lapponica*	B	M	M
Ruddy Turnstone	*Arenaria interpres*	—	B	—
Black Turnstone	*Arenaria melanocephala*	—	—	W
Surfbird	*Aphriza virgata*	B	—	W
Red Knot	*Calidris cauntus*	—	—	M
Sanderling	*Calidris alba*	M	M	M
Semipalmated Sandpiper	*Calidris pusilla*	B	B	—
Western Sandpiper	*Calidris mauri*	B	B?	M
Least Sandpiper	*Calidris minutilla*	B	—	B
White-rumped Sandpiper	*Calidris fuscicollis*	B	B	—
Baird's Sandpiper	*Calidris bairdii*	B	B	—
Pectoral Sandpiper	*Calidris melanotos*	B	B	M
Sharp-tailed Sandpiper	*Calidris acuminata*	M	—	M
Rock Sandpiper	*Calidris ptilocnemis*	—	—	W
Dunlin	*Calidris alpina*	B	B	M
Stilt Sandpiper	*Calidris himantopus*	B	B	—
Buff-breasted Sandpiper	*Tryngites subruficollis*	B	B	—
Ruff	*Philomachus pugnax*	—	B	—
Short-billed Dowitcher	*Limnodromus griseus*	—	—	M
Long-billed Dowitcher	*Limnodromus scolopaceus*	B	B	M
Common Snipe	*Gallinago gallinago*	B	B	B
Red-necked Phalarope	*Phalaropus lobatus*	B	B	M
Red Phalarope	*Phalaropus fulicaria*	B	B	M
SONGBIRDS & OTHER BIRDS				
Great Blue Heron	*Ardea herodias*	—	—	R
Rufous Hummingbird	*Selasphorus rufus*	B	—	B
Belted Kingfisher	*Ceryle alcyon*	B	—	R
Yellow-bellied Sapsucker	*Sphyrapicus varius*	B	—	—
Downy Woodpecker	*Picoides pubescens*	R	—	R
Hairy Woodpecker	*Picoides villosus*	R	—	R
Three-toed Woodpecker	*Picoides tridactylus*	R	—	R
Black-backed Woodpecker	*Picoides arcticus*	R	—	—
Northern Flicker	*Colaptes auratus*	B	—	B
Olive-sided Flycatcher	*Contopus cooperi*	B	—	—
Western Wood-Pewee	*Contopus sordidulus*	B	—	B
Alder Flycatcher	*Empidonax alnorum*	B	—	—
Hammond's Flycatcher	*Empidonax hammondii*	B	—	—
Say's Phoebe	*Sayornis saya*	B	—	—
Northern Shrike	*Lanius excubitor*	B	—	—
Gray Jay	*Perisoreus canadensis*	B	—	—
Steller's Jay	*Cyanocitta stelleri*	B	—	R
Black-billed Magpie	*Pica hudsonia*	B	—	R
Northwestern Crow	*Corvus caurinus*	R	—	R
Common Raven	*Corvus corax*	R	R	R
Horned Lark	*Eremophila alpestris*	B	—	—
Tree Swallow	*Tachycineta bicolor*	B	—	B
Violet-green Swallow	*Tachycineta thalassina*	B	—	B

Table 3.2-5 (cont'd). *Common and scientific names and status of bird species found along the TAPS ROW, on the North Slope, and in Prince William Sound. B = breeder, B? = possible breeder, M = migrant, R = resident (usually includes breeding), S = summer visitor, W = winter visitor (accidentals or vagrants were not included in the list); status along TAPS ROW varies among regions.*

Common Name	Scientific Name	TAPS ROW	North Slope	PWS
SONGBIRDS & OTHER BIRDS (Cont'd)				
Bank Swallow	*Riparia riparia*	B	—	B
Cliff Swallow	*Petrochelidon pyrrhonota*	B	—	—
Black-capped Chickadee	*Poecile atricapilla*	R	—	R
Chestnut-backed Chickadee	*Poecile rufescens*	R	—	R
Boreal Chickadee	*Poecile hudsonia*	R	—	—
Gray-headed Chickadee	*Poecile cincta*	R	—	—
Red-breasted Nuthatch	*Sitta canadensis*	R	—	R
Brown Creeper	*Certhia americana*	R	—	R
Winter Wren	*Troglodytes troglodytes*	—	—	R
American Dipper	*Cinclus mexicanus*	R	—	R
Golden-crowned Kinglet	*Regulus satrapa*	B	—	B
Ruby-crowned Kinglet	*Regulus calendula*	B	—	B
Arctic Warbler	*Phylloscopus borealis*	B	—	—
Bluethroat	*Luscinia svecica*	B	—	—
Northern Wheatear	*Oenanthe oenanthe*	B	—	—
Mountain Bluebird	*Sialia currucoides*	B	—	—
Townsend's Solitaire	*Myadestes townsendi*	B	—	—
Gray-cheeked Thrush	*Catharus minimus*	B	—	—
Swainson's Thrush	*Catharus ustulatus*	B	—	—
Hermit Thrush	*Catharus guttatus*	B	—	B
American Robin	*Turdus migratorius*	B	—	R
Varied Thrush	*Ixoreus naevius*	B	—	R
European Starling	*Sturnus vulgaris*	B	—	—
Yellow Wagtail	*Motacilla flava*	B	B	—
American Pipit	*Anthus rubescens*	B	—	—
Bohemian Waxwing	*Bombycilla garrulus*	B	—	—
Orange-crowned Warbler	*Vermivora celata*	B	—	B
Yellow Warbler	*Dendroica petechia*	B	—	B
Yellow-rumped Warbler	*Dendroica coronata*	B	—	B
Townsend's Warbler	*Dendroica townsendi*	B	—	B
Blackpoll Warbler	*Dendroica striata*	B	—	—
Northern Waterthrush	*Seiurus noveboracensis*	B	—	—
Wilson's Warbler	*Wilsonia pusilla*	B	—	—
American Tree Sparrow	*Spizella arborea*	B	—	—
Chipping Sparrow	*Spizella passerina*	B	—	—
Savannah Sparrow	*Passerculus sandwichensis*	B	B	B
Fox Sparrow	*Passerella iliaca*	B	—	—
Song Sparrow	*Melospiza melodia*	R	—	R
Lincoln's Sparrow	*Melospiza lincolnii*	B	—	—
White-crowned Sparrow	*Zonotrichia leucophrys*	B	—	B
Golden-crowned Sparrow	*Zonotrichia atricapilla*	B	—	B
Dark-eyed Junco	*Junco hyemalis*	B	—	B
Lapland Longspur	*Calcarius lapponicus*	B	B	—
Smith's Longspur	*Calcarius pictus*	B	B	—
Snow Bunting	*Plectrophenax nivalis*	B	B	W
Red-winged Blackbird	*Agelaius phoeniceus*	B	—	—
Rusty Blackbird	*Euphagus carolinus*	B	—	—
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*	B	—	—
Pine Grosbeak	*Pinicola enucleator*	R	—	R
Red Crossbill	*Loxia curvirostra*	R	—	R
White-winged Crossbill	*Zonotrichia albicollis*	R	—	R
Common Redpoll	*Carduelis flammea*	R	B	R
Hoary Redpoll	*Carduelis hornemanni*	M	B	W
Pine Siskin	*Carduelis pinus*	R	—	R

similar, with eggs being incubated in June, young reared in July-early September, and departure from the nesting grounds by late September. Statewide population estimates for these species range from 2,636 Yellow-billed Loons to about 70,000 Pacific Loons (Groves et al., 1996).

Yellow-billed Loons occur during summer only at the northern end of the TAPS ROW and are uncommon breeders on the Arctic Coastal Plain, where they primarily breed on the Colville River Delta and in the National Petroleum Reserve-Alaska (NPR-A) (Chipp/Alaktak rivers) (Sjolander and Agren, 1976; Johnson and Herter, 1989). During spring migration, Yellow-billed Loons use lakes with open water along the Dalton Highway. A few Yellow-billed Loons have occasionally nested in the vicinity of the ROW (Sage, 1971, 1974; ABR, Inc., unpublished data). Deep-water lakes and ponds were found to be of highest value to nesting and brood-rearing Yellow-billed Loons on the Colville River Delta (Johnson et al., 1997).

Common Loons are uncommon breeders along the TAPS ROW. They nest primarily south of the Brooks Range (Gabrielson and Lincoln, 1959; Groves et al., 1996). This species nests on boreal lakes, generally one pair per lake. Wintering birds occur at the southern end of the ROW near Valdez and in Prince William Sound.

Pacific Loons are common breeders at the northern end of the ROW and in lakes south of the Brooks Range (Gabrielson and Lincoln, 1959; Johnson and Herter, 1989). Pacific Loons arrive on the coastal plain in late May once open water appears, and move to nesting lakes as they thaw in early June. Pacific Loons nest on lakes about half the size of those used by Yellow-billed Loons (Johnson and Herter, 1989; McIntyre, 1994), and use ponds with emergent vegetation (sedges and grasses) for brood-rearing (Bergman and Derksen, 1977; Rothe et al., 1983; Johnson and Herter, 1989; Kertell, 1994).

Red-throated Loons are common breeders at the northern end of the TAPS ROW on the coastal plain and also can be found along the ROW between the Brooks Range and Chugach Mountains (Gabrielson and Lincoln, 1959; Johnson and Herter, 1989). Red-throated Loons nest on smaller, shallower ponds than those used by other loons (Johnson and Herter, 1989; Smith, Byrne et al., 1993, 1994; Dickson, 1994; Johnson et al., 1996). On the coastal plain, Red-throated Loons use not only isolated ponds with emergent vegetation, but also basin wetland complexes, especially during brood-rearing (Bergman et al., 1977; Derksen et al., 1981). Presumably due to the small size and shallowness of their nesting lakes on the coastal plain, Red-throated Loons, unlike other loons, fly to nearshore marine waters to hunt fishes for their young (Bergman and Derksen, 1977).

BP Exploration

***Photo 3.2-3**. Red-throated Loon.*

Tundra and Trumpeter Swans

Tundra Swans are common breeders across the Arctic Coastal Plain of Alaska and at the northern end of the TAPS ROW, where they are present from late May to mid-September (Johnson and Herter, 1989). Tundra Swans nest in relatively low densities across the entire coastal plain, but occur in highest densities on the major river deltas (Colville, Sagavanirktok, and Canning) (Johnson et al., 1998; Anderson et al., 1999). Some Tundra Swans migrate north over the Brooks Range in spring and may stage briefly in the TAPS ROW along the Dalton Highway, but some also arrive on the Arctic Coastal Plain from the east, having traveled up the Mackenzie River valley in the Yukon (Johnson and Herter, 1989). Tundra Swans nest along the northern part of the TAPS ROW during the breeding season (late May-September). Swans are most sensitive to disturbance during nesting (May-early July), when both adults attend the nest, and during brood-rearing (July-September), when both adults and young are flightless for several weeks. During brood-rearing, Tundra Swans occur frequently in habitats that support stands of the emergent grass *Arctophila fulva*, which is a primary food for both adults and young (Bergman et al., 1977; Derksen et al., 1981). A few Tundra Swans breed along the TAPS ROW south of the Brooks Range, but Trumpeter Swans are more abundant in those sections of the ROW.

BP Exploration

***Photo 3.2-4.** Tundra Swans.*

Trumpeter Swans are uncommon to common breeders along the TAPS ROW from south of the Brooks Range to the terminus at Valdez (Gabrielson and Lincoln, 1959). Several areas have been identified as nesting and brood-rearing areas for Trumpeter Swans along the ROW between MP 645 and 716 (APSC, 1993). This region encompasses the drainages of the Gulkana, Copper, and Klutina rivers and adjacent wetlands with numerous ponds that support nesting swans. Nest locations identified during the last statewide aerial survey in 1995 are presented in the *Alaska Trumpeter Swan Atlas* (Conant et al., 1996). The 1995 estimate for the statewide population of Trumpeter Swans

was 15,823, of which approximately 59 percent were in the Gulkana and Lower Tanana land units, which encompass much of the southern TAPS ROW (Groves and Conant, 1998). The ROW also intersects major migration routes for Trumpeter and Tundra swans near Delta Junction in the upper Tanana River valley, near Gulkana, and along the Copper River (Cooper et al., 1991).

Geese

Canada Geese, Greater White-fronted Geese, Snow Geese, and Brant nest on the Arctic Coastal Plain and in the northern section of the TAPS ROW (Johnson and Herter, 1989). Geese are present along the ROW from approximately mid-May to early September each year. They winter primarily outside Alaska. The distribution of each species varies and is influenced by their different nesting habits. Canada and Greater White-fronted geese are common breeders around Pump Station 1 and the northern end of the TAPS ROW, where they nest in isolated pairs on the tundra or on small islands in lakes and ponds. In contrast, Brant and Snow Geese are less common breeders in the northern end of TAPS. They nest in colonies of a few to several hundred pairs at traditional coastal sites in the Prudhoe Bay area (Johnson, 1991, 2000a; Murphy and Anderson, 1993; Stickney et al., 1994; Sedinger and Stickney, 2000). During spring migration, Canada, Greater White-fronted, and Snow geese aggregate in snow-free habitats along the Dalton Highway as far south as Atigun Pass. Brant migrate to the oil fields from the west and are rarely found along the Dalton Highway south of the oil fields during spring. Goose-nesting concentration areas have been identified along the ROW between MP 0 and MP 78 (APSC, 1993). The Atigun Pass area is used as a corridor by geese during fall migration.

Canada Geese are patchily distributed across the Arctic Coastal Plain and reach their highest densities in the Prudhoe Bay area (Johnson and Herter, 1989). On the coastal plain, Canada Geese prefer to nest on small islands in ponds and lakes that provide safety from predators (Murphy and Anderson, 1993). This species is also a common breeder south of the Brooks Range, in the Yukon and Tanana flats, and into the Copper River area (Gabrielson and Lincoln, 1959).

Greater White-fronted Geese are the most common breeding geese on the Arctic Coastal Plain, declining in abundance to the east of Prudhoe Bay (Johnson and Herter, 1989). Unlike Canada Geese, this species nests on the tundra, often away from ponds or lakes. Greater White-fronted Geese are uncommon breeders south of the Brooks Range along TAPS, but some nest on the Yukon Flats and Minto Flats (Gabrielson and Lincoln, 1959).

Declan Tray

Photo 3.2-5. *Brant pair.*

Brant are strongly associated with coastal habitat types during nesting and brood-rearing and occur in only a few locations along the TAPS ROW on the Arctic Coastal Plain. A small nesting colony of less than 10 pairs of Brant is located about 5 km southwest of Pump Station 1, and a colony of less than 25 pairs is located about 4 km northeast of the pump station (Stickney et al., 1994). Larger Brant colonies of 25 to 100 or more pairs are located near the coast in Prudhoe Bay and on Howe Island (Stickney et al., 1994). Scattered pairs of Brant probably also nest within the ROW near Pump Station 1 (Stickney et al., 1994; Sedinger and Stickney, 2000). Brood-rearing Brant tend to concentrate along the coast in the North Slope oil fields, but a small brood group frequently has been seen inland in the Lake Colleen area east of Pump Station 1 (Stickney et al., 1994; Sedinger and Stickney, 2000; ABR, Inc., unpubl. data). Brant do not breed or occur regularly along the TAPS ROW south of the coastal plain, but small numbers may move through Valdez during spring migration.

Until the mid to late 1990s, Snow Geese nested primarily in a single large colony of 300 to 500 pairs on Howe Island in the outer Sagavanirktok River delta and only rarely nested in isolated pairs on the tundra (Johnson, 1991, 2000a). In recent years, other small Snow Goose colonies have become established in the Colville River delta and in NPR-A (Johnson, 2000a). No nests are known in the vicinity of Pump Station 1 or the ROW, but Snow Geese regularly stage during spring migration in areas of early snowmelt that occur in the “dust shadow” of the Dalton Highway and along the Sagavanirktok River from Sagwon north. (Dust produced by traffic on the gravel highway falls out on the snow downwind of the road and causes earlier snowmelt and thus open ground in those areas.)

Sandhill Crane

Sandhill Cranes are rare breeders at the northern end of the TAPS ROW, but are more common breeders between the Brooks Range and Chugach Mountains (Gabrielson and Lincoln, 1959; Johnson and Herter, 1989). The TAPS ROW intersects the major migration route of Sandhill Cranes in Interior Alaska along the Tanana River at Delta Junction (Kessel, 1984; Cooper et al., 1991); 200,000 to 300,000 cranes pass through this area during spring and fall migration each year as they move between their breeding areas in

western Alaska and Siberia and their wintering areas in the southwestern U.S.

Ducks

Eighteen species of ducks have been recorded on the Arctic Coastal Plain at the northern end of TAPS, and an additional six species occur south of the Brooks Range (Table 3.2-5). Ducks along the ROW can be divided into arctic-nesting species, boreal-nesting species, and Pacific coastal-nesting species. The arctic-nesting species include Long-tailed Duck (formerly knows as Oldsquaw), Northern Pintail, and eiders (Common, King, Spectacled, and Steller's eiders). Boreal-nesting species include the common dabbling ducks, such as Mallard and Green-winged Teal, and diving ducks, such as White-winged Scoter and Canvasback (Table 3.2-5). An important Pacific coastal-nesting species is the Harlequin Duck (Lanctot et al., 1999; see Section 3.2.7).

R. Lanctot

Photo 3.2-6. *Harlequin Duck.*

Long-tailed Duck is the most widely distributed of the arctic-nesting species on the Arctic Coastal Plain, whereas the distribution of eiders is more patchy (Johnson and Herter, 1989). Northern Pintails are locally abundant in many locations on the coastal plain and breed in low numbers, but are generally more common breeders in the boreal region of the state (Johnson and Herter, 1989). Common Eiders breed primarily on barrier islands along the Beaufort Sea coast and thus do not occur within the TAPS ROW, but King and Spectacled eiders are relatively common nesters on tundra in the Prudhoe Bay region (Johnson and Herter, 1989; TERA, 1997). King Eiders nest along the northern end of the TAPS ROW, in the vicinity of Pump Station 1. Spectacled and Steller's eiders, both threatened species, are discussed in Section 3.2.7.

Prince William Sound and Tanker Routes

At least 53 species of waterbirds (loons, grebes, herons, waterfowl, and cranes) have been recorded in the North Gulf of Alaska Coast/Prince William Sound region (Gabrielson and Lincoln, 1959; Isleib and Kessel, 1973; DeGange and Sanger, 1987). Of these species, 25 may breed in the region, and one is considered endangered by FWS and the State of Alaska (Steller's Eider: Alaska breeding population only; although this is the population listed, the geographic origin of Steller's Eiders in PWS is unknown). The North Gulf of Alaska Coast/Prince William Sound region is important to waterbirds for nesting, especially on the Copper River Delta, although some seaducks also nest along rockier shorelines. Prince William Sound is an important overwintering area for seaducks, especially scoters, Harlequin Ducks, goldeneyes, and mergansers.

3.2.4.2 Raptors

Nineteen species of raptors regularly occur along the TAPS ROW (Table 3.2-5). Four species are cliff-nesting raptors that have received substantial attention from regulatory agencies: Peregrine Falcon (discussed in Section 3.2.7), Rough-legged Hawk, Gyrfalcon, and Golden Eagle. Two other raptors, the Bald Eagle and the Northern Goshawk, have been identified as species sensitive to disturbance during TAPS ROW developments (Ritchie, 1999, pers. comm.). Bald and Golden eagles receive special protection under the federal Eagle Protection Act (50 CFR 22). All species of raptors occurring along the TAPS ROW also are protected under the Migratory Bird Treaty Act (50 CFR 10 and 21). Schempf (1989) describes the range and habitat use of Alaskan raptors.

Hawks, Falcons, and Eagles

Rough-legged Hawks nest along drainages in the northern foothills of the Brooks Range, and regularly occur along TAPS from Franklin Bluffs to Galbraith Lake. Their abundance and productivity reflect annual cycles in the abundance of their major prey, lemmings. When prey are abundant, Rough-legged Hawks have used artificial substrates for nesting and have taken advantage of suboptimal sites (Ritchie, 1991). Their seasonal use is similar to that of the Peregrine Falcon (see Section 3.2.7).

Gyrfalcons are resident and use traditional cliff nest sites (Cade, 1960), which they may attend during winter. Gyrfalcons occur in mountainous areas along TAPS, from north of the Brooks Range along the Sagavanirktok River to the Alaska Range. Seventeen nest sites were identified within 3 km of the TAPS alignment in the early 1970s (White et al., 1977). Gyrfalcons also have been found nesting on top of the pipeline VSMs in old raven nests (Ritchie, 1991).

Golden Eagles occupy mountainous habitats similar to those of Gyrfalcons, but regularly nest in other habitats, including cliffs along the Yukon and Tanana rivers. They can be found along TAPS from Slope Mountain to the coastal mountains near Valdez. Over 60 territories were identified during aerial surveys along the TAPS route in the early 1970s (White et al., 1977).

Bald Eagles are a common breeding raptor in Interior Alaska, primarily nesting in large cottonwood trees near

drainages south of the Yukon River. Nest sites occur near TAPS on the Tanana, Gulkana, Copper, and Lowe rivers and their tributaries (Ritchie and Ambrose, 1996). Most Bald Eagles migrate to winter ranges along the coast and depend on open water for fish prey. A few Bald Eagles winter in Interior Alaska near the junction of the Tanana and Delta rivers (Ritchie and Ambrose, 1987).

The Northern Goshawk, a resident species, nests along the TAPS ROW as far north as the South Fork of the Koyukuk River. Goshawks nest primarily in deciduous woodlands in Interior Alaska, but nesting activities and productivity are erratic, reflecting the cyclic abundance of major prey (McGowan, 1975). The Queen Charlotte race of the Northern Goshawk in Southeast Alaska is of concern to the U.S. Fish and Wildlife Service (FWS, 1996a), and the Northern Goshawk is listed as a species of special concern by the State of Alaska (ADF&G, 1996).

The U.S. Forest Service Region 10 (Alaska) considers ospreys sensitive to disturbance (AKNHP, 2000). They rarely occur along TAPS but are known to nest in the Tanana and Susitna valleys in Interior Alaska (Schempf, 1989). Observations in the Copper River Basin suggest that they may also nest there (Cooper et al., 1991). Other raptor species such as Northern Harrier and American Kestrel occur along the TAPS ROW and are relatively common where nesting habitat is available.

Owls

Snowy Owls are common on the Arctic Coastal Plain (Pitelka, 1974; Johnson and Herter, 1989), and when their primary microtine food (lemmings) is abundant, they can be found nesting near TAPS. In years when lemming numbers are low, Snowy Owls may be present but not breed or may not be present on the coastal plain and near TAPS. Short-eared Owls also nest on the ground in tundra habitats along the TAPS ROW. Other owls in Alaska, such as Great Horned Owl and Boreal Owl, are primarily woodland species distributed along the ROW in forest habitats south of the Brooks Range.

Prince William Sound and Tanker Routes

At least 22 species of raptors have been recorded in the North Gulf of Alaska Coast/Prince William Sound region (Gabrielson and Lincoln, 1959; Isleib and Kessel, 1973); however, the 9 species of owls are terrestrial and not marine. Of these 22 species, 16 either possibly, probably, or definitely breed in the region, and at least 2 are sensitive species (i.e., federally endangered or threatened, state species of special concern, or FWS Region 10 sensitive species): Osprey and the *pealei* subspecies of Peregrine Falcon. It is unknown whether two other subspecies of Peregrine Falcon that recently were delisted (*anatum* and *tundrius*) migrate through the region (Anderson et al., 1988). The Bald Eagle clearly is one of the most abundant raptors of this region, and over 8,000 birds nest and winter there (Bernatowicz et al., 1996).

3.2.4.3 Shorebirds

Declan Troy

Photo 3.2-7. *Red-necked Phalarope.*

The Arctic Coastal Plain is an important breeding area for many species of shorebirds, approximately 20 of which occur on the central North Slope (Troy, 2000). Considerable research describing distribution and abundance has taken place in the Prudhoe Bay area (Johnson and Herter, 1989; Troy, 2000.) However, relatively little work on shorebirds has occurred along most of the TAPS ROW. Nesting shorebirds were studied along TAPS at MP 12 and near Franklin Bluffs (Hanson and Eberhardt, 1982). In the Prudhoe Bay oil field, species composition and abundance of shorebirds are influenced by tundra characteristics (habitat), proximity to the coast (a sharp environmental gradient occurs with distance to coast), and location on an east-west axis.

The most numerous species nesting along the TAPS ROW on the Arctic Coastal Plain are two *Calidris* sandpipers (e.g., Pectoral Sandpiper and Semipalmated Sandpiper) and Red-necked Phalarope (Hanson and Eberhardt, 1981). Available information suggests that nesting abundance peaks on the southern coastal plain approximately 25 km south of Pump Station 1 and then decreases rapidly towards the foothills of the Brooks Range. In the foothills region, the most numerous breeding shorebirds are American Golden-Plover, Pectoral Sandpiper, and Buff-breasted Sandpiper (Hanson and Eberhardt, 1981). The nearly extinct Eskimo Curlew may have nested in this zone (see Section 3.2.7.1). Some species, such as American Golden-Plover, Bar-tailed Godwit, Whimbrel, and Buff-breasted Sandpiper, appear to occur at their peak densities in the southern coastal plain/foothills region. Little information on shorebird abundance is available for the TAPS ROW through the Brooks Range. Sage (1974) summarized bird observations in the Atigun and upper Sagavanirktok river valleys and reported 17 species of shorebirds, but most were infrequently encountered. The most widespread species appear to be American Golden-Plover, and Baird's

Table 3.2-6. *Relative abundance of shorebirds (birds/route) by ecoregion. Based on breeding-bird survey (BBS) routes within 50 km of the TAPS ROW (from USGS, 1999). The BBS is a large-scale survey of North American birds. It is a roadside survey conducted during the peak of the nesting season. Each route is 24.5 miles long, with a total of 50 stops located at 0.5-mile intervals along the route. A three-minute point count is conducted at each stop, during which the observer records all birds heard or seen within 0.25 mile of the stop (Sauer et al., 1999). The relative abundances reported below are the weighted averages [birds/(years x routes)] of number of birds per route by ecozone.*

			Interior Forests					
	Arctic Foothills	Brooks Range	Forested Lowlands & Uplands	Bottomlands	Highlands	Alaska Range	Copper Plateau	Pacific Coastal Mountains
Number of Routes	1	2	5	3	2	3	3	2
Routes*Years	6	12	27	21	9	16	26	14
American Golden-Plover	2.5	2.8	0.0	0.0	0.0	1.7	0.0	0.0
Semipalmated Plover	0.5	0.0	0.0	0.8	0.0	2.4	0.5	0.7
Killdeer	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Greater Yellowlegs	0.0	0.0	0.0	0.2	0.0	1.3	0.1	0.0
Lesser Yellowlegs	0.2	1.1	1.5	4.9	2.4	2.9	11.5	2.9
Unidentified Yellowlegs	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Solitary Sandpiper	0.0	0.0	0.3	0.2	1.6	0.0	2.1	0.2
Spotted Sandpiper	0.0	0.1	0.0	6.1	1.3	0.3	0.7	0.7
Upland Sandpiper	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Whimbrel	0.2	0.3	0.3	0.0	0.0	3.2	0.0	0.0
Ruddy Turnstone	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Semipalmated Sandpiper	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Least Sandpiper	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
Common Snipe	3.3	1.3	2.2	4.9	0.6	6.8	5.8	4.3
Red-necked Phalarope	0.0	0.9	0.0	0.0	0.0	6.7	0.4	2.4
Total Shorebirds	6.8	6.4	4.5	16.9	5.9	26.4	21.4	11.2

and Least sandpipers. Breeding bird surveys (USGS, 1999) from the Brooks Range ecoregion suggest low densities of shorebirds comprised of species more typically found farther south rather than those found in regions to the north (Table 3.2-6).

No information is available on shorebirds in the TAPS ROW during the post-breeding period. However, based on trends from the Prudhoe Bay oil field and other portions of the North Slope, most shorebirds would be expected to be closer to the coast, rather than inland near TAPS (Myers and Pitelka, 1980; Connors et al., 1979; TERA, 1994). This pattern would be even more pronounced after nesting, when shorebirds tend to shift from nesting areas to coastal areas. However, some species increase in abundance inland in the oil field and for an unknown distance along the TAPS route, and additional species are found on the southern coastal plain and foothills.

Quantitative data on shorebird distribution and abundance along the section of the TAPS ROW from the Brooks Range to Valdez are limited. The most standardized coverage comes from breeding-bird surveys (USGS, 1999) (Table 3.2-6). This description is preliminary because no ecoregion was well-covered by the surveys (maximum 5). The shorebird community south of the Brooks Range differs markedly from that to the north. In contrast to the *Calidris* sandpipers that dominate the tundra, the boreal forest zone is characterized by Tringinae shorebirds, such as yellowlegs. These birds occur in and around small lakes and fens, and in the case of Spotted Sandpiper, along rivers. Some arctic species, such as American Golden-Plover and Whimbrel, occur in alpine tundra. The most widespread shorebirds along the entire ROW south of the Brooks Range (and locally to the north) are Lesser Yellowlegs and Common Snipe (Table 3.2-6).

Shorebird abundance along this portion of TAPS appears to be highest in and south of the Alaska Range. One species of interest is the Upland Sandpiper, because it is considered threatened or endangered in some states, although not in Alaska. It occurs in subalpine areas along the southern slope of the Brooks Range, in open habitats of the Interior (such as near Delta), and in the Alaska Range (Anderson et al., 2000).

At least 45 species of shorebirds have been recorded in the North Gulf of Alaska Coast/Prince William Sound region (Gabrielson and Lincoln, 1959; Isleib and Kessel, 1973; Isleib, 1979; Senner, 1979; DeGange and Sanger,

1987; Gibson and Kessel, 1989). Of these, only 11 may breed in the region, indicating the importance of the region for migration rather than for nesting. No species are federally threatened or endangered, or are state species of special concern. The Copper River Delta, however, is a migratory stopover site of great importance to shorebirds (part of the Western Hemisphere Shorebird Reserve Network), and large proportions of the world populations of several species and subspecies (e.g., Western Sandpiper, *roselaari* subspecies of Red Knot, *pacifica* subspecies of Dunlin, *beringiae* subspecies of Marbled Godwit, Black Turnstone, Surfbird) traverse this region.

3.2.4.4 Seabirds

R. Lanctot

Photo 3.2-8. *Sabine's Gull.*

Fourteen species of seabirds regularly occur in the vicinity of the TAPS ROW: Pomarine, Parasitic, and Long-tailed jaegers; Bonaparte's, Mew, Herring, Sabine's, Glaucous, and Glaucous-winged gulls; Black-legged Kittiwake; Arctic Tern; Pigeon Guillemot; and Marbled and Kittlitz's murrelets (Gabrielson and Lincoln, 1959; Isleib and Kessel, 1973; Johnson and Herter, 1989). Eleven of these species are larids (jaegers, gulls, and terns), and three are alcids (Pigeon Guillemot and the murrelets).

At the northern end of the ROW, Pomarine and Parasitic jaegers prey on small birds (shorebirds and passerines) and small mammals (primarily lemmings) on the Arctic Coastal Plain. The Long-tailed Jaeger is a predator of small mammals and bird eggs. It nests on the North Slope and in alpine areas of the Brooks Range and Alaska Range along TAPS. Only Parasitic and Long-tailed jaegers are likely to be found nesting along the ROW, mainly north of the Brooks Range.

The Glaucous Gull is an arctic-nesting gull that occurs primarily on the Arctic Coastal Plain (Johnson and Herter, 1989). It winters mainly in the Bering Sea and occurs in smaller numbers in the Gulf of Alaska. In contrast, the Glaucous-winged Gull occurs only in the vicinity of the Valdez Marine Terminal. Bonaparte's, Mew, and Herring gulls nest throughout Interior Alaska along the TAPS ROW, with all three species migrating to the Pacific Coast during the winter. Bonaparte's and Mew gulls nest in trees, and Mew and Herring gulls nest in small colonies on gravel bars and on small, protected islands in lakes. Arctic Terns and Sabine's Gulls nest in scattered small colonies across the Arctic Coastal Plain on islands and polygonal tundra. Arctic Terns also nest throughout the Interior and along the southern coast on gravel bars and rocky islands in the vicinity of the Valdez Terminal. Arctic Terns undergo the longest annual migration of any bird species, spending the boreal winter in the Antarctic and returning to the Northern Hemisphere to nest every year.

The Pigeon Guillemot, Marbled Murrelet, and Kittlitz's Murrelet are alcids that occur in the vicinity of the Valdez Terminal. Guillemots may nest in rock crevices along the shorelines of the terminal, whereas the murrelets probably nest inland around the terminal, in trees (Marbled Murrelet), and on mountain tops (Kittlitz's Murrelet). A fourth species, the Black Guillemot, is a winter vagrant in scattered locations of Interior Alaska, including the vicinity of the TAPS ROW near Paxson. It breeds along the Beaufort Sea coast in the vicinity of the North Slope oil fields.

At least 47 species of seabirds (tubenoses, cormorants, larids, and alcids) have been recorded in the North Gulf of Alaska Coast/Prince William Sound region (Isleib and Kessel, 1973; Gould et al., 1982; DeGange and Sanger, 1987). Of these species, 28 may breed in the region (Figure 3.2-3, Table 3.2-7), and one is considered endangered by FWS (Short-tailed Albatross). In addition, Prince William Sound represents a significant portion of the world's population of both Marbled and Kittlitz's murrelets (Agler et al., 1998). The region is especially important to nesting gulls and alcids, particularly in Prince William Sound and on the Kenai Peninsula. However, numbers of wintering birds are much lower than numbers of summering birds. The total estimated population of breeding seabirds in this region is almost 1,000,000 birds (Table 3.2-7). The total population of seabirds in the North Gulf of Alaska Coast/Prince William Sound region may approach 1,500,000 to 2,000,000 birds during summer, when the breeding number is added to the large number of non-breeding albatrosses and Sooty and Short-tailed shearwaters summering from colonies farther south and non-breeding Northern Fulmars, storm-petrels, gulls, and alcids from Alaska (Isleib and Kessel, 1973).

3.2.4.5 Passerines and Other Birds

Passerines

Passerines (songbirds) are the largest group of birds that occur along the TAPS ROW, both in terms of numbers and species (Gabrielson and Lincoln, 1959). The ROW includes almost all habitats occupied by passerines in the state. Of the 174 species of passerines that have been recorded in

Alaska (Gibson, 1999), at least 70 probably regularly occur along TAPS (Gabrielson and Lincoln, 1959). The Boreal Partners in Flight Working Group (1999) recently identified "priority" species of landbirds in various biogeographic regions of Alaska (Table 3.2-8). These species are considered priorities based on their ranks for a series of criteria including whether Alaska contains most of the global population, if they are exclusively a boreal-breeding population, if there are negative population trends, if there are threats during non-breeding season, and if there is negative response to forest cover loss on breeding and wintering grounds. Many of these priority species are neotropical migrants (birds that winter in Central or South America) and have been considered species of concern by the State of Alaska (ADF&G, 1993, 1998). Most of these species also occur in habitats along the TAPS ROW.

Migrant passerines arrive in habitats along TAPS during late April-early June and begin breeding soon after arrival. Most young fledge by August, and southward migration begins soon thereafter. The breeding season for most resident passerines begins earlier — often by early April — and thus young are generally fledged by early summer.

At the northern end of TAPS, only a few species (Common Raven, redpolls, American Dipper) are residents (do not migrate), and the Common Raven is closely associated with areas of human habitation (Johnson and Herter, 1989). Ravens occasionally nest near the coast, primarily on buildings and other structures, including large buildings in the Prudhoe Bay and Kuparuk oil fields (Johnson and Herter, 1989; Ritchie, 1991; Day, 1998). Most passerines migrate to the Arctic Coastal Plain from wintering areas in temperate and tropical regions in North and South America, and a few species migrate from southern Asia. Over 30 species of passerines have been recorded on the coastal plain, and at least 8 are known or probable breeders (Johnson and Herter, 1989) (Table 3.2-5). The most abundant breeding species on the coastal plain is the Lapland Longspur (Johnson and Herter, 1989; TERA, 1993b), with average breeding densities of 21 nests/square kilometer (km^2). Other common breeding species on the coastal plain are the Common and Hoary redpolls, Snow

J. Lukin

Photo 3.2-9. *Common Raven.*

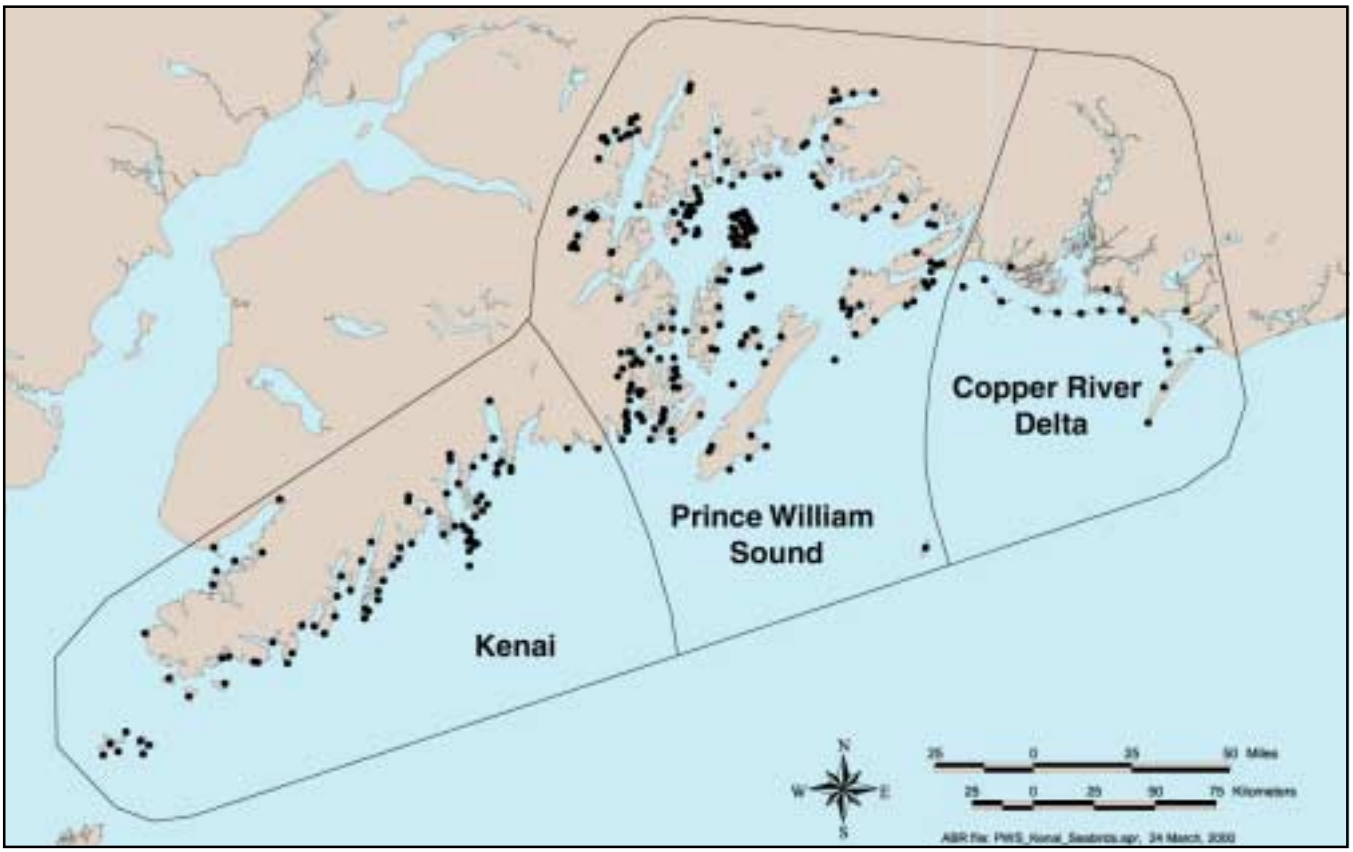


Figure 3.2-3*. Locations of seabird colonies in the North Gulf Coast/Prince William Sound region (Source: see Table 3.2-7).*

Table 3.2-7. *Seabird breeding populations in the vicinity of tanker routes in the North Gulf of Alaska Coast/Prince William Sound region. Colony locations are plotted on Figure 3.2-3. See Table 3.2-5 for scientific names of species.*

Species	Kenai Peninsula (a)	Prince William Sound Area (b)	Prince William Sound Area (c)	Copper River Delta (d)	Total (e)
Northern Fulmar	136	1,584 ± 948	–	–	1,720
Fork-tailed Storm-Petrel	150,000	15,822 ± 11,451	2,060	–	165,822
Leach's Storm-Petrel	Present	400	–	–	400+
Double-crested Cormorant	114	74 ± 110	74	266	454
Red-faced Cormorant	988	11 ± 18	14	166	1,168
Pelagic Cormorant	2,546	263 ± 225	7,880	220	10,646
Unidentified cormorant	765	–	–	–	765
Parasitic Jaeger	–	Present	–	Present	Present
Bonaparte's Gull	–	1,620 ± 1,343	–	Present	1,620+
Mew Gull	206	14,164 ± 5,526	87	820	15,190
Herring Gull	–	–	–	Present	Present
Glaucous-winged Gull	18,058	25,095 ± 6,547	7,630	16,390	59,543
Black-legged Kittiwake	81,324	48,227 ± 18,882	173,256	27,676	282,256
Caspian Tern	–	–	–	Present	Present
Arctic Tern	338	4,852 ± 1,656	1,748	600	5,790
Aleutian Tern	105	320 ± 549	–	5,328	5,753
Common Murre	80,044	2,751 ± 2,151	11,580	11,320	102,944
Thick-billed Murre	328	53 ± 93	100	–	428
Unidentified murre	2,394	–	–	–	2,394
Pigeon Guillemot	802	2,982 ± 905	2,430	–	3,784
Marbled Murrelet	Present	63,455 ± 16,043	–	Present	63,455+
Kittlitz's Murrelet	Present	1,280 ± 1,364	–	Present?	1,280+
Ancient Murrelet	702	188 ± 185	–	–	890
Cassin's Auklet	Present	Present	–	–	Present
Parakeet Auklet	809	809 ± 419	938	–	1,747
Rhinoceros Auklet	2,707	5,000	–	–	7,707
Horned Puffin	10,809	499 ± 391	436	8	11,316
Tufted Puffin	164,999	5,049 ± 2,126	20,951	8,510	194,460
Total	518,174+	352,054+	229,184+	71,304+	941,532+

(a) Data from *Alaska Seabird Colony Catalog* (FWS, 1999b).
(b) Data from Agler and Kendall (1997) for Prince William Sound.
(c) Data from *Alaska Seabird Colony Catalog* (FWS, 1999c) for Prince William Sound and Middleton Island.
(d) Data from *Alaska Seabird Colony Catalog* (FWS, 1999d).
(e) Total includes larger of two numbers presented for Prince William Sound.

Bunting, and Yellow Wagtail (Johnson and Herter, 1989; Johnson et al., 2000). The number of breeding species increases in the foothills, where more shrub habitats are available (Johnson and Herter, 1989). The most numerous passerines in the foothills are Savannah Sparrow, Yellow Wagtail, American Tree Sparrow, Lapland Longspur, and White-crowned Sparrow (Gabrielson and Lincoln, 1959). The Bluethroat, an Asian migrant, is a rare breeder in the shrub-lined drainages near Pump Station 2, where the bird attracts human visitors on wildlife tours traveling the Dalton Highway. Many of the passerines found in the foothills also occur in the Brooks Range, but as a whole, passerines are less numerous there. Another palearctic migrant, the Northern Wheatear, nests in alpine areas along the TAPS ROW and winters in Africa (Johnson and Herter, 1989).

Breeding bird communities of primarily passerines have been studied in the vicinity of TAPS near Fairbanks (Spindler, 1976), Fort Wainwright and Fort Greely (Benson, 1999; Anderson et al., 2000), Gulkana (Cooper et al., 1988), and at various breeding-bird survey routes on the Copper Plateau (USGS, 1999). In general, the numbers of

Table 3.2-8. *Priority bird species and their status by biogeographic regions occurring along the TAPS ROW (Boreal Partners in Flight Working Group, 1999). Biogeographic regions are those of Kessel and Gibson (1978). Scientific names for species are in Table 3.2-5.*

Priority Species	Biogeographic Region (a) and Status (b)		
	Northern	Central	Southcoastal
Gyrfalcon	R	R	—
White-tailed Ptarmigan	—	R	—
Sharp-tailed Grouse	—	R	—
Snowy Owl	B	—	—
Great Gray Owl	—	R	—
Boreal Owl	—	R	—
Rufous Hummingbird	—	—	B
Red-breasted Sapsucker	—	—	R
Black-backed Woodpecker	—	R	B
Olive-sided Flycatcher	—	B	—
Hammond's Flycatcher	—	B	—
Pacific-slope Flycatcher	—	—	—
Northern Shrike	—	B	—
Northwestern Crow	—	—	R
Chestnut-backed Chickadee	—	—	R
American Dipper	—	R	—
Gray-cheeked Thrush	B	B	B
Varied Thrush	—	B	B
Bohemian Waxwing	—	R	—
Townsend's Warbler	—	B	B
Blackpoll Warbler	—	B	B
Golden-crowned Sparrow	—	B	B
Smith's Longspur	B	B	—
Rusty Blackbird	—	B	—
White-winged Crossbill	—	R	—
Hoary Redpoll	B	—	—

(a) Corresponding major vegetational zones for the biogeographic regions: Northern = Arctic Coastal Plain, Arctic Foothills, Brooks Range; Central = Interior Forests, Alaska Range, Copper Plateau; Southcoastal = Pacific Coastal Mountains, Western Hemlock-Sitka Spruce Forests

(b) Status is R = resident breeding species or B = migrant breeding species; dash indicates it does not occur regularly in that region.

resident and migrant breeding birds increase in the more southern sections of the TAPS ROW, with upwards of 20 species breeding in some of the Interior forest habitats (Spindler, 1976; Benson, 1999; Anderson et al., 2000). White-crowned Sparrows and Dark-eyed Juncos are ubiquitous, occurring commonly in all ecoregions south of the Brooks Range. Alder Flycatcher, Swainson's Thrush, and American Robin are similarly widespread but less numerous in the Alaska Range. Other characteristic passerines by ecoregion are as follows:

- **Interior Forests:** Orange-crowned, Yellow-rumped, and Wilson's warblers.
- **Alaska Range:** American Tree Sparrow; Cliff Swallow; Wilson's and Arctic warblers.
- **Copper Plateau:** Cliff Swallow; Yellow-rumped and Wilson's warblers.
- **Pacific Coastal Mountains:** Orange-crowed, Yellow-rumped, and Wilson's warblers; Hermit Thrush.

At least 111 species of other bird species — involving a widely ranging group that includes both non-passerine groups and all passerine species — have been recorded in the North Gulf of Alaska Coast/Prince William Sound region (Gabrielson and Lincoln, 1959; Isleib and Kessel, 1973). Of these species, 63 may breed somewhere in the region, and at least 4 are state species of special concern: Olive-sided Flycatcher, Gray-cheeked Thrush, and Townsend's and Blackpoll warblers. All four of these species are found in terrestrial and not marine habitats.

Other Birds

Other birds found along the TAPS ROW include grouse and ptarmigan, Rufous Hummingbird, Belted Kingfisher, and six species of woodpeckers. Few quantitative studies have been conducted on these species, other than grouse and ptarmigan, which are game species.

Three species of ptarmigan (Rock, Willow, and White-tailed) are residents along TAPS. The first two species are common from the Arctic Coastal Plain to the Chugach Mountains, whereas White-tailed Ptarmigan are restricted primarily to the Thompson Pass area of the Chugach Mountains (Gabrielson and Lincoln, 1959; Kessel and Gibson, 1978). Although most Rock and Willow ptarmigan make a short migration to the Arctic Foothills and the Brooks Range in winter (Irving et al., 1967; Johnson and Herter, 1989), some remain year-round on the coastal plain. In spring as they again move northward to the coastal plain, these two species commonly use open tundra in the dust shadows of the Dalton Highway. Forest-dwelling grouse (Ruffed and Spruce) occur along the ROW between the Brooks Range and the Chugach Mountains, and Sharp-tailed Grouse occur in more open, grassy habitats between Fairbanks and Glennallen (Gabrielson and Lincoln, 1959).

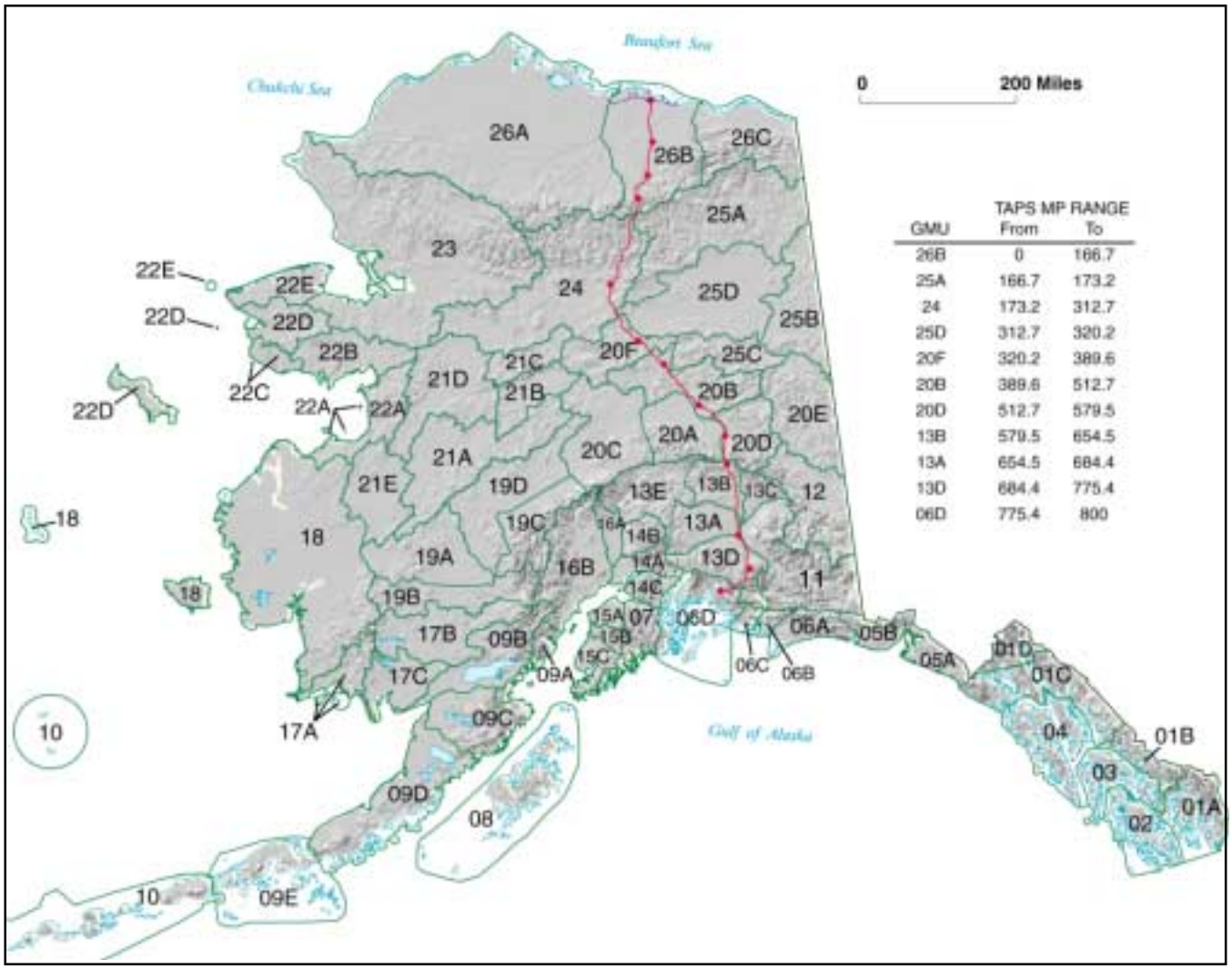
3.2.5 Terrestrial Mammals

By W. Ballard, H. Whitlaw, B. Lawhead, B. Burgess, S. Murphy, and M. Cronin

This section describes the distribution, numbers, and other characteristics of terrestrial mammals in the vicinity of the TAPS ROW, on the Alaska North Slope, and in the Prince William Sound region (Table 3.2-9). It is important to note that the *population* or the *herd* (for caribou or bison) is the unit of management for wildlife in Alaska. However, populations are often difficult to define due to emigration

Table 3.2-9. *Terrestrial mammal species, game management unit or herd, and recent population/herd status near TAPS ROW.*

Common Name	Scientific Name	Game Management Unit (GMU) or Herd	Recent Population/Herd Status
Moose	*Alces alces*	GMU 6	Low density; stable since 1960
		GMU 13	Currently at high density and stable; below management objectives
		GMU 20A	Currently stable or increasing slightly; population increased between 1976 and 1994
		GMU 20B	Currently increasing; increase began in 1980
		GMU 20D	Currently stable or increasing slightly; increase began in the early 1980s; low density; below management objectives
		GMU 24	Currently stable; low density
		GMU 26B	Currently declining and at low density; increased between 1950 and 1980; stable during late 1980s
Caribou	*Rangifer tarandus*	Nelchina Herd	Currently declining or stable at low numbers; increased between 1977 and 1996
		Delta Herd	Currently stable; declined between 1969 and 1975; increased between 1976 and 1989; declined between 1990 and 1993
		Ray Mountains Herd	Population trend unknown
		White Mountains Herd	Recognized as a distinct herd in early 1980s; currently stable or slowly increasing
		Central Arctic Herd	Currently stable; increased between 1975 and 1992
		Western Arctic Herd	Currently decreasing slightly; increased from 1976 to 1996
Muskoxen	*Ovibos moschatus*	GMUs 26B and 26C	Currently stable or increasing slightly; increase began with reintroduction in 1969
Bison	*Bison bison bison*	Delta Herd	Currently stable; stable since the mid 1980s
		Copper River Herd	Currently stable or increasing slightly
Dall Sheep	*Ovis dalli*	GMUs 11 and 13D (Chugach Mountains)	Current population trend is unknown; increased between late 1980s and the mid 1990s
		GMUs 13B, 20A and 20D (Delta Controlled Use Area)	Currently stable or declining slightly
		GMUs 24 and 26B (Brooks Range)	Currently declining slightly or stable; increased between 1970s and mid 1980s
Deer	*Odocoileus hemionus sitkensis*	GMU 6	Currently stable
Mountain goat	*Oreamnos americanus*	GMU 6	Currently stable; stable since 1990
		GMU 11	Population trend unknown
		GMU 13D	Currently stable or declining slightly
Brown bear (grizzly bear)	*Ursus arctos*	GMU 6	Stable or declining slightly since 1989
		GMU 13	Declining since 1980 due to ADF&G bear reduction efforts
		GMU 20	Currently stable or declining; decline initiated in 1981 due to ADF&G bear-reduction efforts
		GMU 24	Currently stable or increasing slightly
		GMU 26B	Currently stable or increasing slightly
Black bear	*Ursus americanus*	GMU 6	Currently stable
		GMU 13	Currently stable or increasing slightly
		GMU 20	Population trend unknown
Wolf	*Canis lupus*	GMU 6	Population trend unknown
		GMU 13	Currently stable or increasing slightly
		GMU 20	Currently stable
		GMU 24	Currently stable or increasing slightly
		GMU 26B	Currently stable



GMU	TAPS MP RANGE From	To
26B	0	166.7
25A	166.7	173.2
24	173.2	312.7
25D	312.7	320.2
20F	320.2	389.6
20B	389.6	512.7
20D	512.7	579.5
13B	579.5	654.5
13A	654.5	684.4
13D	684.4	775.4
06D	775.4	800

Figure 3.2-4. *State of Alaska game management unit map.*

and immigration among populations, and variation in range use and distribution. As a result, the ADF&G Division of Wildlife Conservation delineated biologically relevant game management units (GMUs) (Figure 3.2-4). ADF&G regularly conducts research projects on wildlife populations in GMUs to better understand processes and patterns in Alaskan ecosystems. Besides these research projects, ADF&G management staff produces annual survey-inventory reports designed to track the status of wildlife populations in each GMU (Miller, 1997). These reports provided much of the information presented in this section. The status of each terrestrial wildlife species in the GMUs through which the TAPS ROW passes is described. Information on these species specific to the ROW is sparse and sometimes anecdotal. Available information is integrated in Sections 4.3.2.5 and 4.4.2.5.

Alyeska Security helicopter flights provide records of terrestrial mammal observations along the ROW. However, flight procedures and data documentation have not been consistent from year to year. Therefore, although the data on the tables on the following pages cannot be used to compare populations from year to year, they do indicate that mammals regularly use the TAPS ROW. Between January 1991 and August 1996, observations of wildlife in the ROW were recorded between MP 150 and 800. Wildlife observations for MP 0 through 150 are not available. Flights were typically conducted in a helicopter at 90 knots and an altitude of 200 feet (ft) above ground level. Observations were made within the field of view of the observers while traveling along the ROW. More frequent flights were made during the first four years than for 1995 and 1996. The program was terminated on July 31, 1996.

During the flights, an onboard observer recorded wildlife sightings by species, milepost, and activity. In some cases, moose and caribou calves and bear cubs were identified, but generally only the species and numbers of ani-

mals, and not sex or age, were recorded. The five and one-half years of continuous data demonstrate that various birds and mammals regularly use the TAPS ROW. However, the data should be considered as indicative of general use of the ROW and not a formal census or an experiment. Identification of sex and age (e.g., calf moose or caribou or bear cubs) was opportunistic, and the level of effort per length of the ROW was not standardized. Thus, these data cannot be used for quantitative comparisons with other areas, but they provide a general assessment of wildlife use of the TAPS ROW. The raw data are recorded on field data sheets and a computer file, and are available from APSC.

Table 3.2-10 lists the large mammals observed by year during the Alyeska Security flights. Tables 3.2-11 through 3.2-16 tabulate the observations of six species by calendar month. The relatively low numbers for all species in 1995 and 1996 reflect the reduced frequency of flights and observer presence in those years. Other animals regularly sighted include snowshoe hares, squirrels, porcupines, horses, passerine birds, ptarmigan, grouse, geese, Sandhill Cranes and hawks.

Moose were the most common and consistently found mammal along TAPS (Table 3.2-11), although the numbers of animals vary considerably among years. Many moose cows with calves, including twin calves, were observed. The data suggest that moose continue to use traditional wintering and calving grounds. Note the sudden increase of moose numbers in May, coinciding with the calving period, following a declining trend for January through April. Of 3,113 moose observed in January and February, 76 percent were within 5 miles of traditional winter habitat, as identified in APSC (1993). Likewise, of 1,271 moose observed in May, 53 percent were found in 22 percent of the ROW within 10 miles of traditional calving grounds, as identified in the same source. Activities most often recorded for moose were feeding and resting (80 percent combined), as the helicopter flew overhead. These animals seem to have habituated to regular helicopter activity.

Other observations by Alyeska personnel indicate habituation of moose to TAPS. For example, in March 1978, Holland (1978) counted moose tracks along a section of TAPS between Shaw Creek and Rosa Ridge. Holland (1978) noted that "There were several signs of moose walking directly under the pipe for spans of 60 ft. Vegetation partially exposed directly under the pipe, appeared to serve as an attractive (sic) to the moose…Signs of grazing were evident in many locations as indicated by areas of hoofed out snow... One can only assume that the elevated pipe is presenting little to no determent (sic) to moose movement. In fact, it appears that the moose are utilizing the workpad more extensively this year than in past years and this is probably a result of less and less Alyeska utilization of the workpad."

These observations suggest the elevated pipeline intercepts snow or forms a windbreak resulting in less snow and more exposed vegetation directly under the pipe in some areas. This may attract moose in winter. In addition, these observations in 1978 suggest that as construction activity declined from the early 1970s, moose use of the ROW increased. Moose also use buried sections of TAPS in the spring, because snow melts earlier there, making vegetation available (Trudgen, 1999, pers. comm.).

Alyeska Security flight data indicate that caribou were also common along the ROW throughout the year (Table 3.2-12). Observations of caribou cows with calves were common. The data indicate that caribou continue to use a traditional migration route while transecting the TAPS and Richardson Highway in GMU 13. Of 1,206 caribou observed in May, 89 percent were found in 12 percent of the ROW within 10 miles of the traditional migration route of the Nelchina Caribou Herd, as indicated in APSC (1993). Likewise, of 2,040 caribou observed in October, 83 percent were in the same 12 percent of the ROW within 10 miles of the traditional migration route. Nelchina caribou have been observed moving under elevated TAPS pipe (Trudgen, 1999, pers. comm.). During the first months of 1993, large groups of caribou, presumably of the Fortymile and Delta herds, congregated around MP 450 and 600, respectively (Table 3.2-12). Sixty-five percent of the caribou recorded during helicopter overflights were feeding and resting.

Bison are common just south of Delta Junction where the TAPS traverses the Delta River and Richardson Highway. Of 1,618 total bison observed, 90 percent were found in 2 percent of the ROW within a traditional travel and use area, as indicated in APSC (1993). Movements were recorded primarily in spring and late summer (Table 3.2-13). In 1992 and 1994, a few Dall sheep were observed using the ROW at the northern limit of the Security surveillance flights in the Atigun Pass area.

Predators, including black bears, grizzly bears, and wolves, are also frequently seen in the TAPS ROW (Table 3.2-10). Wolverines, lynx, fox, and coyote were observed less frequently. Bear sows with cubs were commonly observed. This includes several observations of both black and grizzly bears with twin or triplet cubs. The observed presence of bears and wolves along the ROW was tabulated by calendar month in Tables 3.2-14 through 3.2-16. Active feeding on moose and other unidentified prey by wolves, coyotes, foxes, lynx, hawks, and bears was recorded. Whether this was from active predation or scavenging is not

Table 3.2-10. *Species observations within the TAPS ROW as recorded during Alyeska Security flight surveillance (effort not consistent throughout study with a marked decrease in 1995 and 1996).*

	1991	1992	1993	1994	1995	1996 (a)
Bison	361	273	444	270	109	161
Bear (species unknown)	6	21	3	3	0	0
Black bear	97	84	77	47	21	4
Caribou	785	3,191	5,433	626	458	444
Coyote	39	32	22	9	1	2
Dall sheep	0	21	0	12	0	0
Fox	22	16	20	5	8	0
Grizzly bear	78	38	52	17	27	0
Lynx	1	2	3	4	1	1
Moose	2,628	2,886	2,563	2,050	726	248
Wolf	68	142	129	84	12	4
Wolverine	0	0	2	0	0	0
Total	4,085	6,706	8,748	3,127	1,363	864

a. Observer program terminated July 31, 1996.

Table 3.2-11. *Moose observations along the TAPS ROW by month and year as recorded during Alyeska Security flight surveillance (effort not consistent throughout study with a marked decrease in 1995 and 1996).*

	1991	1992	1993	1994	1995	1996 (a)	Total
January	423	469	292	267	105	32	1,588 (b)
February	397	483	230	246	104	65	1,525 (b)
March	284	330	198	172	81	56	1,121
April	245	134	160	90	71	29	729
May	271	329	285	252	94	40	1,271 (c)
June	110	195	72	69	23	13	482
July	81	132	126	90	47	13	489
August	42	84	112	85	38	-	361
September	139	126	261	100	62	-	688
October	176	118	206	130	56	-	686
November	154	176	411	242	16	-	999
December	306	310	210	307	29	-	1,162
Total	2,628	2,886	2,563	2,050	726	248	11,101

a. Observer program terminated July 31, 1996.
b. Strong presence of moose around traditional wintering areas.
c. Strong presence of moose around traditional calving areas.

Table 3.2-12. *Caribou observations along the TAPS ROW by month and year as recorded during Alyeska Security flight surveillance (effort not consistent throughout study with a marked decrease in 1995 and 1996).*

	1991	1992	1993 (a)	1994	1995	1996 (b)	Total
January	0	3	894	20	51	10	
February	0	68	1,165	45	0	0	1,278
March	21	163	1,591	36	0	5	1,816
April	40	72	616	118	9	21	876
May	548	157	226	145	111	19	1,206 (c)
June	56	101	3	15	0	2	177
July	6	5	109	2	14	387	523
August	40	93	81	10	15	-	239
September	1	323	236	48	0	-	608
October	12	1,363	378	147	140	-	2,040 (c)
November	27	453	68	40	1	-	589
December	34	390	66	0	117	-	607
Total	785	3,191	5,433	626	458	444	10,937

a. Large groups congregating around MP 450 and 600 during January, February, and March 1993.
b. Observer program terminated July 31, 1996.
c. Strong presence of caribou around a traditional migration route during May and October.

Table 3.2-13. *Bison observations along the TAPS ROW by month and year as recorded during Alyeska Security flight surveillance (effort not consistent throughout study with a marked decrease in 1995 and 1996).*

	1991	1992	1993	1994	1995	1996 (a)	Total
January	0	0	2	0	0	0	2
February	83	0	64	0	0	0	147
March	85	12	198	28	1	4	328 (b)
April	55	31	77	148	16	33	360 (b)
May	75	34	0	0	0	0	
June	5	13	0	2	0	0	
July	58	172	53	0	92	124	499 (b)
August	0	1	50	92	0	-	143 (b)
September	0	0	0	0	0	-	0
October	0	10	0	0	0	-	10
November	0	0	0	0	0	-	0
December	0	0	0	0	0	-	0
Total	361	273	444	270	109	161	1,618

a. Observer program terminated July 31, 1996.
b. Strong presence of bison within a traditional travel route in March, April, July and August.

Table 3.2-14. *Wolf observations along the TAPS ROW by month and year as recorded during Alyeska Security flight surveillance (effort not consistent throughout study with a marked decrease in 1995 and 1996).*

	1991	1992	1993	1994	1995	1996 (a)	Total
January	13	2	0	15	0	4	34
February	4	9	16	10	1	0	40
March	9	68 (b)	16	3	6	0	102
April	10	13	2	6	2	0	33
May	2	4	6	3	0	0	15
June	1	1	2	5	1	0	10
July	2	3	4	4	0	0	13
August	1	3	5	2	0	-	11
September	5	0	5	0	1	-	11
October	15	16	42	6	0	-	79
November	4	5	23	21	0	-	53
December	2	18	8	9	1	-	38
Total	68	142	129	84	12	4	439

a. Observer program terminated July 31, 1996.
b. Single pack of ten wolves recorded once on 7 March and twice on 8 March travelling north from MP 432 until seen stationary at MP 422.

Table 3.2-15. *Black bear observations along the TAPS ROW by month and year as recorded during Alyeska Security flight surveillance (effort not consistent throughout study with a marked decrease in 1995 and 1996).*

	1991	1992	1993	1994	1995	1996 (a)	Total
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	3	0	4	0	3	0	10
May	41	17	42	24	4	1	129 (b)
June	10	14	6	9	3	2	44
July	22	16	7	6	3	1	55
August	20	20	12	8	5	-	65
September	0	13	3	0	3	-	19
October	1	4	3	0	0	-	8
November	0	0	0	0	0	-	0
December	0	0	0	0	0	-	0
Total	97	84	77	47	21	4	330

a. Observer program terminated July 31, 1996.
b. Spring emergents concentrated between MP 280-295, 340-403, and 720-790 amidst some traditional and some non-traditional use areas.

Table 3.2-16. *Brown (grizzly) bear observations along the TAPS ROW by month and year as recorded during Alyeska Security flight surveillance (effort not consistent throughout study with a marked decrease in 1995 and 1996).*

	1991	1992	1993	1994	1995	1996 (a)	Total
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	2	0	0	0	1	0	3
May	54	10	34	3	12	0	113 (b)
June	10	7	4	4	5	0	30
July	5	2	10	2	5	0	24
August	0	9	0	0	2	-	11
September	1	8	1	7	2	-	19
October	6	2	3	1	0	-	12
November	0	0	0	0	0	-	0
December	0	0	0	0	0	-	0
Total	78	38	52	17	27	0	212

a. Observer program terminated July 31, 1996.
b. Spring emergents concentrated between P/L MP 160-305 and 610-700 amidst some traditional and some non-traditional use areas.

known, but both are likely. Details on animals' activities are in the raw data set from Alyeska security flights.

The APSC wildlife observation program has documented that wildlife regularly use the TAPS ROW on a year-round basis. It is likely that animals used habitats within the ROW, in addition to passing through the area.

3.2.5.1 Moose

Population History and Status

Moose are present in the vicinity of the TAPS ROW throughout its entire length. The following discussion is organized into three sections based on geography and state GMU boundaries: Southcentral (GMUs 6 and 13), Interior (GMUs 20 and 24), and Northern (GMU 26B) (Figure 3.2-5). In general, moose populations have fluctuated in response to various factors. Populations in most of the GMUs the ROW crosses are limited primarily by predation and weather. Hunting, accidental mortalities (e.g., vehicle collisions), and habitat quality also influence moose populations to various degrees.

J. Lukin

Photo 3.2-10. *Cow moose.*

Southcentral. In GMU 6 at the southern end of the TAPS ROW, moose are generally limited to the lower 40 km of the Lowe River valley, less than 8 km from the TAPS ROW (APSC, 1995a). This small population has not extended its range since at least 1960, and currently numbers about 60 animals (Hicks, 1996a).

Moose in GMU 13 have fluctuated in numbers since the early 1900s. The first major population increase in recent times occurred in the 1940s and 1950s, peaking in the early 1960s in response to frequent wildfires, low predator numbers due to extensive federal predator control, and relatively low harvest by humans (Ballard et al., 1987, 1991; Tobey, 1996a). Since the 1960s, moose declined to low levels around 1975 as a result of severe winters, predation, and fire suppression. They then increased to relatively high numbers around 1987 in response to predator control and mild winters, and declined again to stable levels around 1991 as a result of severe winters and increased predation (Ballard et al., 1991; Tobey, 1996a). Recent herd-census data in GMU 13 were 25 to 30 percent below management objectives (Hicks, 1998b), but at generally high density nonetheless (Testa, 1999). Moose populations in this area are limited by weather; predation by wolves, brown bears, and black bears; and range conditions primarily related to fire suppression (Ballard et al., 1987, 1991; Collins, 1999; Testa, 1999). An estimated 50 moose per year are killed in GMU 13 by collisions with motor vehicles (Sinnott, 1999, pers. comm.).

Interior. In Interior Alaska, moose populations have followed similar trends to those in Southcentral. All GMUs in this area (20A, 20B and 20D) had relatively low numbers of moose in the 1940s and early 1950s. Populations increased in the late 1950s and early 1960s in response to federal predator-control programs, and in some areas to extensive wildfires (GMU 20B) and/or mild winters (20D) (Gasaway et al., 1983; Boertje et al., 1996; DuBois, 1996a; Dale, 1996b).

Moose in GMU 20A reached high densities estimated at

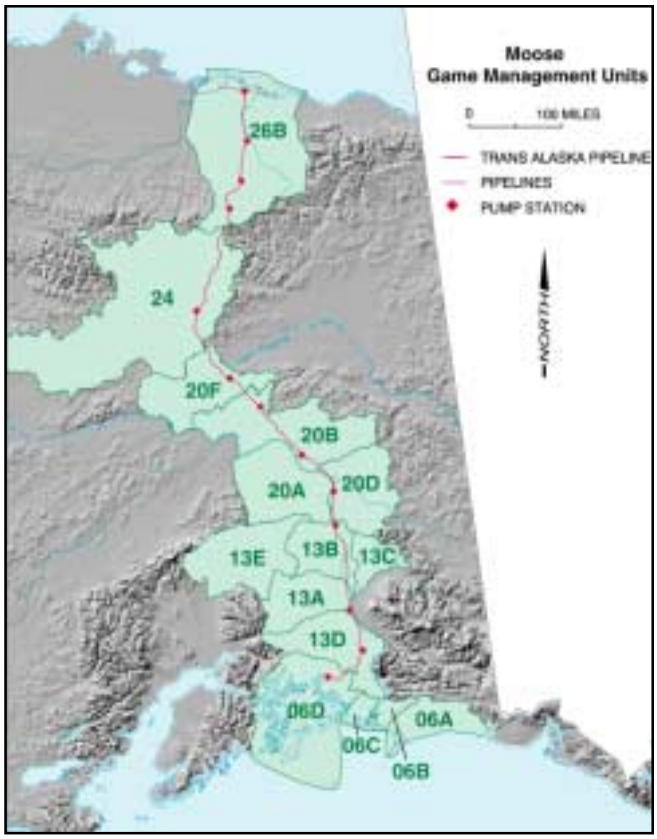


Figure 3.2-5. *Game management unit map for moose along TAPS.*

1.5 to 2.0/km^2 in the mid-1960s (Boertje et al., 1996). A rapid population decline about 1970 followed this peak, probably in response to a series of severe winters, high harvests by humans, wolf predation, and habitat overutilization (McNay, 1989). Moose were at their lowest numbers by the mid-1970s, but subsequently increased in response to a wolf reduction program during 1976-1981 (Gasaway et al., 1983). Between 1976 and 1994, a series of censuses and population estimates showed an increase in moose numbers: 3,511 in 1978, 11,072 in 1992, and 13,300 in 1994 (McNay, 1993; Hicks, 1995a). In 1997, moose numbers in GMU 20 were high at approximately 1.3/km^2 (Boertje et al., 1999). The population in GMU 20A is currently stable or increasing slightly (Dale, 1996a). Predation limits this population (Boertje et al., 1996), although harvest by humans, and forage and nutrition may also play a role in certain years (Boertje et al., 1999).

After the predator-control-related increase in the 1950s, moose populations in GMU 20B declined between the late 1960s and late 1970s following a series of severe winters, increasing wolf numbers, and excessive harvest by humans (Gasaway et al., 1983; Dale, 1996b). From 1980 to the present, the population has increased due to wolf control (1980-86) and restrictive hunting regulations. In 1990, moose numbers in this unit were estimated at 9,800. Moose/vehicle and moose/train collisions are important sources of mortality in GMU 20B; strategies to reduce these deaths include increased public awareness and education (Dale, 1996b). An estimated 50 moose per year are killed by motor vehicle collisions in GMU 20 (all subunits) (Sinnott, 1999, pers. comm.).

In the mid-1960s, moose numbers in GMU 20D were relatively high but declined through the early 1970s following severe winters (DuBois, 1996a). Population growth after the decline was slow and limited due to overharvest and to predation by wolves, brown bears, and black bears. In the early 1980s, moose numbers began to increase in response to wolf control and a series of mild winters. By 1995, the population in GMU 20D had not achieved management objectives (DuBois, 1996a).

Moose colonized GMU 24 during the 1930s-1950s and population growth was relatively slow. With the initiation of the federal predator-control program in the late 1950s, the population in this unit grew steadily, peaked in the mid-1970s, and declined shortly thereafter (Osborne, 1993). In 1989, the population estimate for the central area of GMU 24 was 3,000 to 4,000 moose (Osborne, 1989).

Northern. North of the Brooks Range, moose were scarce during the first half of the century (LeResche et al., 1974; Coady, 1980). Numbers in GMU 26B eventually increased from the mid-1950s to the early 1980s in response to predator-control programs and reductions in harvest by humans around 1950 (Stephenson, 1993). The population in GMU 26B was estimated to be stable in the mid-1980s at approximately 700 moose, with an estimated density of 0.50 moose/km^2 in 1986-87 (Nowlin, 1989; Stephenson, 1996a).

In 1990, the unit's population peaked at 0.58 moose/km^2, or approximately 1,000 to 1,200 animals, while a "significant" population decline was detected in 1992, perhaps due to poor habitat conditions (Stephenson, 1996a). The decline has continued with population estimates of 0.41 moose/km^2 in 1994-95 and 0.15/km^2 in 1995-96 (Stephenson, 1996a). Stephenson (1996a, p. 475) reported, "Population surveys in 1994 indicated numbers had declined by approximately 40 percent compared to surveys in the late 1980s. 1995 surveys indicated moose numbers declined by 60 percent since 1994, with an overall decline of 75 percent since the late 1980s. The reasons for the dramatic decline are not well understood, but available evidence indicates predation, insect harassment, and range deterioration may all be factors. Calf survival and recruitment have been extremely low in the last few years. Unless conditions improve, moose populations on the North Slope

will probably persist at low density."

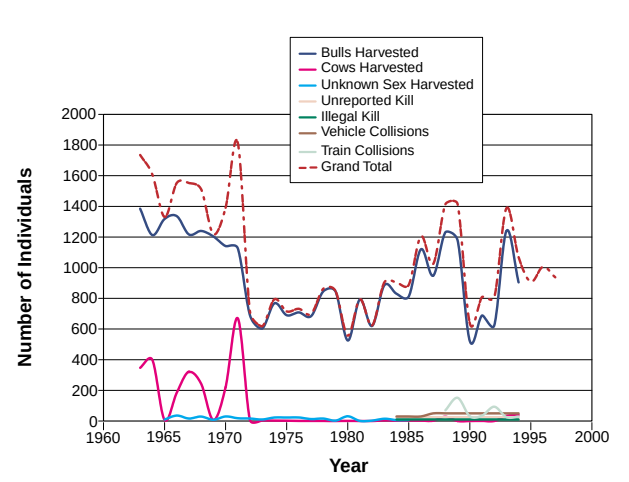
Stephenson (1993) indicated that habitat severely limited the number of moose that could be sustained and harvested in GMU 26B, and that although harvest by humans was not a factor in initiating or maintaining the early 1990s decline, it was the limiting factor that ADF&G could control. Roadkills have not been identified at this time as a significant limiting factor on moose in GMU 26B (Sinnott, 1999, pers. comm.).

Harvest by Humans and Population Management

Southcentral. The harvest and population-management goals for moose in the three Southcentral GMUs in the vicinity of TAPS are very different from each other. Near Valdez, where the population has remained small since the 1960s, the total harvest from 1960 through 1994 was approximately 34 moose (Hicks, 1996a). No moose were harvested during either 1994-95 or 1997-98 (Hicks, 1998a).

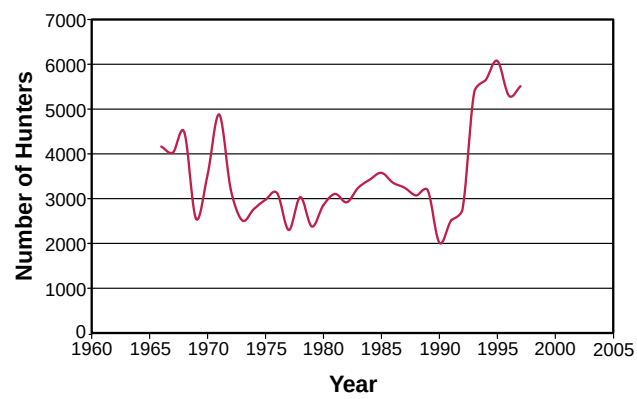
In contrast, GMU 13 has historically been one of the most important hunting areas in Alaska because of easy road access and proximity to human population centers (Ballard et al., 1991; Tobey, 1996a). As moose populations declined in this unit between the late 1960s and 1975, season lengths were reduced and regulations restricted to reduce total harvest (Figure 3.2-6) (Tobey, 1996a). An attempt to liberalize the restrictions (brief cow harvest and extended bull season) in response to the 1987 population peak was cancelled after one year because of severe winter weather. It is expected that harvest numbers will decline due to poor calf recruitment (Hicks, 1998b). Annual hunting pressure (i.e., hunter numbers) in GMU 13 has increased since the 1960s (Figure 3.2-7). Hunting pressure was most likely influenced by hunting restrictions in adjacent federally managed areas. In 1976, the ADF&G management goal for this area was to provide the greatest opportunity to participate in hunting moose. Current management objectives call for increasing the moose population to 20,000 to 30,000 adults and for annual harvests between 1,200 and 2,000 moose (Hicks, 1998b).

Interior. Moose harvests and regulations in Interior GMUs have been determined primarily in response to fluctuations in population numbers. In GMU 20A the highest average annual harvest of 617 moose was recorded during and slightly after a population peak in 1969-74 (McNay, 1989). Previously, the annual harvest averaged 311 in 1963-69. Between 1975 and 1978, in response to declining moose numbers, ADF&G restricted harvests to bulls only, resulting in a reduced average annual harvest of only 64 moose. These restrictions contributed to the subsequent population increase, and between 1983 and 1994, the average moose harvest rose to 365 annually (Dale, 1996a). In 1996-97, a cow season was initiated for the first time in almost 30 years (Hicks, 1997a). The 1978-95 management objectives for GMU 20A included direction to achieve and maintain a November population of between 10,000 and 12,000 adult moose by 1995, and to allow a cow harvest when the population was above 10,000 adults. By 1993, State objectives had been met.



Source: Tobey (1996a)

Figure 3.2-6. *Moose mortality chart for GMU 13.*



Source: Tobey (1996a)

Figure 3.2-7. *Moose hunter numbers for GMU 13.*

In GMU 20B, hunting pressure has traditionally been high because of its proximity to Fairbanks and extensive road systems (Dale, 1996b). Annual harvests have ranged from 299 to 438 bulls since 1984. Management objectives for GMU 20B include direction to manage for a population of 10,000 adult and yearling moose by 1993, and to sustain an annual harvest of 300 to 400 bulls until the population

objective is reached. Although the harvest objectives have been met since the mid-1980s, the population objective has not yet been achieved (Dale, 1996b).

GMU 20D is relatively remote, and hunting pressure is highest in the unit's more easily accessible portions such as Delta Junction and vicinity (DuBois, 1996a). Before the 1970s, the hunting season was long, and harvest of both bulls and cows was legal. The season was closed during 1971-73 because the population declined, and reopened in 1974 with restricted permit-only hunting regulations (McIlroy, 1974). The season has gradually been liberalized with increasing moose numbers in 1975-88 (DuBois, 1996a). From 1988 to present, changes have been made in the regulations to stabilize the harvest and moose numbers, and to improve the age/sex structure of the population. In the vicinity of the TAPS ROW, current management goals of 3,000 moose in the northern portion of the unit and 2,500 moose in the southwestern portion have not been met (DuBois, 1996a).

Moose hunting in GMUs 24 and 26B is influenced by the presence of the Dalton Highway. The highway was opened for commercial use (including hunting guides) in 1978 and opened to the general public in 1995 (Osborne, 1989; Stephenson, 1996a). The Dalton Highway Corridor Management Area (DHCMA) extends 8 km from each side of the Dalton Highway from the Yukon River north to the Prudhoe Bay Closed Area. The DHCMA is closed to sport hunting with rifles, but game may be taken with bow and arrow. No motorized vehicles, except aircraft, boats and licensed highway vehicles, may be used to transport game or hunters within the DHCMA. All hunters traveling on the Dalton Highway must stop at check stations operated by ADF&G within the DHCMA.

During the past 25 years, moose harvests have ranged from 44 to 134 annually in GMU 24; harvests did not exceed 100 until 1980 (Osborne, 1989). Biologists believe that harvests increased because more local hunters were aware of reporting requirements, reporting compliance increased, and improved access was available with the opening of the Dalton Highway to commercial uses. In response to population fluctuations, seasons in GMU 24 have been relatively liberal until recently, when antler restrictions to harvest older bulls were implemented (Osborne, 1989). Hunting pressure and numbers of moose harvested along the Dalton Highway have increased since its opening in 1978. In 1996, hunting pressure along the highway had stabilized at approximately 119 hunters and 54 moose harvested per year (Hicks, 1996b). The determination of actual harvests in GMU 24 has been a continual challenge for ADF&G biologists. In 1989, illegal and unreported harvests were hampering moose management, and the actual harvest was estimated to be twice the reported harvest. Management objectives for GMU 24 include direction to determine harvests and to increase the moose population north of Bettles, excluding Gates of the Arctic National Park, to 3,000 to 3,500 adults (Hicks, 1996b).

Northern. As the moose population in GMU 26B increased between the early 1970s and late 1980s, harvest season and restrictions remained liberal (1978-87 any-moose season) (Stephenson, 1993, 1996a). In the late 1970s, harvests increased with increased use of the Dalton Highway, but in 1980 following implementation of the DHCMA, hunting pressure shifted somewhat to GMU 26A (Melchoir, 1980). Between 1986 and 1995, annual moose harvests in GMU 26B ranged from 25 in 1990-91 to 52 in 1986-87 (Stephenson, 1996a). During 1987-94, regulations were changed to any-bull in response to reduced population growth and changes in age/sex composition. These regulation changes apparently reduced the harvest to a sustainable level in the DHCMA and in the remainder of GMU 26B (Stephenson, 1996a). However, antler restrictions were imposed in 1994 in response to the detected population decline, and the season in GMU 26B was closed in 1996 (James, 1996). The concentrated nature of moose distribution (primarily in riparian areas) and open habitat create the potential for excessive harvest in accessible areas (Stephenson, 1993).

Distribution and Habitat Use

Southcentral. In GMU 6 the small moose population is restricted to the lower 40 km of the Lowe River, just north of Valdez (APSC, 1995a). Moose winter and calving concentration areas occur in the vicinities of the Lowe and Tiekel river valleys adjacent to TAPS (APSC, 1993).

In GMU 13, the moose population has remained below habitat carrying capacity since the 1960s (Tobey, 1996a). Initial analyses presented by Ballard et al. (1985) indicated that spruce and willow vegetation types were preferred habitats in GMU 13. Ballard et al. (1991) determined that moose in Southcentral Alaska preferred lower-elevation sites during winter due to shallow snow depths. They also reported that moose were widely distributed over GMU 13 during summer. In all seasons, factors such as browse quantity, snow depth, elevation, thermal and escape cover, traditional use, slope, and aspect influenced where moose were located (Ballard et al., 1991).

Moose movement studies have been conducted in GMU 13 in relation to the TAPS ROW. Van Ballenberghe (1978) and Eide et al. (1986) both reported that migratory and nonmigratory moose populations came in contact with the

ROW. In addition, Ballard et al. (1991) identified three periods of movement (movement to rutting, and autumn and spring migrations) and seasonal and total home range sizes for moose in GMU 13 near TAPS.

Along a 110-km portion of the ROW between Glennallen and Paxson, Van Ballenberghe (1978) identified moose populations and population segments adjacent to portions of TAPS. He also identified and described the seasonal ranges of these populations, in addition to the extent, timing, and duration of migratory movements between the ranges. Migratory moose tagged in the eastern Alphabet Hills west of TAPS during autumn moved south or southeast during early winter to their winter range, and returned traveling north or northwest along the same routes during spring to their summer range in the Alphabet Hills (Van Ballenberghe, 1978). Moose tagged during autumn in the upper Gakona River east of TAPS migrated south or southeast during movements to winter range, and then north or northwest in spring to return to the traditionally used summer and autumn ranges of the river. These movements crossed TAPS and the adjacent Richardson Highway. Van Ballenberghe (1978) also documented nonmigratory moose in both populations.

Within the 110-km stretch of TAPS studied by Van Ballenberghe (1978), Eide et al. (1986) determined that the 60.4-km segment from the buried Glenn Highway crossing near Glennallen to the buried Richardson Highway crossing at Hogan Hill was the best moose habitat during the first year of pipeline operation (based on the number of moose crossings [n = 533] in this section).

Interior. Moose in the Interior GMUs generally have not been limited by habitat availability or quality, but rather by winter weather and predation (Gasaway et al., 1983; Boertje et al., 1996). Habitat (i.e., forage quality and availability) may have been overutilized in the 1960s when populations were high. Habitat assessments have not been regularly conducted in these units; however, a 1994 wildfire burned 22,400 acres in GMU 20D and probably improved habitat conditions in that area.

Moose are distributed throughout GMUs 20A, 20B, and 20D, although densities are dependent on season and available habitat. Gasaway et al. (1983) documented that the Interior moose population in the TAPS vicinity was composed of both migratory and nonmigratory segments. Moose encountered TAPS during seasonal migrations and during their regular daily movements. Migratory radio-collared adults typically moved in February-April to the Tanana Flats, where cows calved in May. They remained there during summer and returned during August-October to adjacent hills and mountains (Gasaway et al., 1983). Nonmigratory moose were common in the Tanana Flats and southwestern mountains (Gasaway et al., 1983).

During February and March 1982 and 1983, Sopuck and Vernam (1986a, b) investigated the distribution and movements of nonmigratory resident moose adjacent to the TAPS ROW between Pump Station 8 and Big Delta. Within a 15-km-wide corridor centered on the pipeline, over 75 percent of groups observed during aerial surveys and 75 percent of moose trails observed were within 500 m of a stream. Most (49 percent) of these trails were in shrub and burned/disturbed habitats (Sopuck and Vernam, 1986a, b). Observed trails near TAPS were thought to be used for travel between feeding in shrub habitats and riparian willow habitats and bedding sites in conifer and deciduous/mixed-wood areas.

Northern. Habitat use and distribution in GMUs 24 and 26B are more highly dependent on the availability of riparian areas than in the Southcentral and Interior regions. TAPS-specific distribution and habitat use are not available in these northern GMUs. Moose are generally found in many habitats in these areas, except for high, steep, rocky slopes (BLM, 1989). Lowland bogs are important components of summer range in providing habitat for calving concentration areas.

Conditions in the Koyukuk River lowlands in GMU 24 are good and provide abundant winter habitat. In addition, frequent lightning-caused fires result in good browse conditions. Browse availability has not limited moose populations in this area (Osborne, 1989, 1993).

Farther north, moose are relatively recent residents of the North Slope, and their habitat use and distribution are seasonal. During some years, moose range to the coast during the summer (Noel and Olsen, 1999a, b), yet during the winter are limited to inland riparian and shrub habitats (Coady, 1980). In other years, habitat use is limited primarily to riparian areas on a year-round basis (Mould, 1980).

3.2.5.2 Caribou

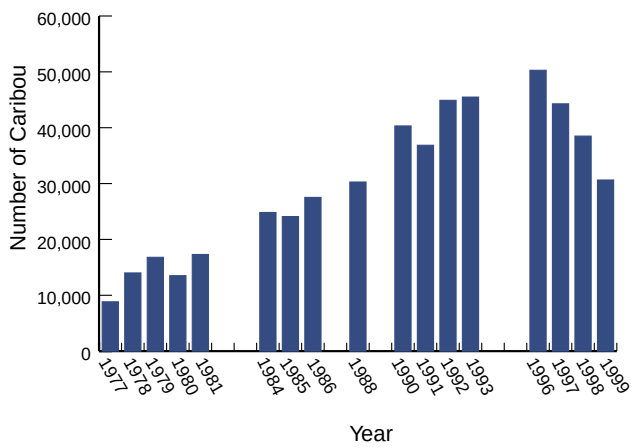
The Nelchina, Delta, Central Arctic, and Western Arctic caribou herds regularly encounter the TAPS ROW in portions of their summer or winter ranges, or during migrations to seasonal ranges. Several other herds also occur in the vicinity of TAPS and the Dalton Highway (i.e., the Ray Mountains and White Mountains herds), and may encounter the ROW. Although the Mentasta, Macomb, and Fortymile herds occur near TAPS, their ranges do not overlap the ROW and they are not addressed here. The traditional ranges of the Teshepuk Lake and Porcupine herds on the North Slope do not include the TAPS ROW, but they are

near the North Slope oil fields. See Figure 3.2-8 for a graphic representation of caribou herd distribution in the vicinity of the TAPS ROW. It is important to note that caribou herds are defined by calving grounds, and herds may not be totally independent. They may have overlapping fall or winter ranges and exchange animals (Cronin et al., 1997, 1998). Thus, the term *herd* is used rather than *population.*

Herd History and Status

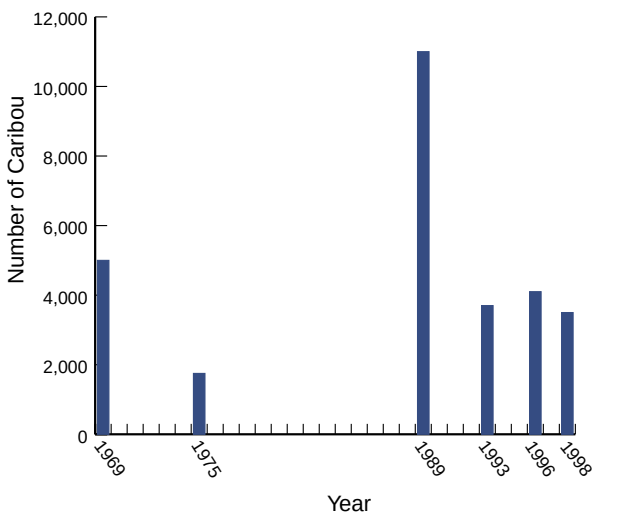
Nelchina Herd. During the late 1940s, the Nelchina Caribou Herd (NCH) was estimated at 5,000 to 15,000 animals (Lieb, 1989). The herd increased during the 1950s and 1960s, reached approximately 71,000 caribou by 1962 (Siniff and Skoog, 1964; Skoog, 1968), and then declined to possibly less than 10,000 by 1972 (Bos, 1975). The population decline was attributed to heavy hunter harvests (Skoog, 1968; Bos, 1975), in addition to wolf predation and unfavorable weather conditions (Van Ballenberghe, 1985; Bergerud and Ballard, 1988, 1989). From 1977 to 1983, the NCH again increased from 14,000 to 25,000 animals (Pitcher, 1984), and continued to increase to an estimated high of 50,280 by 1995-96 (McDonald, 1996) (Figure 3.2-9). By 1999, the herd had declined to about 31,365 adults (McDonald, 2000). During the past four years, the NCH has fluctuated in response to forage and weather conditions, predation, and increased harvests by humans. The current management objective for the NCH is to stabilize the herd to 35,000 to 40,000 caribou by harvesting the annual growth increment (McDonald, 2000).

Delta Herd. The Delta Caribou Herd (DCH) decreased from 5,000 animals in 1969 to approximately 1,500 to 2,000 in 1975, increased to nearly 11,000 in 1989, and then declined to about 3,700 caribou in 1993 (Davis et al., 1991; ADF&G unpubl. data cited in Eagan, 1995) (Figure 3.2-10). The initial herd increase was a result of wolf control between 1975 and 1982, combined with favorable weather conditions (Gasaway et al., 1983; Boertje et al., 1996). The decline in the early 1990s was thought to result from synergistic interactions of adverse weather and wolf predation. Range conditions apparently did not limit the growth of this high-density herd (Boertje et al., 1996). In 1996 the DCH had increased to about 4,100 (James, 1997a) in response to renewed wolf-control efforts by ADF&G (Boertje et al., 1996), and the herd stabilized at just over 3,500 based on the 1997-98 census results (Dale, 1997a; Valkenburg et al., 1999). Results of long-term research on the DCH and adjacent caribou herds suggest that adverse weather can cause decreased production of calves and increased vulnerability to predation over a wide range of caribou densities (Boertje et al., 1996; Valkenburg, 1997).



Sources: McDonald (1996, 2000), ADF&G (1999)

Figure 3.2-9. *Nechina Caribou Herd population estimates.*



Sources: Davis et al. (1991), Eagan (1995), James (1997a), Valkenburg et al. (1999)

Figure 3.2-10. *Delta Caribou Herd population estimates.*

Ray Mountains Herd. Robinson (1988) generated a herd estimate of 500 caribou for the Ray Mountains Herd (RMH) based on a survey of all known upland ranges. In 1994 the herd was estimated at 1,000 to 1,500 caribou (Osborne, 1995). In June 1995, counts from photographs of aggregated RMH caribou calculated herd size to be 1,737 caribou (Woolington, 1997a). The current herd trend is unknown, and Woolington (1997a) suggested that predation was probably the main limiting factor for RMH caribou. Hunting harvest currently does not appear to affect the growth of this herd (Hicks, 1997b).

White Mountains Herd. The White Mountains Herd

(WMH) was recognized as distinct from the Fortymile Herd in the early 1980s (Valkenburg, 1988; Boudreau, 1997). A BLM survey completed in 1992 estimated 832 caribou, while a 1996 ADF&G survey estimated 1,200 to 1,400, indicating that the herd is stable or slowly increasing (Boudreau, 1997). Factors limiting growth of the WMH have not been identified. The ADF&G herd management objectives are to allow continued growth and natural regulation of the WMH; these goals are being met (Nowlin, 1998a).

Central Arctic Herd. The Central Arctic Herd (CAH) was first identified as a discrete herd in the mid-1970s (Cameron and Whitten, 1979). The CAH grew from an estimated 5,000 caribou in 1975 to over 23,000 in 1992 (Cameron and Whitten, 1979, 1980; Whitten and Cameron, 1983b; Garner and Reynolds, 1986; Whitten, 1988; Fancy et al., 1992; Valkenburg, 1993; ADF&G files cited in Woolington, 1997b) (Figure 3.2-11). Rates of herd growth were highest between 1975 and 1985, and then declined between 1988 and 1992, although the CAH continued to grow during the entire period (1975-94 logistic growth rate was 0.249; Cronin, Ballard et al., 1998). In 1989, BLM (1989, p. 3-8) recognized the CAH as "currently one of the fastest growing herds in Alaska." As the CAH stabilized, the 1995 post-calving herd estimate of 18,100 (Woolington, 1997b) declined from the 1992 estimate of 23,000. Cameron (1993) suggested that the herd may have reached or exceeded habitat carrying capacity. In 1997, the CAH had increased to 19,700 caribou (Cronin et al., in press), and in 2000, the herd further increased to 27,128 (Lenart, 2000).

Warren Ballard

Photo 3.2-11. *CAH caribou in North Slope oil field.*

Factors limiting CAH growth have not been fully investigated, and the effects of wolf and brown bear predation on the CAH are unknown (Woolington, 1997b). Summer mortality of caribou, particularly calves, is probably low because the summer range has few wolves. Wolves may prey upon CAH caribou during winter while they are in the Brooks Range (Woolington, 1997b). Oil field development and relatively low harvests by humans do not appear to have limited the growth of the CAH (see Section 4.3.2.5).

Western Arctic Herd. The Western Arctic Herd (WAH) is the largest herd in the state and numbers about 463,000 caribou (Dau, 1997). In the early 1970s, the WAH was estimated at approximately 243,000 caribou, but this peak was followed by a dramatic decline to about 75,000 animals in the mid-1970s. From 1976 to 1993, the herd grew rapidly, with a logistic growth rate of 0.182 (Dau, 1997; Cronin, Ballard et al., 1998). More recently, Dau (1997) suggested that the rapid growth rate was slowing down. Sources of mortality for WAH caribou include predation, starvation, disease, accidents, and hunting (Ballard et al., 1997; Dau, 1997). The WAH and the CAH may overlap on winter ranges (Figure 3.2-8).

Teshekpuk Lake Herd (TLH). During 1978-82, the Teshekpuk Lake Herd (TLH) was estimated at approximately 3,000 to 4,000 animals (Carroll, 1995). The first comprehensive census in 1984 totaled 11,822 caribou, and subsequent counts increased steadily to 27,686 in 1993. The herd probably peaked in 1992, before high levels of mortality occurred in the winter of 1992-93 (Carroll, 1995). The 1995 count was 25,076 (Bente, 1997), 9 percent lower than in 1993.

Harvest by Humans and Population Management

Nelchina Herd. The NCH has historically been one of the most important caribou herds in the state because of its proximity for hunting to large population centers and because the herd is easily accessible by road (Lieb, 1989). Between 1954 and 1993, hunters harvested a total of at least 131,000 caribou from the NCH (Tobey, 1995a). From 1955 to 1971, harvests were liberal, with bag limits varying between two and four caribou and seasons fluctuating between two and seven months. After the herd decline in 1971, the bag limit was reduced to one caribou, and seasons were reduced to 15 to 40 days. However, these restrictions continued to allow harvests exceeding ADF&G

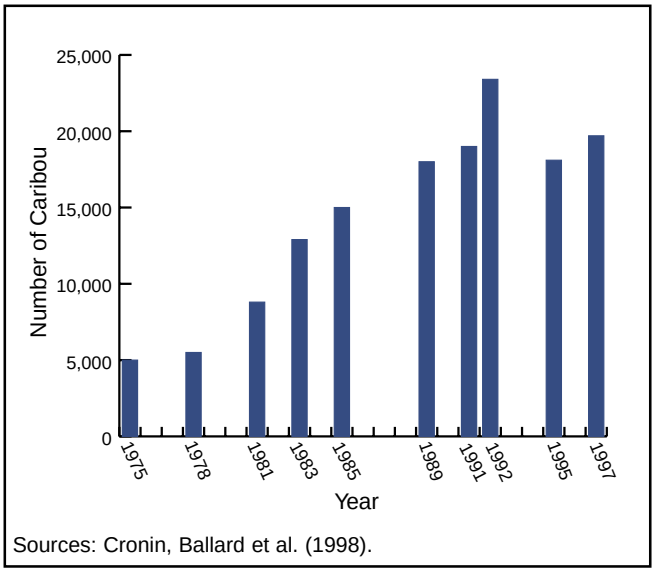
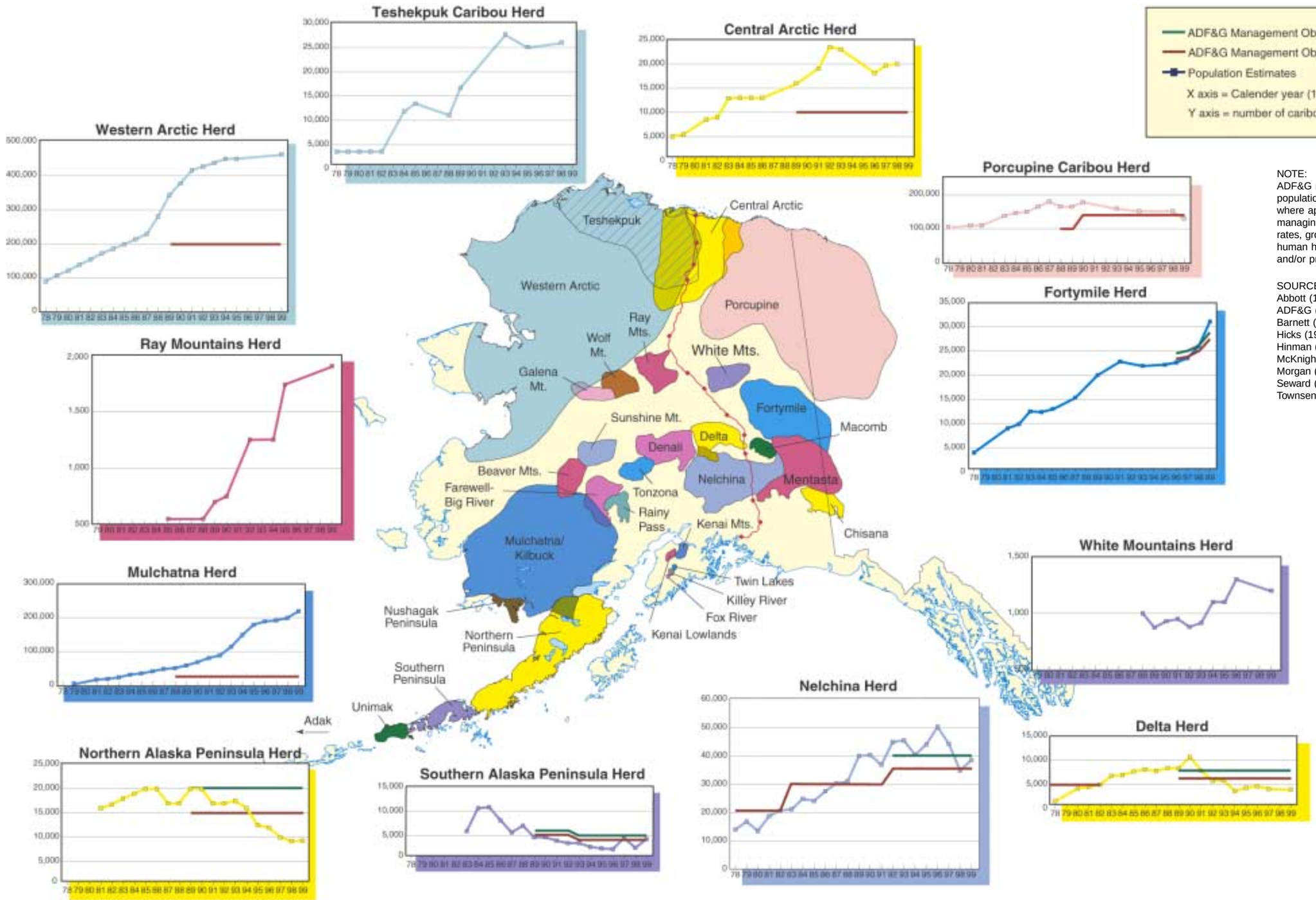


Figure 3.2-11. *Central Arctic Herd population estimates.*



NOTE:
ADF&G management objectives for selected populations are displayed on the charts where applicable. Other objectives include managing for bull:cow ratios, productivity rates, growth and body condition parameters, human harvest, predation rates, range size and/or productivity, stable populations, etc.

SOURCES:
Abbott (1992, 1993)
ADF&G (1999)
Barnett (1983, 1984)
Hicks (1995a,b, 1996h, 1997a,b, 1998, 1999)
Hinman (1977, 1979, 1980, 1981)
McKnight (1973, 1975, 1976)
Morgan (1988, 1990)
Seward (1985)
Townsend (1986, 1987)

Figure 3.2-8.
ADF&G caribou herd map with population estimates.

harvest objectives during some years between 1972 and 1976. Since 1977, permit-only hunting has restricted harvesting of NCH caribou. Between 1984-85 and 1996-97, the annual caribou harvest from the NCH has varied from 989 to 5,279 (Tobey, 1995a; McDonald, 1997) (Figure 3.2-12). During this time, ADF&G has used hunting as a tool to manage NCH numbers.

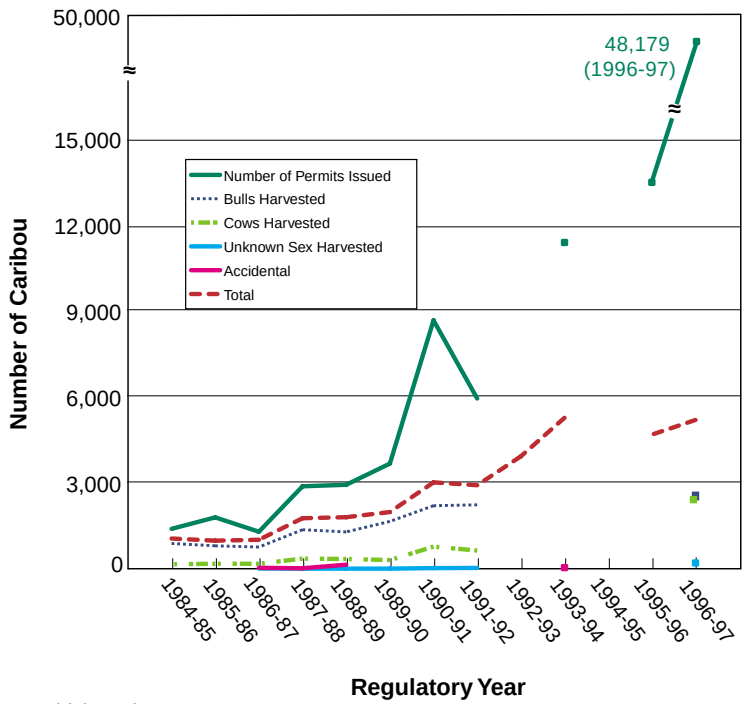
Delta Herd. DCH harvests ranged from 104 to 1,302 caribou between 1980 and 1991 (Boertje et al., 1996). The season was closed in 1992 in response to reduced herd numbers (Eagan, 1995). In 1996 a limited drawing of 75 permits was approved, and under this system, harvests have ranged between 25 and 35 caribou (Nowlin, 1998a).

Ray Mountains Herd. Osborne (1995) indicated that the RMH was lightly hunted because few people knew about the herd and it was largely inaccessible during the hunting season. Until 1984-85, RMH caribou were hunted under the same regulations governing the WAH. After that date, the season and bag limits were changed in an effort to prevent overharvest near the Dalton Highway (Woolington, 1997a). Harvest from the RMH is low, averaging fewer than 10 caribou/year over the last 10 years (Woolington, 1997a; Nowlin, 1998a). In 1989, BLM (1989) indicated that most of the reported harvest of RMH caribou occurred along the Dalton Highway.

White Mountains Herd. WMH harvests are below sustainable yield levels and have ranged from 6 to 21 since 1985 (James, 1997a; Boudreau, 1997; Nowlin, 1998a). Boudreau (1997) suggested that remoteness and inaccessibility were the major contributors to the low harvest. Increasing hunting opportunities and improving the likelihood that hunters will participate in this hunt are ADF&G management objectives for the WMH (Boudreau, 1997). Between 1987 and 1996, hunting was restricted to drawing permits, but opportunities for winter caribou hunting increased in 1997 with the conversion to registration permit hunts (Nowlin, 1998a). The number of hunters has increased since 1985 (range 6 to 150) (Boudreau, 1997).

Central Arctic Herd. Between the mid-1970s and early 1980s, the harvest of CAH caribou was low (1976-80 estimated harvest of 50 to 100 caribou/year) and restricted by registration-permit hunting only (Whitten, 1981). Whitten, (1981, pp. 60-62) indicated that during this period, "the TAPS haul road was open only to industrial traffic and to local miners, hunting guides, or cabin owners who have property or business interests along the road. Access for general public hunting was not allowed. Nevertheless, the harvest reports show that some caribou hunters were able to gain access to the road. Big game hunting within 8 km (5 miles) of the road was permissible by bow and arrow only."

Including estimates of unreported harvest, the annual harvest of CAH caribou increased from 50 to 100 caribou



Sources: Tobey (1995a), McDonald (1997).

Figure 3.2-12. *Nelchina Caribou Herd mortality causes and harvest permits issued.*

in 1980 (Whitten, 1981) to 762 to 862 caribou in 1986 (Woolington, 1997b). In response to CAH growth during this period, the season and bag limit were liberalized for the 1983-84 season (Golden, 1989). However, in 1986 more restrictive regulations were adopted to curtail the increasing harvest trend (Valkenburg, 1993). As a result, the 1987-91 average annual harvest was 340 caribou (range 196 to 386; Woolington, 1997b), noticeably lower than the 1986 harvest of 762 to 862 caribou. Golden (1989, p. 170) concluded that "the rise in harvest of CAH caribou was due to easy access hunters had to caribou along the Dalton Highway. Restriction of highway vehicles traveling north of Disaster Creek was poorly enforced, and prohibitions on ORV [off-road vehicle] travel from the road were unenforceable."

In 1991, interest in hunting CAH caribou increased (1991 estimated harvest of 508 to 608 caribou), particularly within the Dalton Highway Corridor Management Area (DHCMA), "largely because of reduced opportunities to hunt caribou in the Delta, Macomb and Fortymile herds" (Woolington, 1997b, p. 224). Since the 1991 harvest peak, the annual number of caribou taken from the CAH has steadily declined (Woolington, 1997b), and the 1992-98 average annual harvest was 450 caribou (Woolington, 1997b; James, 1997a; Nowlin, 1998a). See Section 4.3.2.5 for the history of public access along the Dalton Highway.

Most of the harvest of CAH caribou occurs in GMU 26B (Woolington, 1997b). Therefore, in addition to the ADF&G season and bag limit restrictions for the management unit, additional regulations affecting CAH harvests include both state and federal laws within the DHCMA. The DHCMA extends 8 km (5 miles) on either side of the Dalton Highway between the Yukon River and the Prudhoe Bay Closed Area. It is closed to hunting except with bow and arrow. Archery hunters must possess a valid International Bow Hunter Education Program card when hunting in the corridor (Woolington, 1997b). In addition, the use of motorized vehicles for non-subsistence hunting is prohibited within the DHCMA, and all hunters must stop at ADF&G check stations in the management area. Most hunters using firearms in GMU 26B use aircraft, highway vehicles, and/or boats for access (Woolington, 1997b).

Western Arctic Herd. Currently, subsistence harvests by local hunters who live west of the Dalton Highway and north of the Yukon River total approximately 20,000 WAH caribou annually. In addition, non-local hunters take about 1,000 to 3,000 WAH caribou annually (Dau, 1997). Almost all harvest by non-local hunters occurs between late August and late October, when the WAH may be in the vicinity of the Dalton Highway. Subsistence harvest occurs throughout the year.

Teshekpuk Lake Herd (TLH). Caribou from the TLH are harvested primarily by subsistence hunters from the North Slope villages of Nuiqsut, Atqasuk, Barrow, Wainwright, and Anaktuvuk Pass, with annual harvests from 800 to more than 2,500 (Carroll, 1995); the sport harvest is low (Philo et al., 1993).

Distribution and Habitat Use

Nelchina Herd. The NCH is a migratory herd which moves between spring/summer and autumn/winter ranges. These movements require crossing the Richardson Highway and the TAPS ROW (Eide et al., 1986). NCH caribou typically calve west of TAPS in the eastern Talkeetna Mountains on traditionally used calving areas, and westward movements to calving grounds usually occur between March and May (Eide et al., 1986). After calving, NCH caribou disperse to summer range, which includes other areas of the eastern Talkeetna Mountains, the north side of the Susitna River, and the Alphabet Hills. During autumn, caribou may be spread among all of the aforementioned areas, including the Lake Louise Flats and the Gakona and Chistochina river drainages. In October, NCH caribou typically begin migration to winter range, moving eastward across the TAPS ROW and the Richardson Highway. When caribou numbers were low, most caribou wintered on the Lake Louise Flats and east to the upper Copper River drainages of GMU 11. However, in recent years, 50 to 70 percent of NCH caribou have wintered farther east in neighboring GMU 12 and even as far as the Yukon Territory (Tobey, 1995a). In winter, NCH caribou mix with animals from the Mentasta Caribou Herd (Tobey, 1995a).

Delta Herd. Between the 1950s and the mid-1980s, DCH caribou traditionally used calving areas between the Delta River and the little Delta River in southeastern GMU 20A west of the TAPS ROW and south of Big Delta (Davis et al., 1991; Eagan, 1995). As the herd increased from 1980 to 1987, calving areas expanded south to the northern foothills of the Alaska Range between Dry Creek and the Delta River (Valkenburg et al., 1988). After the DCH declined in the early 1990s, range size of the herd also declined slightly, although southern expansion of the calving area continued (Valkenburg, 1997). During the autumn and winter, DCH caribou traditionally migrate west from the calving grounds (APSC, 1993; Eagan, 1995). Although most Delta caribou continue this pattern, some were observed east of the Delta River, and the TAPS ROW and Richardson Highway, in the areas of Iowa Creek and Donnelly Dome beginning in the early 1990s (APSC, 1993; Eagan, 1995; Valkenburg, 1997; Valkenburg et al., 1999).

Ray Mountains Herd. The RMH is the easternmost of three small herds (including Galena Mountain and Wolf Mountain) that exist in the Kokrines Hills and the Ray Mountains, north of the Yukon River between Galena and the Dalton Highway (Woolington, 1997a) (Figure 3.2-9). The origin of these herds is unknown, and although some local residents believe these animals are feral reindeer, available evidence indicates that they are caribou that may have originated from the Western Arctic Herd, which occasionally winters in this area (Cronin et al., 1995; Osborne, 1995).

The RMH calves primarily on the south side of the Ray Mountains in the upper Tozitna River drainages (Woolington, 1997a). During fall and winter, the herd moves to the north side of the Ray Mountains, primarily in the Kanuti-Kilolitna drainage (Woolington, 1997a). During autumn, RMH caribou have occasionally been observed in the vicinity of the TAPS ROW near Pump Station 5 (APSC, 1993) and the Dalton Highway at Old Man, and near Caribou Mountain (Woolington, 1997a). Movements and survival of RMH caribou are monitored through cooperative telemetry studies involving ADF&G, BLM and FWS.

White Mountains Herd. The WMH was delineated in the early 1980s after the Fortymile Herd declined (around the 1960s) and abandoned the traditional White Mountains calving area (Davis and LeResche, 1978). Public reports and observations by biologists, however, documented and confirmed the existence of a caribou herd that used the White Mountains on a year-round basis (Valkenburg, 1988). The resident WMH was recognized on this basis, and the herd uses a distinct calving area (Boudreau, 1997).

All seasonal WMH habitats and ranges are east (approximately 32 km at a minimum) of the TAPS ROW and Dalton Highway. There are no reports of WMH caribou crossing the pipeline or the highway. However, as illustrated by other Alaskan caribou herds, if this population increases, seasonal ranges may expand and the WMH may then encounter the TAPS ROW and the Dalton Highway. WMH calving areas are generally in the higher elevations of the White Mountains in selected drainages east of Beaver Creek, although scattered calving also occurs west of Beaver Creek (Durtsche and Hobgood, 1990). In autumn (August or September), WMH caribou move northwest crossing Beaver Creek and arrive on their winter range in the upper Hess and Victoria creek drainages, and the upper Tolovana River drainage (Boudreau, 1997). Radio-collared caribou are tracked as part of a cooperative project between ADF&G and BLM, and these data are used to determine the identity and distribution of caribou in the White Mountains. Much of the area used by the WMH is managed by the BLM as the White Mountains National Recreation Area. ADF&G management objectives for the WMH include a statement to ensure that increased recreational use and mining development do not adversely affect the WMH. Boudreau (1997, p. 201) concluded that "protection of key seasonal ranges from mining and recreational development should be considered during any land-use planning…"

Central Arctic Herd. Caribou of the CAH migrate north each spring from their winter range in the Brooks Range and its northern foothills to calving grounds and summer range on the Arctic Coastal Plain between the Canning and Colville rivers. Although small numbers of the CAH spend the winter on the coastal plain, the region encompassing the existing oil fields is not considered important winter range (Carruthers et al., 1987; Murphy and Lawhead, 2000). Census data indicate that about half of the CAH tends to spend the calving and insect seasons of late May to mid-August west of the Sagavanirktok River, including the area with existing oil-field development, and half ranges east of the Sagavanirktok River (Lawhead, 1988). Regular interchange of animals probably occurs between the east and west ranges (Cronin et al., 1997).

BP Exploration (Alaska) Inc.

Photo 3.2-12. *Caribou on North Slope.*

Pregnant cows move north toward the calving grounds in April and May (Cameron and Whitten, 1979), accompanied by barren cows and many yearlings. Bulls and other yearlings follow later. Although pregnant cows of the CAH disperse widely across the coastal plain during calving (Curatolo and Reges, 1984; Whitten and Cameron, 1985), calving tends to be more concentrated within 30 miles of the sea coast in the area of the Kuparuk and Milne Point oil fields and in the area south of Bullen Point (Whitten and Cameron, 1985; Lawhead and Cameron, 1988). Calving begins in late May and normally peaks near the end of the first week of June (Curatolo and Reges, 1984; Whitten and Cameron, 1985; Lawhead and Cameron, 1988). Virtually all births occur within a three-week period, and each pregnant cow bears a single calf.

Between late June (2 to 3 weeks after calving) and early August, the dominant influence on caribou movements is harassment by mosquitoes (≥5 *Aedes* spp.) and oestrid flies (warble fly *Hypoderma tarandi*, nose-bot or nostril fly *Cephenemyia trompe*) (White et al., 1975; Roby, 1978;

Dau, 1986). Warm, calm summer days in the Arctic result in high levels of insect activity, and Fancy (1986) reported that insect harassment could cause a negative balance in daily energy budgets of lactating females. Thus, it has been hypothesized that summers with above-average insect activity may result in energetic stress that adversely affects the ability of females to bear calves the following spring (White, 1983; Cameron et al., 1993; Cameron, 1994).

Mosquito-harassed caribou on the coastal plain coalesce into large groups and move upwind (generally northward) to reach relief habitats, which include cool and windy coastal beaches, low bluffs, sparsely vegetated river bars and deltas, and oil field gravel roads and pads (White et al., 1975; Roby, 1978; Dau, 1986; Lawhead, 1988; Pollard et al., 1996b). Caribou in the western range of the herd frequently encounter oil-field infrastructure during these movements (White et al., 1975; Curatolo and Murphy, 1986; Murphy and Curatolo, 1987; Pollard et al., 1996a; Cronin, Amstrup et al., 1998). The location of mosquito-relief habitat varies with weather conditions (primarily air temperature and wind speed), and mosquito-harassed caribou appear to move only as far as necessary to reach insect-free conditions on any given day (Lawhead, 1988). When mosquito harassment abates, caribou move from the coast to inland areas thought to have better forage (Smith, 1996).

By mid-July, oestrid flies begin to exert strong effects on caribou movements and behavior on the outer coastal plain (Dau, 1986; Lawhead, 1988). Larval infestations of these parasites can be detrimental to the general health and fecundity of caribou (Kelsall, 1968; Thomas and Kiliaan, 1990), and caribou react strongly to the adult flies, often apparently ignoring other stimuli (Espmark, 1968; Karter and Folstad, 1989). Group bonds break down during fly harassment as small unstable groups or individual caribou move in a highly variable, seemingly random fashion seeking relief habitats (Espmark, 1968; Roby, 1978; Lawhead, 1988). These habitats include a variety of unvegetated and elevated sites, such as river bars, mud flats, dunes, pingos, and gravel pads and roads in the oil fields (White et al., 1975; Roby, 1978; Dau, 1986; Pollard et al., 1996b). Caribou of the CAH begin to migrate south from summer range during the fly season in August (Roby, 1978; Lawhead, 1988).

Western Arctic Herd. WAH caribou calve in the Utukok Hills in the northwestern portion of the Brooks Range near Eagle Creek, and on the inner Arctic Coastal Plain. Approximately 2 weeks after calving, the herd begins to move south and west, and these movements are often described as an arc through the Lisburne Hills and then eastward through the De Long Mountains and Brooks Range. During the summer and fall, caribou disperse farther southeast within the northern portions of their range. During September and October, WAH caribou migrate as far south as the Seward Peninsula onto winter range, and as far east as the TAPS ROW (APSC, 1993; Woolington, 1997b).

Teshekpuk Lake Herd (TLH). Caribou from the TLH winter over a wide range from the Arctic Coastal Plain to the Seward Peninsula, south of the Brooks Range (Philo et al., 1993; Carroll, 1995). In some years, a portion of the herd winters on the coastal plain (Philo et al., 1993). The calving grounds and summer range of the TLH are on the Arctic Coastal Plain (Philo et al., 1993; Carroll, 1995). The principal calving grounds are located around Teshekpuk Lake, and the summer range extends across the coastal plain west of the Colville River delta (Philo et al., 1993; Carroll, 1995). The TLH ranges west of existing oil-field infrastructure, which now extends as far west as the Colville River delta (Alpine Development Project), although insect-induced movements occasionally bring animals onto the delta in midsummer (Philo et al., 1993). The calving and summer ranges of the herd are overlapped by recent oil and gas exploration leases in the northeastern part of NPR-A (BLM and MMS, 1998).

3.2.5.3 Muskoxen

Population History and Status

Muskoxen were extirpated from Alaska by the early 1900s (Woolington, 1997; Reynolds, 1998). They were reestablished in the state when muskoxen from Greenland were introduced in 1935-36 to Nunivak Island off Alaska's west coast (Reynolds, 1998). In 1969-70, 64 animals from Nunivak Island were released on or near Barter Island on the coastal plain of the Arctic National Wildlife Refuge, and at the Kavik River, approximately 25 km west of ANWR (Reynolds, 1998; Woolington, 1997; BLM, 1988; Jingfors and Klein, 1982). The total number of muskoxen on the Arctic Coastal Plain has increased steadily since reintroduction, and at least 800 muskoxen now inhabit the area (Reynolds, 1998; Woolington, 1997) (Figure 3.2-13).

Warren Ballard

Photo 3.2-13. *Muskoxen.*

From 1977 through 1981, the muskox population in the Arctic National Wildlife Refuge (ANWR) increased at an

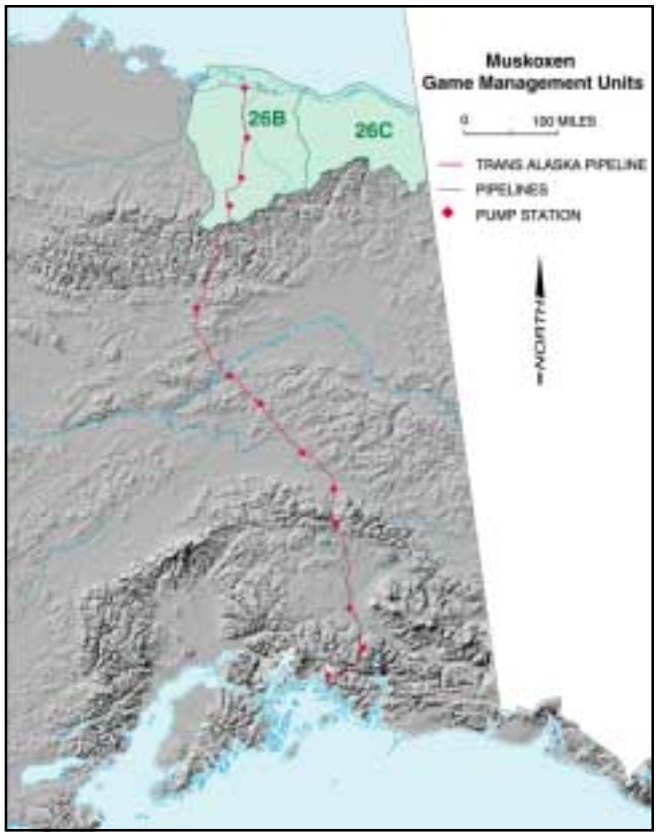


Figure 3.2-13. *Game management unit map for muskoxen along TAPS.*

annual growth rate (r) of 0.24. During 1982-86, the population growth rate declined to 0.14 (Reynolds, 1998). After 1986, the number of muskoxen in ANWR declined, stabilizing at approximately 300 individuals. Reynolds (1998) suggested that this decline was related to decreases in calf production, dispersal of mixed-sex groups into other regions, and reduced survival due to predation by brown bears (Gunn and Miller, 1982; Case and Stevenson, 1991; Clarkson and Liepins, 1993) and gray wolves; declining forage availability from intraspecific competition; and weather.

Westward dispersal of muskoxen from ANWR began in the early 1980s, with individual bulls and small numbers of mixed-sex groups being observed as far west as the Kuparuk and Prudhoe Bay oil fields (BLM and USACE, 1988; USACE, 1997; Reynolds, 1998). Dispersal in large numbers was first recorded in 1986-87 and continued sporadically through 1994-95 (Reynolds, 1998). In 1986 as many as 18 muskoxen were repeatedly observed along the Sagavanirktok River north of Franklin Bluffs (BLM and USACE, 1988). In addition, muskoxen have been seen near the Dalton Highway and as far south as Pump Station 3 (Thompson, 1999, pers. comm.). Movements of radio-collared females in ANWR confirmed the westward expansion of muskoxen from the regions they first occupied (Reynolds, 1998). Muskoxen populations in areas west of ANWR have grown since 1986 (1986-90 $r = 0.55$; 1990-95 $r = 0.15$) and are currently stable (Reynolds, 1998). In 1996 "…91 animals were recorded west of the TAPS near the Colville River (Whitten, 1997, pers. comm.)" (BLM and MMS, 1998, p III-B-43). At present, the total distribution of muskoxen on the Arctic Coastal Plain covers a linear distance of approximately 500 km, extending from the Colville River west of Prudhoe Bay to beyond the Babbage River in northwest Canada (Reynolds, 1998). A breeding population has become established in the Itkillik-Colville rivers area (Johnson et al., 1996). No geographical barriers to range expansion exist along the Arctic Coast, and the potential range for muskoxen is extensive (Smith, 1984). For muskoxen to have expanded their range from ANWR to the Colville River, some animals had to cross the TAPS ROW or travel through the oil fields on the North Slope.

Harvest by Humans and Population Management

Management of the North Slope's muskoxen population falls under both federal (FWS) and state (ADF&G) jurisdictions (Woolington, 1997; Hicks, 1998c). Both agencies perform and participate in aerial population counts and composition surveys in addition to managing annual hunts. The number of hunting permits issued in GMU 26B and 26C has increased over the past 15 years (5 in 1986-87, 15 in 1995-96), and harvests have ranged from 5 to 10 bulls/year. The current management objective limits the annual harvest to less than 20 bulls in order to ensure that muskoxen dispersal and population growth are not limited by hunting (Hicks, 1998c).

Distribution and Habitat Use

During the snow-free season, muskoxen generally use moist habitats and associated lush meadow and riparian vegetation (Klein, 2000; BLM, 1988). The most important summer habitats on the Arctic Coastal Plain are riparian, upland shrub, and moist sedge-shrub meadows, which provide preferred willow, forb, and sedge species (Robus, 1984; Johnson et al., 1996; BLM and MMS, 1998). Muskoxen use upland tussock areas and riparian drainages as calving habitat between late April and late June (Reynolds, 1984; APSC, 1993; USACE, 1997).

Between late November and the end of February, muskoxen frequently use riparian and dry tundra habitats such as ridges and bluffs. Winter forage depends largely on snow depth and hardness (Klein, 2000). In late winter, muskoxen feed on windblown vegetated bluffs that have shallow snow cover (Wilson and Klein, 1991; Klein et al.,

1993; USACE, 1997). On the coastal plain, these areas are distributed in narrow bands along creeks, rivers, and the coastline. During winter, muskoxen remain in localized areas and reduce their movements and activity; once they move to a winter area, they seldom leave it unless disturbed (Wilson and Klein, 1991). The potential exists for muskoxen to compete with caribou for available seasonal forage and habitats (Klein and Bay, 1994; BLM, 1988; Thomas and Edmonds, 1984; Wilkinson et al., 1976); however, research in this area has not documented adverse effects of competition.

Winter range and calving areas are seasonally important habitats, and avoidance of these habitats by humans has been recommended (Wilson and Klein, 1991; Reynolds, 1998). Muskoxen use areas near the TAPS ROW seasonally and during migrations (APSC, 1993).

3.2.5.4 Bison

Herd History and Status

Bison were extinct in Alaska prior to settlement by European, but they were reintroduced to Alaska in 1928. There are two bison herds in the vicinity of the TAPS ROW — the Delta herd and the Copper River herd. The Delta herd ranges from Donnelly Dome to Big Delta in GMUs 20D and 20A, and the Copper River herd is distributed east of the Copper River in the northwestern portion of GMU 11 (APSC, 1993) (Figure 3.2-14).

Delta Herd. In 1928, 23 plains bison were transplanted to the Delta River/Big Delta area from the National Bison Range in Montana (DuBois and Rogers, 1999). The Delta bison herd grew to more than 500 animals during the early 1950s, and then declined to a low of approximately 225 animals between 1950 and 1960 in response to winter severity, limited available forage in late-succession habitats, and overpopulation (ADF&G, 1976). Since 1983, pre-calving populations have ranged from 275 in 1987-88 to 392 in 1993-94 (BLM and USACE, 1988; Taylor, 1994a). The most recent pre-calving herd estimate for the Delta herd was 361 bison (Hicks, 1998d). Pre-calving herd objectives have gradually increased since the mid-1970s (250 in 1976, 325 during mid-1980s to 1993, and 360 from 1993 to present) as the herd increased and stabilized (ADF&G, 1976; Taylor, 1994a; Hicks, 1998d; DuBois and Rogers, 1999).

Shawn Haskell

Photo 3.2-14. *Bison.*

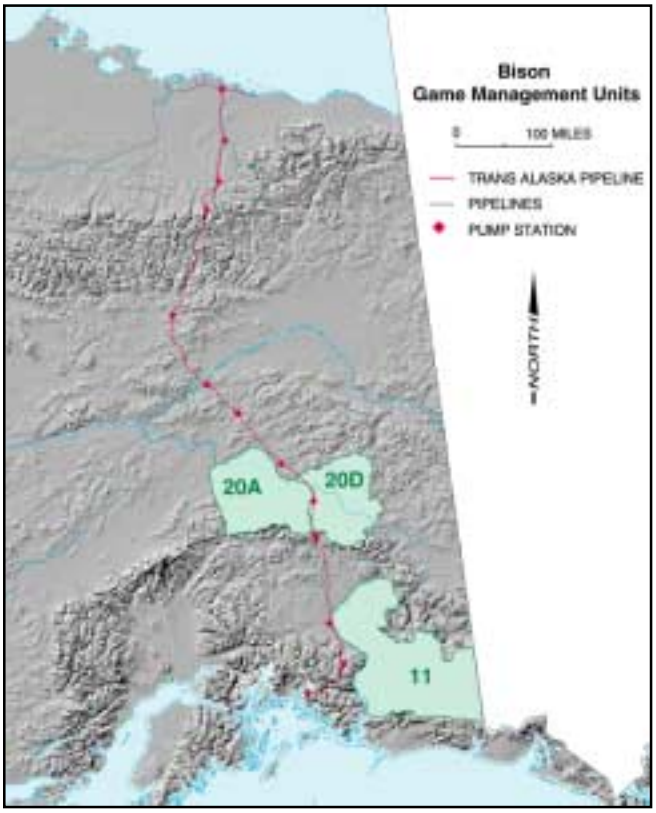


Figure 3.2-14. *Game management unit map for bison along TAPS.*

The most important limiting factor for this herd is harvest by humans (Taylor, 1994a; DuBois and Rogers, 1999). Natural mortality has not been quantified for the Delta herd, although Taylor (1994a) suggested that it is probably low. There are no records of predation on Delta bison, although wolves, brown and black bears, and coyotes occur in the area. Drowning, hunting-wounding losses, and accidents are other potential limiting factors, but winter severity is not a major mortality factor (Taylor, 1994a; DuBois and Rogers, 1999). The greatest potential for non-hunting mortality to Delta bison is disease transmitted from domestic livestock in the area (Taylor, 1994a). In addition to natural mortality, Kiker and Fielder (1980) reported that fewer than 10 individuals are killed annually in vehicle collisions. Most collisions occurred at known crossing sites along local highways and roads, although Delta bison have established many trails and may cross transportation corridors in many areas.

Copper River Herd. This bison herd originated from 17 individuals translocated from the Delta herd in 1950 (Tobey, 1998). The herd was relatively stable at over 100 animals during the late 1960s and 1970s, following a population increase in the 1950s (Tobey, 1981a, 1998). During the early 1980s, the herd declined slightly, but stabilized

and grew to an estimated 90 bison in 1988. Bison were adversely affected by the severe winter of 1988-89, which caused a 27 percent decline in the population (Tobey, 1998). Herd size increased slightly in the early 1990s to approximately 65 to 70 bison, and since that time, herd estimates have ranged from 75 to 87 individuals (McDonald, 1998a; Tobey, 1994a, 1998). The management objective for Copper River bison is to maintain the herd at a minimum of 60 overwintering adults (Tobey, 1998). Limiting factors on this herd include winter severity (i.e., snow depth) and the potential for winter starvation; accidental death (e.g., falling off steep bluffs that border the Copper River; drowning due to winter ice conditions and/or crossing attempts); and harvest by humans (Tobey, 1998). Predation by wolves, black bears, and brown bears is likely in this area; however, research into predation rates on Copper River bison has not been conducted.

Harvest by Humans and Population Management

Delta Herd. Harvest of the Delta bison herd by humans began in 1950. Delta bison hunts are one of the most popular permit-drawing hunts in the state, with over 15,000 people applying in recent years for approximately 100 to 130 permits (Taylor, 1994a; DuBois and Rogers, 1999). Since the hunt's inception, the number of permits issued, applicant numbers, and total harvest have all increased (Taylor, 1994a). ADF&G has successfully used hunting as the primary tool for managing the size and composition of the Delta herd for the past 30 years (Taylor, 1994a; DuBois and Rogers, 1999). The number of bison annually harvested since 1986 ranges from 6 in 1986-87 to 109 in 1993-94 (DuBois, 1998).

Copper River Herd. The last Copper River bison hunt was held during 1988, when seven bison were harvested (Tobey, 1998). Historically, this hunt has been popular with local rural residents. Based on census and herd-composition data, McDonald (1998a) recommended reopening the Copper River bison hunt in years with good calf production to allow harvest opportunities while the herd is high.

Distribution and Habitat Use

Delta Herd. Delta bison are migratory, moving alone or in groups of up to 50 animals, and seasonally use various portions of their annual home range (DuBois, 1995; DuBois and Rogers, 1999). Personnel from ADF&G and the Delta Junction Bison Range (DJBR) monitor the movements of radio-collared bison to determine bison/agriculture conflicts (Hicks, 1998d). The Delta herd normally travels to the floodplain of the Delta River from mid-February to March, crossing the Richardson Highway and the TAPS ROW. In early spring (April-May), cows move to secluded meadows in close proximity to the Delta River, where they calve (Hemming and Morehouse, 1976; APSC, 1993; DuBois and Rogers, 1999). This area is west of the TAPS ROW between Pump Stations 9 and 10. During the summer, the herd ranges along the Delta River floodplain and adjacent uplands, southwest of Delta Junction between Black Rapids Glacier and the mouth of the river (DuBois and Rogers, 1999). Bison are frequently visible during this period from the Richardson Highway.

In July, August, or September, the herd migrates from the Delta River, again crossing the TAPS ROW and the Richardson Highway, onto the DJBR and private agricultural lands, where they stay for the majority of the fall and winter (DuBois and Rogers, 1999). With development of agriculture in the 1950s, bison began using farms extensively during the fall and winter. The state developed the DJBR in 1979 to perpetuate free-ranging bison by providing adequate winter range and to alter seasonal movements of bison to reduce bison/agriculture conflicts (DuBois and Rogers, 1999).

Bison are grazing animals, and in the Delta area only limited amounts of preferred foods such as grasses and sedges are available along rivers and in recent burns (Campbell and Hinkes, 1983; Berger, 1996; DuBois and Rogers, 1999). The availability of winter forage was an important limiting factor for the Delta bison (ADF&G, 1976), but agriculture (e.g., barley production) has augmented natural forage for bison.

Copper River Herd. The Copper River herd ranges in the area of the Dadina and Chetaslina rivers, although the original animals were translocated farther north in GMU 11 (Tobey, 1998). Current bison range is bounded by the Dadina River on the north, the Copper River on the west, the Kotsina River to the south, and the Wrangell Mountains to the east. Most of the range is black spruce forest, with bison frequenting swamps, sedge openings, grass bluffs, and river bars (Tobey, 1998). Seasonal distributions include intensive use of the Copper River floodplain and bluffs during winter and spring, while bison move to higher elevations along selected rivers to feed on plants during green-up (Tobey, 1998). Habitat assessment studies have not been conducted on the Copper River bison range; however, "field observations of … preferred feeding locations such as the Copper River bluffs show evidence of heavy use and reduced forage production" (Tobey, 1998, p. 4).

Before 1990, there were very few reports of Copper River bison crossing the river, and observations of animals along the west bank of the Copper River in GMU 13 were infrequent (Tobey, 1998). Recently, however, bison have

been reported grazing in hay and crop fields in the Kenny Lake area west of the Copper River and just east of the TAPS ROW. Tobey (1998) raised the concern that serious conflicts with farmers could arise if many bison cross the river and make extensive use of Kenny Lake farms.

Warren Ballard

Photo 3.2-15. *Dall sheep.*

3.2.5.5 Dall Sheep

Dall sheep are found in the vicinity of the TAPS ROW in the Chugach Mountains (GMUs 11 and 13D), the Alaska Range (Delta Controlled Use Area in GMUs 13B, 20A and 20D), and the Brooks Range (GMUs 24 and 26B) (Figure 3.2-15). Because sheep are generally nonmigratory, populations that are not in the immediate vicinity of the TAPS ROW are not addressed here (i.e., populations in the South Wrangell Mountains, the Tok Management Area, and the Tanana Hills).

Population History and Status

Chugach Mountains (GMUs 11 and 13D). In 1949, there were an estimated 600 sheep in the Chugach Mountains of GMUs 11 and 13D (Scott et al., 1950 cited in Sinnott, 1996a). The Chugach Mountains sheep population increased until the mid-1980s and then declined in the late 1980s due to severe winters and possibly because sheep populations had exceeded range carrying capacity (Sinnott, 1996a). In 1990-91, the population in GMU 13D was estimated at 1,450 sheep (Harkness, 1993), and in the mid-1990s, Sinnott (1996a) extrapolated that there were as many as 2,000 to 3,000 sheep in the subunit. In the early 1990s, there were approximately 400 sheep in the GMU 11 portion of the Chugach Mountains. The current status of the Chugach Mountains population is uncertain. Factors potentially limiting sheep populations in this area include winter severity and predation by wolves, coyotes, bears, wolverines, and golden eagles (Sinnott, 1996a).

Delta Controlled Use Area (GMUs 13B, 20A and 20D). In 1980, D.M. Johnson (1982) estimated that the Delta Controlled Use Area (DCUA), renamed in 1981 from the Delta Management Area, contained approximately 1,500 sheep and that the population "may have declined somewhat in recent years" (Johnson, D.M., 1982, p. 70). He speculated that "if the population is experiencing a long-term decline," non-hunting sheep mortality in the management area should be examined (Johnson, D.M., 1982, p. 70). Trend counts in the Granite Mountain count area of the DCUA indicate that the sheep population was stable between 1975 and 1993, although it may have declined since then (DuBois, 1996b). The 1995 aerial census indicated approximately 1,400 to 1,900 sheep in the DCUA (DuBois, 1996b). Although wolves, brown bears, black bears, and golden eagles are found in the DCUA and presumably prey on sheep, predation rates are unknown (DuBois, 1996b). Winter severity is an important factor for other sheep populations in Alaska, but DuBois (1996b) indicated that it was not limiting sheep numbers in the DCUA.

Brooks Range (GMUs 24 and 26B). Dall sheep are found throughout the Brooks Range and adjacent foothills east, west, and in the vicinity of the TAPS ROW; and densities are generally highest in the northern drainages (BLM, 1989; Stephenson, 1996b). Sheep in the Brooks Range east of the Dalton Highway (including the Dalton Highway Corridor Management Area) were "generally abundant in the last several decades," and recent available data, anecdotal reports, and hunter observations suggest "relatively high populations during the 1980s, followed by declines in numbers in recent years" (ca. late 1980s and early 1990s) (Stephenson, 1996b, p. 148). Poor recruitment due to se-

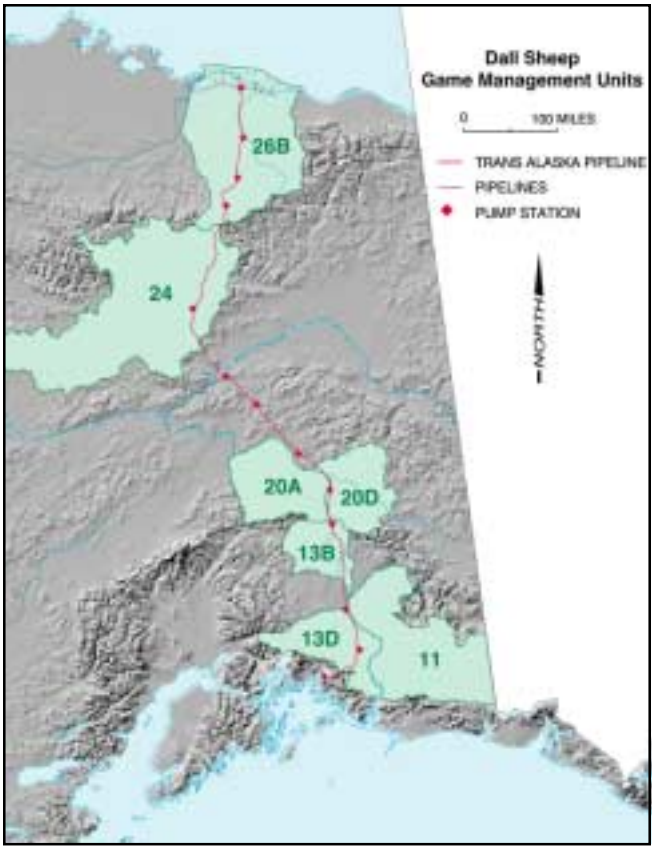


Figure 3.2-15. *Game management unit map for Dall sheep along TAPS.*

vere weather, and the possibility of increased predation may have contributed to this decline (Stephenson, 1996b). Most recently, Heimer (1985) estimated 13,000 sheep in the eastern Brooks Range. BLM (1989) estimated that there were 30,000 sheep throughout the entire Brooks Range and referenced Jakimchuk et al. (1984) in reporting 545 sheep between the Atigun and Sagavanirktok rivers. Systematic aerial surveys have not been completed since Heimer (1985)'s survey, and sheep populations have been tracked with trend data collected during ground composition counts since 1985 (Stephenson, 1996b). Trend counts in the Atigun drainage have remained relatively stable (range 236 to 493), with peak numbers being recorded in 1990-91 (Stephenson, 1996b). Causes of natural mortality and other factors potentially limiting the eastern Brooks Range sheep population are not available.

In the western Brooks Range within Gates of the Arctic National Park and west of the Dalton Highway Corridor Management Area, the sheep population showed signs of growth between 1982 and 1987 (Adams, 1988, cited in Osborne, 1996). Singer (1984 cited in Osborne, 1996) estimated that there were 4,417 sheep in the park. Although no population estimates have been calculated since then, Osborne (1996, p. 159) suggested "available data indicate there are now fewer sheep in the park than in the 1980s."

Harvest by Humans and Population Management

Chugach Mountains (GMUs 11 and 13D). Annual harvest of rams with full-curl horns is currently assumed to comprise about 3 percent of the total population in GMU 13D (Sinnott, 1996a). Since 1990, harvests, hunter numbers, and hunter success rates have been increasing (Sinnott, 1996a). A total of 44 to 88 sheep have been harvested annually in GMU 13D since 1987 (Harkness, 1993; Sinnott, 1996a). A portion of the sheep population in GMU 13D exists in the Tonsina Controlled Use Area, which is bounded on the east by the Copper River and on the west by the Richardson Highway and the TAPS ROW. ADF&G restricts big game hunting and access in this area. Hunting in GMU 11 is limited to local subsistence hunters under federal regulations (Harkness, 1993). In 1997-98, the total harvest for the Chugach Mountains was 171 sheep (McDonald, 1998b).

Delta Controlled Use Area (GMUs 13B, 20A, and 20D). Sheep in the DCUA are managed by both ADF&G and the federal government, each having its own management and harvest objectives (DuBois, 1996b). As a result, the consumptive-use objective for the DCUA is to provide opportunities to hunt under aesthetically pleasing conditions (DuBois, 1996b). Sheep seasons and harvest were originally liberal, but have become more restrictive with increases in hunting pressure and improved knowledge of sheep management requirements. In 1977, hunters killed 78 rams in the DCUA, even though the harvest objective was 40 rams (Larsen, 1979). Consequently, sheep hunting in the DCUA was restricted by drawing permit in 1978 (60 permits issued), and the harvest was reduced to 31 rams in 1978. The number of permits issued was increased in 1982 to 150 (DuBois, 1996b), and total harvests have ranged from 28 to 50 since 1987 (DuBois, 1996b; Nowlin, 1998b).

Brooks Range (GMUs 24 and 26B). Stephenson (1996b) reported that human use (i.e., hunting, viewing, and photography) of sheep in the eastern Brooks Range increased steadily during the 1980s, but stabilized through the 1990s. He indicated that this area experienced a long-term increase in hunter numbers and harvest beginning in the early 1970s, but that numbers of hunters have decreased in recent years. Sheep harvests reached their peak in 1990-91 with 268 sheep harvested, and declined to 122 sheep harvested in 1993-94 (Stephenson, 1996b). This decline may have been due in part to a decline in sheep numbers and to more restrictive harvest regulations involving implementation of a draw permit system in certain areas and harvesting only full-curl rams.

In the western Brooks Range, sheep are managed in Gates of the Arctic National Park (not in the TAPS ROW) under federal laws that mandate subsistence use (Osborne, 1996). ADF&G's primary management goal in this area is to maintain and enhance the sheep population and its habitat in concert with other components of the ecosystem. Since 1988, ADF&G has managed the park subsistence hunt. Before 1981, the entire area of GMU 24 east and west of the Dalton Highway was open to general sheep hunting; the average harvest during this time was 50 rams/year (Osborne, 1996). The 1989-94 average harvest was 47 sheep, including subsistence harvest, which averaged 23 sheep.

Distribution and Habitat Use

Chugach Mountains (GMUs 11 and 13D). Sheep are found throughout the Chugach Mountains. In GMU 13D, they are most abundant between the Nelchina and Klutina glaciers west of the TAPS ROW, and are also present in the Tonsina Controlled Use Area adjacent to the ROW (Tobey, 1996c). Sheep are found in mountainous areas below 3,000 m in elevation, although concentrations vary among drainages. During the winter, sheep in the Chugach Mountains are found in relatively snow-free areas and on windblown ridges above 900 m in elevation. Winter range is probably the most important seasonal habitat, and snow depth and

hardness, rather than forage quantity and quality, are essential components. In the spring from mid-May through the end of June, lambing areas are widely scattered and are often found in steep terrain with southern exposure. APSC (1993) identified a lambing area about 1.5 to 3.0 km west of TAPS and Tonsina.

Delta Controlled Use Area (GMUs 13B, 20A and 20D). The DCUA is located at the north end of Isabel Pass in the Alaska Range. ADF&G biologists have marked sheep in the area with visual collars, although summaries of sighting reports are not available at this time (DuBois, 1996b). Within the DCUA, APSC (1993) identified lambing and mineral lick areas adjacent to and within 15 km of the TAPS ROW. These areas occur both east and west of the pipeline, north of Pump Station 10 (APSC, 1993). Habitat use in the DCUA is not summarized, although it is known that stable sheep winter range is provided by the area's moderate climate including high winds, warm temperatures, and low snow depths. DuBois (1996b) indicated that sheep habitat appears sufficient to support the population at current levels, and suggested that the "2 greatest threats to sheep habitat in the DCUA are mining activities and military exercises on state land" (DuBois, 1996b, p. 81).

Brooks Range (GMUs 24 and 26B). In the eastern Brooks Range, highest densities of sheep occur in the northern drainages that provide favorable weather and habitat conditions during winter (Stephenson, 1996b). Drainages such as the Junjik, East Fork Chandalar, and Hulahula rivers may also inhibit sheep movements, resulting in discrete subpopulations in the Brooks Range. In the vicinity of the TAPS ROW, APSC (1993; Maps 5-8) identified several lambing areas and mineral licks between Pump Stations 4 and 5. These areas occur both east and west of the pipeline (<13 km), in addition to overlapping the ROW in selected areas. Sheep movement zones associated with lambing areas have been identified west of the ROW near Chandalar and Atigun Pass, and sheep may occasionally cross the Dalton Highway in these areas (APSC, 1993). The BLM Poss Mountain, Snowden Mountain, and Galbraith Lake ACECs, which are designated to protect Dall sheep habitat and mineral lick areas, occur in the Brooks Range near TAPS and the Dalton Highway, and are used year-round (BLM, 1989) (see Section 3.2.1).

3.2.5.6 Deer

Population History and Status

Deer have inhabited northern Southeast Alaska since their emigration from southern refugia following the Pleistocene epoch (Klein, 1965). The Sitka black-tailed deer population in the vicinity of the TAPS ROW (GMU 6, Figure 3.2-16) resulted from introductions to two islands in Prince William Sound during 1916 through 1923 (Griese, 1989a; Burris and McKnight, 1973). In 1916, eight deer were captured near Sitka, Alaska, and released on Hawkins and Hinchinbrook islands. Between 1917 and 1923, an additional 16 deer were released (Griese, 1989a). Following introductions, deer quickly increased in number and spread to other islands and the mainland. Since the introduction, the population in GMU 6 has peaked and declined several times in response to various limiting factors (Robards, 1952; Reynolds, 1979). Deer currently exist in all areas of GMU 6 (Griese, 1989a) and are at the northern limits of their range; the population in this unit is stable (Nowlin, 1995a).

Shawn Haskell

Photo 3.2-16. *Sitka black-tailed deer.*

Highest deer densities occur on islands and lowest densities on the mainland in areas surrounding Prince William Sound. Density decreases rapidly with distance inland from

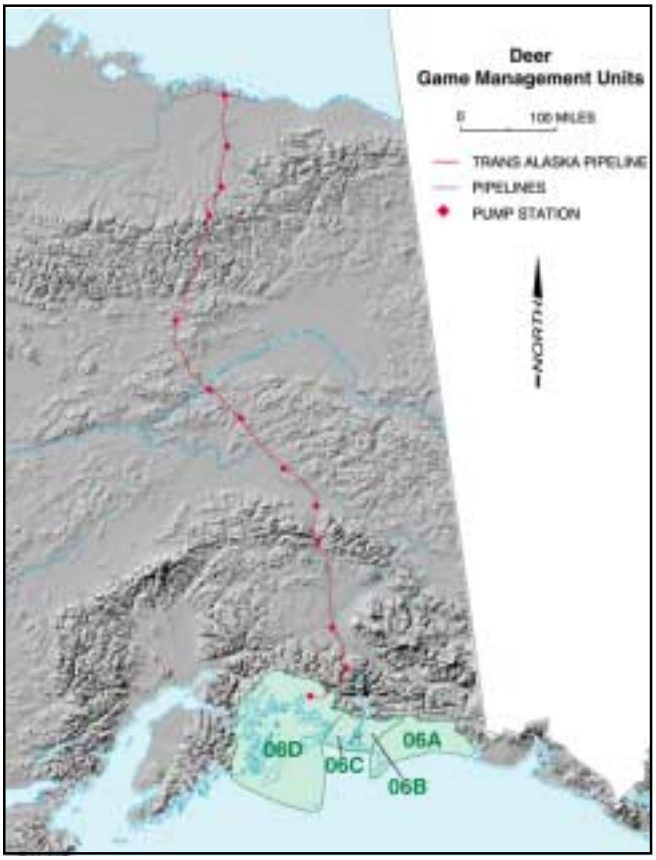


Figure 3.2-16. *Game management unit map for deer along TAPS.*

the Sound (Nowlin, 1995a). Estimates of deer population size are not available for GMU 6, nor for areas in the vicinity of TAPS. As an index of population trends, pellet-group data indicated that all survey locations in GMU 6 had low to moderate deer densities in the early 1990s (Nowlin, 1995a).

Deer have occasionally been reported in the lower Copper River Basin during mild winters when climatic conditions favor temporary range expansion (Roberson, 1986; APSC, 1993). From 1985 through 1989, populations increased to approximately 8,000 to 12,000 deer in GMU 6; subsequent severe winters may have reduced the population from these levels (Griese, 1989a; Nowlin, 1993a). Factors that limit deer distribution, habitat use, and population numbers in southern portions of Alaska include snow depths and duration (Roberson, 1986; Griese, 1989a); wolf predation (Griese, 1991a); mature conifer-forest habitat that provides deer wintering areas (Reynolds, 1979; Shishido, 1986; Nowlin, 1993a); clear-cutting and selective timber management practices (Nowlin, 1995a; Kirchhoff, 1997; Farmer et al., 1998); and hunting (Nowlin, 1993a).

Harvest by Humans and Population Management

Estimated annual harvests in GMU 6 before 1978 ranged between 500 and 1,500 deer (Reynolds, 1979). Nowlin (1995a) indicated that harvests increased after 1978 and peaked at 3,000 in 1987. In 1989 the annual harvest dropped to 1,952 (Griese, 1991a). From 1989 to 1997, annual deer harvests in GMU 6 have ranged from 1,378 to 2,580 (Nowlin, 1995a; Hicks, 1995b, 1996c, 1997c, 1998e). The state management objective is to maintain a deer population that is able to sustain an annual harvest of 1,500 deer, and this objective is being met (Hicks, 1998e). Bag limits and restrictions on season length for doe harvests have been used as a management strategy to reduce harvests and allow deer-population growth following severe winters (Griese, 1989a; Nowlin, 1993a). Nowlin (1993a) suggested that hunting was an important source of mortality, particularly during severe winters when deer concentrate at lower elevations and are more vulnerable to hunters using boats for access.

Habitat Use and Distribution

Old-growth forest is critical deer-wintering habitat during deep snow years (Reynolds, 1979; Shishido, 1986; Nowlin, 1993a). These areas provide shelter and feeding habitats (APSC, 1993). These mature conifer forests are also used during non-winter months (Farmer et al., 1998). During summer and fall, deer also use disturbed slide areas in alpine zones, and feed along the margins of muskeg openings interspersed within climax spruce-hemlock forests (APSC, 1993). Although deer may be present in the vicinity of the southern end of the ROW, critical deer habitat has not been identified along the ROW (APSC, 1993).

3.2.5.7 Mountain Goats

Mountain goats are found near the TAPS ROW south of the Alaska Range in GMUs 6, 11, and 13D (Figure 3.2-17).

Population History and Status

GMU 6. Mountain goats are endemic to the mainland and several islands in GMU 6 (Nowlin, 1996a). In 1952, the goat population in GMU 6 was estimated at 4,350 animals (Nowlin, 1996a). Anecdotal data in ADF&G files suggest that the population was reduced due to overharvests by military personnel stationed in Whittier (ca. 1940s) and in Seward (ca. 1950s) (Nowlin, 1996a). Between 1970 and the mid-1980s, goat numbers fluctuated in the Prince William Sound area as a result of severe winters, predation, and hunter harvest (Reynolds, 1981a).

Aerial mountain-goat population surveys began in 1969,

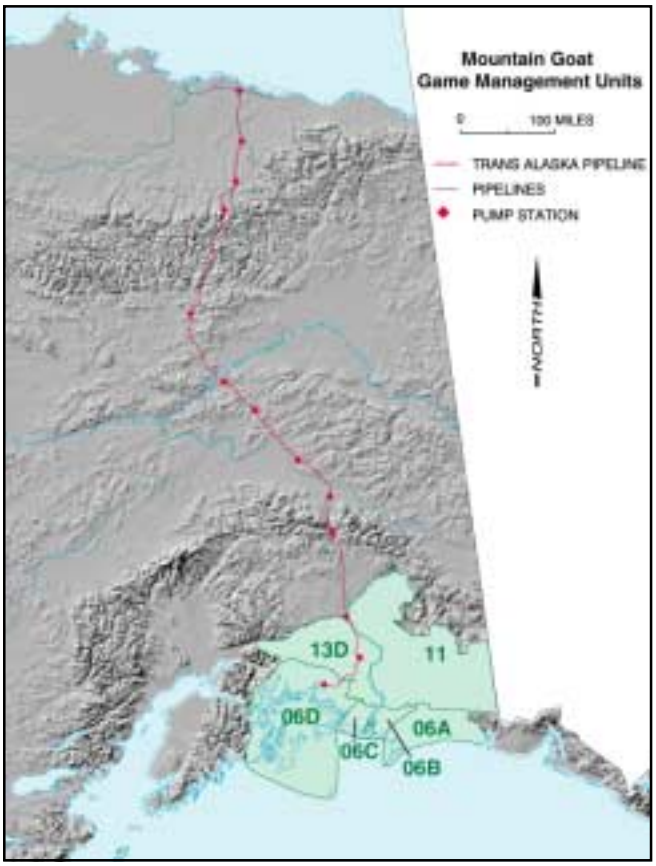


Figure 3.2-17. *Game management unit map for mountain goats along TAPS.*

although they were not standardized until 1986. Since the mid-1980s, mountain goats in Subunit 6D, which is bisected by the TAPS ROW, have increased to the west of TAPS and the Richardson Highway, yet have declined to the east (Nowlin, 1996a). In the entire GMU 6, goat populations declined for at least 5 years before 1993 and were estimated at 3,100 to 3,700 in 1988-89 (Griese, 1990; Nowlin, 1994). Subsequent population estimates were 2,700 to 3,300 in 1990-91 and 2,400 to 2,800 in 1992-93 (Nowlin, 1994). Most recently, the goat population in GMU 6 was estimated at 2,790 (Nowlin, 1996a).

Goat populations in GMU 6 are limited by winter severity and snow depth (Adams and Bailey, 1982; Swenson, 1985); predation (Nowlin, 1996a); and availability of winter habitats provided by old-growth forests (Fox et al., 1989). Nowlin (1996a, p. 55) concluded that "future habitat loss due to clearcut logging is expected in GMU 6D (East)…"

GMU 11. In GMU 11, mountain goats are surveyed and inventoried in only one count area: MacColl Ridge east of the TAPS ROW (Tobey, 1996d). Aerial goat-survey data in the vicinity of TAPS have been collected opportunistically in conjunction with other counts (Tobey, 1996d). Interpretation of annual survey data is confounded because it is difficult to separate actual population fluctuations from survey variability (Tobey, 1996d). As a result, the population history of goats in GMU 11 is not readily available. Currently, biologists estimate that 700 mountain goats inhabit the unit and that there are approximately 300 animals south of the Chitina River near TAPS (Tobey, 1996d).

GMU 13D. The first mountain-goat survey in GMU 13D was done in 1959, and periodic surveys have since been completed (Sinnott, 1996b). Since the mid-1980s, the goat population in the northwestern Chugach Mountains has increased slightly. Mountain goats in GMU 13D declined during the 1970s due to severe winter weather, and since then have slowly increased. Between 1993 and 1995, goat numbers in the GMU 13D count area declined by 17 percent, but Hicks (1998f) cautioned that these counts are often a reflection of survey variability rather than an actual decline, and that the population is likely stable. The population in GMU 13D was most recently estimated at 175 in 1994-95 (Sinnott, 1996b). Before 1995, the management objective for GMU 13 was to maintain a prehunting population of at least 100 goats. Because the goat population in GMU 13D is limited by winter weather and predation (Sinnott, 1996b), objectives were recently changed to maintain viable populations controlled largely by available habitat, climatic conditions, and predation (Hicks, 1998f).

Harvest by Humans and Population Management

GMU 6. Before 1975, mountain-goat hunting seasons were liberal (Nowlin, 1994). As populations in GMU 6 fluctuated, seasons and bag limits were reduced; and in 1986, goats were placed on restricted-registration permit harvest. Biologists recognized that goats, unlike other ungulates, had to be managed on the basis of relatively small geographic units. Mountain goat populations in permit areas are surveyed for population trend and mortality data, and harvest levels are set at 2 to 6 percent of the estimated population (Nowlin, 1994). ADF&G biologists use this method to keep hunting from causing population declines.

Goat harvests in GMU 6 reached a high of 182 in 1983-84 and a low of 41 in 1989-90 (Nowlin, 1994). As a result of the conservative registration hunts, 50 goats were harvested during 1991-92 and 1992-93, which were well below the calculated allowable harvests of 73 and 69, respectively. Population and management objectives for GMU 6 have varied since the 1980s as biologists considered population trends in subunits and management areas, levels of wolf predation, and habitat and logging issues. Currently, the goat population and harvest objectives for GMU 6 are being met (Hicks, 1998g).

GMU 11. Prior to 1972, mountain goat seasons and bag limits were liberal, and harvests were low, although not recorded (Tobey, 1994b, 1996d). Season lengths and bag limits were reduced in the mid-1970s because of increasing hunting pressure and harvests (Tobey, 1996d). In 1980, goat hunting in GMU 11 was placed on the restricted-registration permit system because of the creation of Wrangell-St. Elias National Park and Preserve. Because only subsistence hunting by local residents was allowed in park areas, all other hunters were concentrated on preserve lands (Tobey, 1994b). In 1990, the federal government took over management of subsistence hunting and determined that there was no historical use of goats for subsistence in GMU 11; consequently, the park was closed to goat hunting. Currently, goat hunting is restricted to preserve lands (Tobey, 1996b). In these areas, mountain goats have sustained annual harvest rates of 10 percent of the observed population (Tobey, 1996d). Harvests in GMU 11 are restricted to no more than 35 goats per year (Tobey, 1994b).

GMU 13D. During the 1960s, seasons and bag limits were liberal, and although seasons were reduced over the following decade, the two-goat limit existed until 1975 (Sinnott, 1994). Because of the population decline in the 1970s, the goat season in GMU 13D was closed in 1978. It reopened in 1987 under the restricted-drawing permit system (Sinnott, 1994). Since 1990, fewer than 10 goats have

been harvested each year from GMU 13D (Sinnott, 1996b).

Distribution and Habitat Use

GMU 6. Mountain goats are distributed throughout GMU 6. Near TAPS, goats in Subunit 6D (East and West) use habitats near Thompson Pass (APSC, 1993), where they are found in very rugged and broken terrain with cliffs, ledges, pinnacles, and talus slopes. Occasionally, goats will disperse and move across selected drainages and/or highways. Old-growth forest provides important winter habitat for mountain goats in GMU 6 and other coastal areas of Southeast Alaska (Schoen and Kirchhoff, 1982; Fox et al., 1989; Nowlin, 1996a). During the summer, goats frequent high alpine mountains, where they eat grasses, sedges, and low shrubs (APSC, 1993). Although female goats seek isolated areas to give birth to kids, the availability of winter habitat is the most important seasonal requirement for mountain goats.

GMU 11. The Wrangell and Chugach Mountains are part of the northernmost extension of mountain goat range in Alaska, and goat habitat in these areas is limited (Tobey, 1996d). Near the TAPS ROW in GMU 11, mountain goats are distributed south of the Chitina River in that portion of the Chugach Mountains from the Copper River east to the Canadian border (Tobey, 1996d). This area directly east of and adjacent to the TAPS ROW may provide the most suitable goat habitat in the unit (Tobey, 1996d). East-west movements occur (Tobey, 1996d), and goats in GMU 11 may mix with goats west of TAPS in GMU 13D. Additional information on movements is limited, and major rutting and kidding areas are unknown (Tobey, 1996d). During the winter, goats in GMU 11 are often in areas of lower elevations with shallower snow.

GMU 13D. In GMU 13D, mountain goats are primarily found in the Chugach Mountains adjacent to and west of the TAPS ROW (Sinnott, 1996b). This area is the northernmost edge of mountain goat range in Alaska, and habitat is marginal. During summer, goats feed on open grassy slopes often adjacent to glaciers or snowfields, and seek relief from heat in dense shrub cover, on icefields and glaciers, or under rocky outcrops (Sinnott, 1996b). During winter, goats use steep, timbered hillsides and windblown slopes. Little information is available on precise winter distributions and habitat use, and on kidding and rutting areas (Sinnott, 1996b).

3.2.5.8 Brown (Grizzly) Bear

Brown (grizzly) bears are present in all GMUs that the TAPS ROW crosses (Figure 3.2-18) and on the Alaska North Slope. The following discussions are organized into three sections based on geography and state GMU boundaries: Southcentral (GMUs 6 and 13), Interior (GMUs 20 and 24), and Northern (GMU 26B).

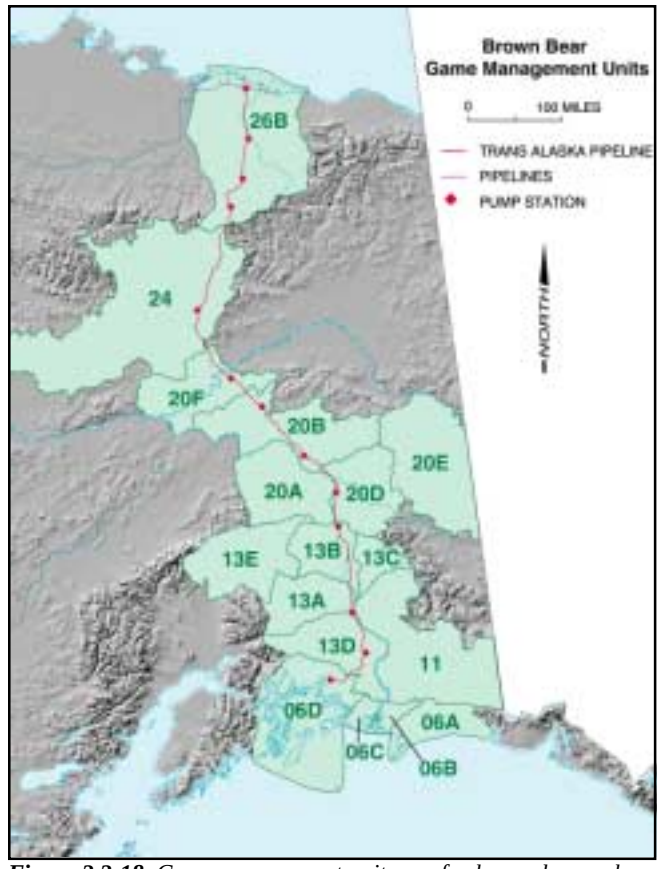


Figure 3.2-18. *Game management unit map for brown bears along TAPS.*

Population History and Status

Southcentral. Brown bears occur throughout the area south of the Alaska Range. In the vicinity of the TAPS ROW, they are present in GMUs 6, 11, and 13. Nowlin (1995b) estimated the GMU 6 brown-bear population to be 739 bears, the highest proportion of which was in GMU 6D (280 bears). Within this subunit, 116 bears were estimated to be in mainland management areas near TAPS (Rude River-Ellamar and Valdez Arm areas) (Nowlin, 1995b). These population estimates translate into a relatively low mainland brown-bear density of <40 bears/1,000 km^2 (Nowlin, 1995b). The GMU 6D population has been stable or declining

Warren Ballard

Photo 3.2-17. *Brown bear.*

slightly since 1989, primarily because of overharvests in the Rude River-Ellamar area (Nowlin, 1995b). This decline comes after an all-time high population in GMU 6 (Griese, 1989b). Before 1980, sufficient data to determine brown bear status or population trends were not available for GMU 6 (Reynolds, H.V., 1981a). Sources of brown bear mortality include legal and illegal harvest, defense of life and property (DLP) kills, accidents, and non-hunting and natural causes (Nowlin, 1995b; McDonald, 1998c).

Brown bears were numerous in GMU 13 until 1948-53 when the federal poisoning programs directed at controlling wolves inadvertently killed large numbers of bears (Spraker et al., 1981; Ballard et al., 1991). When wolf-control activities ceased, brown bear numbers in GMU 13 increased, and by the mid- to late 1970s, they were again abundant (estimated population of 1,500) and at relatively high densities for an Interior Alaskan bear population (Ballard et al., 1980; Tobey, 1981b, 1995b). Population growth stabilized about 1980, when harvest rates increased (Tobey, 1995b).

Although the exact number of brown bears in GMU 13 is not known, several population estimates were made between the late 1970s and the mid-1990s. Miller and Ballard (1982) estimated bear densities at 1/41.5 km^2 in the upper Susitna River in 1979, while Miller et al. (1987) estimated densities at 1/36.3 km^2 in an adjacent area in 1985. These estimates were extrapolated to the remainder of GMU 13 and resulted in a population estimate of 1,400 to 1,600 bears. In 1987, Miller (1988) re-estimated the bear population in the upper Susitna River at 1/95.8 km^2, suggesting that the population had declined by about 50 percent (Tobey, 1995b). McDonald (1998c) concluded that determining a population trend for brown bears in GMU 13 was difficult. During 1980-90, brown-bear harvest regulations in this unit were designed to cause declines in brown bear density in order to increase moose and caribou calf survivorship and moose availability for harvest by hunters (Miller and Ballard, 1992; Miller, 1993; Miller, 1997). In 1995 this bear reduction effort was accelerated with the adoption of the most liberal brown-bear hunting regulations in Alaska (Miller, 1997). Miller (1993) estimated that bear numbers in GMU 13 have been reduced by 23 to 48 percent since 1980 as a result of liberalized hunting seasons.

In addition to legal sport harvest, brown bear mortality in GMU 13 also occurs as a result of DLP kills (i.e., nuisance bears), illegal harvest, and predation by other bears (Tobey, 1995b). An average 2.8 nuisance bears per year were killed between 1961 and 1993, with an increase to an average of 5 per year between 1990 and 1993 as a result of confrontations at private home sites and mining claims (Tobey, 1995b). Miller and Chihuly (1987) documented that more bears were killed in defense of life and property at remote sites than in any other site category. Tobey (1995b) indicated that the number of remote cabin sites in GMU 13 had increased during the past 15 years and if that trend continued, the number of nuisance bears killed would also increase.

Interior. Prior to 1980, little information was available on brown-bear population size, movements, or distribution in GMU 20, although incidental observations and other indices suggested that the population was moderate in number and increasing in most areas (Jennings, 1981). Since 1981, brown bears in the western portion of the unit (northern Alaska Range in GMU 20A) have been studied during a long-term research project designed in phases to gather baseline population information, to measure the response of brown bear populations to high rates of human-caused mortality, and to then assess population recovery (Reynolds and Hechtel, 1986, 1992; Reynolds, H.V., 1997, 1999). H.V. Reynolds (1997) concluded that although density estimates were unchanged in the study area between 1981 and 1992 (based on mark/recapture survey techniques), annual direct-count estimates indicated that the population had declined by more than 30 percent. Densities in this area are currently estimated at 14 to 17 bears/1000 km^2 (Eagan, 1996).

Within the remaining areas of GMU 20, Eagan (1996) reported low bear densities (1 to 3 bears/1000 km^2) in the Tanana Flats (GMU 20A), the western portion of GMU 20B, and the northeastern portion of GMU 20F due to poor or moderate habitat conditions, high human density, and good hunter access. Moderate densities of 5 to 10 bears/1000 km^2 were reported for the Tozitna River drainage and Ray Mountains in GMU 20F, in the eastern portion of GMU 20B, and south of the Tanana River in GMU 20D (Eagan, 1996; DuBois, 1995). Eagan (1996) extrapolated these densities and estimated that there were 446 to 782 brown bears of all ages in the management area (except 20D), resulting in a density of 6 bears/1000 km^2. DuBois (1995) estimated 76 to 86 total bears in GMU 20D south of the Tanana River. The status of this population is equivocal, and although heavy harvests may cause numbers to decline, Dubois (1993) reported that local residents and hunters thought the population was increasing. Brown bear mortality in GMU 20 occurs as a result of harvest by humans (legal, illegal, and DLP kills) and predation by other brown bears (Eagan, 1996; DuBois, 1995). Since 1990, a total of 10 to 15 bears have been killed in DLP incidents, and approximately 10 were killed illegally (Eagan, 1996; DuBois, 1995).

H.V. Reynolds (1981b) indicated that brown bear num-

bers in GMU 24 were stable or growing. In 1986, H.G. Reynolds (1987) estimated 165 to 225 bears in the northern portions of GMU 24. In 1987, the number of bears in GMU 24 was estimated to be 770 to 930, with the majority of the animals (320 to 480) in Gates of the Arctic National Park (Reynolds, H.G., 1989). In 1991, the GMU 24 brown-bear population was stable or slowly increasing (Osborne, 1991). Human-related mortality is the primary cause of death for bears in GMU 24; one to two bears are killed annually in DLP-related incidents.

Northern. H.V. Reynolds (1981b) indicated that brown bears in GMU 26B were beginning to recover from a population decline in the 1960s that was due to aircraft-supported hunting associated with guiding (Stephenson, 1995). Brown bear numbers in GMU 26B have increased since 1977, densities are currently high, and the population is stable (Stephenson, 1995). In 1993, there were an estimated 262 brown bears in GMU 26B and 1,817 in the eastern Brooks Range and upper Yukon River area (Stephenson, 1995). One or two brown bears are killed each year in DLP incidents in GMU 26B. Relatively little is known about natural mortality of brown bears in this unit (Stephenson, 1995).

Harvest by Humans and Population Management

Southcentral. Between 1961 and 1986, the average annual harvest of brown bears in GMU 6 was 32 bears (range 14 to 63) (Nowlin, 1995b). During this period about 3 percent of the annual harvest was attributed to bears killed illegally or in defense of life or property (i.e., nuisance bears) (Griese, 1991b). During 1987-92, the average yearly harvest rose to 50 bears (range 40 to 60), and most of the increased harvest was from the Prince William Sound area (Nowlin, 1995b). Harvests in 1992-93 (44 bears) and 1993-94 (22 bears) were below average; the majority of these harvests came from GMU 6D (26 in 1992-93 and 15 in 1993-94). Between 1987 and 1994, about 13 percent of the total estimated brown-bear kill was attributed to illegal kill and 4 percent to non-hunting mortality (Nowlin, 1995b). Average harvest between 1995 and 1998 was 16 bears per year (McDonald, 1998c). Reduced harvests in GMU 6 since 1992-93 have been a result of restrictions to harvest regulations and of spring weather conditions (Nowlin, 1995b).

Brown bear harvests have increased in GMU 13 since the early 1960s. Average annual harvests were 39 bears between 1961 and 1969, 58 bears between 1970 and 1979, and 109 bears between 1980 and 1987 (Tobey, 1995b). Miller (1988) calculated a sustainable harvest rate for GMU 13 bears of 5.7 percent per year. Since 1987, harvest rates have exceeded this quota by an average of 14 bears per year (Tobey, 1995b). Between 1989 and 1994, seasons and bag limits became more restrictive (one bear every four years), and the average annual harvest was 86 bears (range 66 to 111) (Tobey, 1995b). Since 1995, harvests have averaged 117 bears per year (range 109 to 123) (McDonald, 1998c). Before 1980, the management objective for GMU 13 brown bears was to maintain a sustained-yield harvest while providing the greatest opportunity to participate in hunting of brown bears (Tobey, 1991a). Seasons were short and there was no spring season.

Following research on bear/moose relationships which indicated that brown bears were significant predators of calf and adult moose (Ballard et al., 1981; Ballard and Larsen, 1987; Ballard et al., 1990; Ballard and Miller, 1990), bear hunting seasons in GMU 13 were liberalized to purposefully reduce bear numbers (Miller and Ballard, 1992; Miller, 1997). After 1980, spring seasons were added and the bag limit was changed from one bear every four years to one per year (Tobey, 1991a). In 1987 the one-bear-per-four-year bag limit was reinstated, and the season length was reduced in 1990 to further lower the harvest of adult female brown bears. In fall 1995, the most liberal bear-hunting regulations for GMU 13 were implemented, changing the bag limit from one bear per four years to one every year, and eliminating the need for resident brown-bear hunters to purchase a tag (Miller, 1997). The intent of these regulations was to "…augment brown bear harvests by encouraging incidental and nondiscriminatory harvests…" by moose and caribou hunters (Miller, 1997, p. 3).

Interior. Before 1981, objectives in GMU 20 were to harvest 3 percent of bears greater than 2 years of age (McNay, 1990). However, in 1981, Reynolds and Hechtel (1986) began their long-term research on the effects of high (>10 percent of the population) harvest by humans on brown-bear population dynamics. Management objectives at that time were to manage harvests to sustain a mean annual exploitation rate of 10 to 15 percent of the estimated population greater than 2 years of age in Subunit 20A. For the remainder of the management area, objectives were to provide a stable population with a mean annual harvest of 30 bears.

In 1988, bear harvests were well below sustained-yield levels, except in the harvest research area of Subunit 20A, and management objectives were being met (McNay, 1990). H.V. Reynolds (1993) recommended that beginning in fall of 1992, mean harvest rates be reduced to 6 to 8 percent of bears older than 2 years to allow the population to recover. Since 1990, harvests in GMU 20 (except 20D) have been stable, with an annual mean of 33 bears. In 1995,

brown bear harvests in GMU 20D south of the Tanana River exceeded the harvest objective, with more than 10 percent of the estimated population being taken by humans (DuBois, 1995). Between 1985 and 1994, the average harvest in this area was 8 bears per year.

Osborne (1991) reported that between 1961 and 1987, annual harvests in GMU 24 rarely exceeded 15 brown bears, except in the early 1970s when bear hunting was closed on the Alaska Peninsula, creating additional pressure in the remainder of the state, particularly in GMU 24. During this period, harvests reached a high of 31 bears annually. During 1977, in response to evidence of overharvest in the Brooks Range, brown bear hunting was placed on drawing permit; in 1985, this system was replaced with a more liberal registration hunt; and in 1990, all permits were eliminated (Taylor, 1993b). Between 1987 and 1993, annual harvests averaged 17 bears, including estimates of unreported and illegal kills (Taylor, 1993b). Based on an estimated sustainable harvest rate of 4 percent, Taylor (1993b) reported that a harvest of 31 to 37 bears could be sustained in GMU 24.

Northern. In response to overharvests in the mid-1960s, hunting of brown bears was closed in 1971-72 (Stephenson, 1995). Since that time, conservative management and a variety of regulations such as drawing-permit hunts have been used to limit harvests and increase population numbers. As the population has increased, the number of permits issued has increased. Beginning in 1987-88, drawing permits were required only for nonresident hunters in GMU 26B, and in 1997, permits were eliminated for all hunters in the unit. The nonresident permit system was reinstated in 1998-99 (Nowlin, 1998c). Between 1988 and 1993, annual harvests averaged 13.5 bears in GMU 26B.

Distribution and Habitat Use

Southcentral. In GMU 6, brown bears are common on the mainland east of the Columbia Glacier and on several islands in Prince William Sound (Griese, 1991b). In these coastal areas, bears emerge from dens in late March (depending on weather conditions) and during spring from mid-April to late July are found in grassland areas such as grass flats, sedge meadows, and saltwater bogs (APSC, 1995a). Brown bears feed on salmon from mid-May through August and use both salmon and berries during the fall from September through early November. Denning begins in late October, with most bears denned by mid-December (APSC, 1995a).

Brown bears in GMU 6 use old-growth forests during spring and early summer (upland forests) and riparian areas within old-growth forests during late summer (Schoen and Beier, 1990). Nowlin (1995b) and Griese (1991b) concluded that logging in these habitats threatens brown-bear abundance and distribution, in addition to providing access roads and increasing human activity. They also expressed concern regarding potential increases in bear/human interactions that may result in bear mortality.

After emergence from dens in the spring, from mid-April through mid-May, most brown bears (except females with cubs-of-the-year) in GMU 13 move down to river bottoms to feed on sprouting plants and overwintered berries, and to scavenge the carcasses of ungulates killed during the winter (Ballard et al., 1982; Miller, 1987; Tobey, 1995b). During the spring, females with cubs are at higher elevations, which reduces contact with other bears. During summer and fall, bear distribution and movements are determined by the presence of salmon and by moose and caribou distributions (Miller, 1987; Tobey, 1995b). Ballard et al. (1982) reported that brown bears in the Nelchina Basin entered dens in late October.

The number of remote cabins and homesites in GMU 13 has increased "substantially" over the past 15 years, and brown bears in the unit are becoming more common in these areas (Tobey, 1995b, p. 127). Miller (1988) documented that bears avoided mining operations at Valdez Creek, although Tobey (1995b) also indicated that nuisance bears were becoming more common at mining claims. Tobey (1995b, p. 127) concluded that "development in remote areas in Unit 13 could reduce brown bear habitat in the unit." Bear/human conflicts and divergent public attitudes towards bears are currently important non-regulatory management concerns (Tobey, 1995b).

Interior. In the vicinity of the TAPS ROW, highest brown-bear densities in GMU 20 occur in the Alaska Range portions of Subunit 20A (Eagan, 1996; Reynolds, H.V., 1997). Medium-density areas include upland forest and tundra habitats at elevations between 150 and 450 m (Eagan, 1996), and those areas of GMU 20D south of the Tanana River (DuBois, 1995). Areas of low brown-bear density contained "significant" human development, areas with poorly drained soils, and permafrost/black spruce parts of the unit (Eagan, 1996, p. 194). APSC (1993) indicated that there were brown-bear spring and "berry-use" areas near TAPS in southern portions of GMU 20.

In GMU 24, brown bears occur throughout the entire area, including the Dalton Highway and TAPS ROW, with higher numbers in the more mountainous areas (Osborne, 1991). No other habitat-use or general-movement patterns have been documented (Reynolds, H.G., 1989).

Northern. Brown bears are distributed throughout GMU 26B; highest densities are in the foothills of the

Brooks Range, while the lowest densities are found on the coastal plain of the North Slope (Stephenson, 1995). APSC (1993) reported brown-bear spring and "berry-use" concentration areas in GMU 26B near TAPS and the Dalton Highway.

Shideler and Hechtel (2000) described brown-bear use of oil fields during 1990-97. Before oil-field development, bears were not common in the oil-field area; however, by 1997 there were 60 to 70 bears in the oil-field study areas (density = 4.0/1,000 km^2). Relatively high densities of arctic ground squirrels, relatively abundant denning habitat, and access to anthropogenic food sources (i.e., garbage) apparently have allowed the bear population to increase to relatively high densities in comparison to other Arctic Coastal Plain habitats. The bears in the oil-field areas do not constitute an isolated population, and there is movement of animals and gene flow among different areas of the North Slope (Cronin et al., 1999).

Most of the bears in the oil-field complex den in natural dens, but some use man-made structures. For example, one bear denned in a pipe casing in the oil field. Shideler and Hechtel (2000) reported that feeding strategies of oil-field bears were similar to other North Slope areas that do not contain oil fields, although 21 percent of radio-collared bears supplemented their diets with anthropogenic food sources in the oil fields. They concluded that overall, bear habitat was more productive in the oil fields than in other North Slope bear-study areas.

Bears with access to anthropogenic food sources in oil fields have relatively large average litter sizes and low cub mortality compared to other bear populations on the Arctic Coastal Plain (Shideler and Hechtel, 2000). However, relatively high subadult and adult mortality offset these benefits. Of 10 deaths, only one occurred in the oil-field complex, when a vehicle hit that bear. Other mortalities included seven bears being killed by hunters or as DLP kills. Only two of the seven kills were officially listed as DLPs, but speculation was that these food-conditioned bears approached camps and were not wary of hunters. Two other bears died of apparently natural but undetermined causes at den sites. Shideler and Hechtel (2000) suggested that oil-field bears which had become habituated to the presence of humans were consequently more vulnerable to harvests by humans when they moved away from the oil fields.

Brown bears in the oil-field complex prey on and scavenge a variety of species including their diet-staple arctic ground squirrels and other microtines, Snow Goose eggs and nestlings, other waterfowl, arctic fox pups excavated from dens, muskoxen calves, and caribou calves (see Shideler and Hechtel, 2000, and references therein). During intensive caribou-calving-ground aerial surveys east and west of the Sagavanirktok River in 1986-90, only a few bears in the oil-field region were seen feeding on dead calves (Shideler, pers. comm., in Shideler and Hechtel, 2000). More recently, brown bears have been observed in the Kuparuk oil field during caribou calving but have seldom been seen foraging on caribou; most bears were associated with anthropogenic food sources (Shideler and Hechtel, 2000).

Shideler and Hechtel (2000) indicated that agency and industry regulations such as prohibition of hunting and firearms within the oil fields, education about bear safety and training in how to handle bear problems, and strict regulations against the feeding of bears had successfully reduced the effects of oil fields on bears. Bear-proof garbage containers are currently being installed in the oil-field complex, and access to the North Slope Borough garbage landfill has been eliminated with chain link and electric fencing. Concerns have been expressed about the impacts of these actions on the bear population. Shideler and Hechtel (2000) anticipated short-term increases in mortality of bears habituated to anthropogenic food sources, but in the long term they expected the bear population would be characteristic of natural populations not exposed to oil fields.

Brown bears have also been associated with anthropogenic food sources in areas other than North Slope oil fields (Shideler and Hechtel, 2000; Harting, 1987). Schullery (1980) reviewed the history of the brown bear/garbage situation in Yellowstone National Park since the late 1800s. Craighead (1980) documented garbage-related bear movements in the park between 1959 and 1970, and the last of the open-pit garbage dumps inside the park were closed in 1970 (Harting, 1987). Extensive controversy surrounded these closures and continues to the present, but is beyond the scope of this review. Other areas that have experienced problems with garbage and bears include Glacier National Park in Montana, Banff and Jasper National Parks in Canada, Katmai National Monument and Denali National Park in Alaska, and Bridger-Teton National Forest (see Harting, 1987 and references therein).

3.2.5.9 Black Bear

Black bears are present in all GMUs that the TAPS ROW crosses, except in the northern GMUs 24 and 26B (Figure 3.2-19). The following discussions are organized based on geography and state GMU boundaries: Southcentral (GMUs 6 and 13) and Interior (GMU 20).

Population History and Status

J. Lukin

Photo 3.2-18. *Black bear.*

Southcentral. In the late 1960s, McIlroy (1970) estimated 0.4 to 5.4 black bears/km^2 near Valdez. He also reported that data on harvests, hunter success, and increasing effort per bear hunted suggested that the black bear population in the Valdez Arm area was declining. However, J.R. Reynolds (1981b, p. 21) stated that before 1981, "sufficient data to determine current status or trend of black bears in Unit 6 were not available." The black bear population in GMU 6 has not been estimated recently, and McDonald (1998d) indicated that the population could sustain the current harvest. Griese (1989c) suggested that trends in black bear harvest are thought to track population trends; black bear numbers in GMU 6 may be stable. In addition to harvest by legal and illegal kills, other factors that may influence black bear numbers in GMU 6 are food abundance, adverse weather, habitat quality and quantity, and competition and predation by brown bears (Griese, 1989c; Nowlin, 1996b).

In 1981, Tobey (1981b) reported that black bears were abundant in suitable habitat in GMU 13. Miller and McAllister (1981, cited in Tobey, 1981b) estimated 1 bear/4.1 km^2 in forested areas of the Susitna River drainage, and in 1985, Miller (1987) estimated 1 bear/1.7 km^2 in the same area. This study area was west of the TAPS ROW and considered marginal habitat and therefore not representative of densities in more favorable habitats in GMU 13 (Tobey, 1996e). Density estimates for black bears in optimal habitat in GMU 13 have not been conducted, and a population estimate is not available for the unit (Tobey, 1996e). Tobey (1989) reported that public reports and miscellaneous sightings indicated that black bears were numerous in GMU 13, and at that time the population appeared to be increasing. Currently, the black bear population in GMU 13 is stable (McDonald, 1998d). In the mid-1980s, predation by brown bears was an important source of natural black-bear mortality (Miller, 1987).

Interior and Northern. Black bears are currently found throughout the Interior in GMU 20, numbering approximately 2,000 to 4,000 (Boudreau, 1996; DuBois, 1996c). Before 1988, few data were available on black bear abundance in the unit (Jennings, 1981; Boudreau, 1996). Hechtel (1991) reported 0.07 adult black bears/km^2 in the Tanana Valley. This density estimate has been extrapolated to the remaining portions of GMU 20, resulting in population estimates of 750 to 1,200 bears in GMU 20B, 400 to 700 bears in GMU 20F, and 750 bears in GMU 20D (Boudreau, 1996; DuBois, 1996c). Population-trend information is not available for GMU 20; however, management objectives are being met (Beasley and McNay, 1989; Boudreau, 1996; DuBois, 1996c). In 1987, Beasley and McNay (1989) concluded that black bear populations in the Interior were stable at moderate densities. Black bear mortality in this area results from harvest by humans (legal, illegal, and DLP kills), predation by brown bears, food shortages that affect cub and yearling survival, and flooding of natal dens (Alt, 1984; Boudreau, 1996; DuBois, 1996c).

Black bear also occur along the north portion of TAPS in GMU 24 and occasionally in southern GMU 26B.

Harvest by Humans and Population Management

Southcentral. In GMU 6, trends in black bear harvest are thought to track population trends (Griese, 1989c), although harvests may also be correlated with hunting effort (McIlroy, 1970). Beginning in 1973, all black bears harvested in Alaska were to be sealed (hide and skull presented

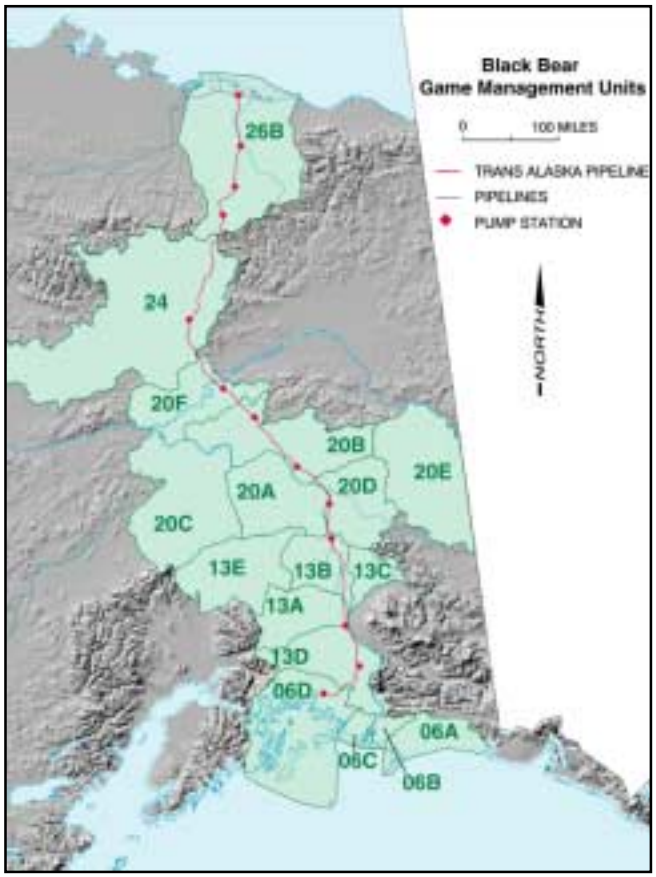


Figure 3.2-19. *Game management unit map for black bears along TAPS.*

for inspection) by an official state representative. Prior to 1973, bear harvests in GMU 6 were largely unreported; Robards (1954) reported "nil" harvest in the early 1950s, while McIlroy (1970) reported over 100 bears harvested during 1965 and 1966. Nowlin (1996b) reported that sealing records indicated an average annual take of 118 black bears between 1973 and 1983, with an increase to 241 between 1984 and 1991 (1986 peak of 279 sealed bears). Since 1991, the average black-bear harvest, including non-hunting mortality and estimates of unreported and illegal kills, in this unit was 227 (range 110 to 304) (Nowlin, 1996b; McDonald, 1998d). Current harvests are above management objectives (Nowlin, 1996b), and a six-month season for all hunters and a bag limit of one per year have been in effect in GMU 6 since 1969 (Griese, 1989c; Nowlin, 1996b). Most hunters come from Anchorage and Fairbanks (Nowlin, 1993b), and more than 70 percent of the harvest occurs in GMU 6D, the subunit containing TAPS.

Although black bear harvests in GMU 13 were not recorded until 1973 when sealing became mandatory, Tobey (1989) estimated that harvests averaged 62 black bears per year between 1970 and 1979 and increased to 83 per year from 1980 to 1983. He attributed higher harvests to increased interest and popularity in black bears as a big game species. During the 1980s, GMU 13 black-bear management objectives were to maintain the existing population of bears, and hunting was open 365 days per year with a bag limit of 3 bears (Tobey, 1989). Recent management objectives call for the black bear population to be largely unaffected by harvest by humans and state that the annual harvest should average less than 125 bears (McDonald, 1998d). Since 1988, harvests including non-hunting mortality, and estimates of unreported and illegal kills have averaged 75 black bears per year (range 53 to 197) (Tobey, 1996e; McDonald, 1998d). Because of a declining percentage of male bears in annual harvests, Tobey (1989) recommended that the bag limit be reduced to one bear. However, as of 1998, seasons and bag limits remained unchanged, and all management objectives had been met (McDonald, 1998d).

Interior. Harvest data were not available before 1974 in GMU 20. Between 1984 and 1995, an average of 210 black bears (range 124 to 303) were taken from GMU 20 (Boudreau, 1996; DuBois, 1996c). Most bear harvest in GMU 20 occurs in the road-accessible portions of GMU 20B, although Boudreau (1996) indicated that hunters are traveling farther away from the road system and from Fairbanks to hunt black bears. In addition, nonresident military hunters can hunt without a tag or license if they hunt on military land. Boudreau (1996, p. 143) concluded that "…military land such as the Yukon Maneuver Area in Unit 20B and the Fort Wainwright land in Unit 20A are hunted intensively. Approximately half of the bear harvest is by military personnel." Most harvest in GMU 20D occurs south of the Tanana River (DuBois, 1996c). Management goals in GMU 20 are being met. These goals are to protect, maintain, and enhance the black bear population and its habitat in concert with other components of the ecosystem; to provide the greatest sustained opportunity to participate in hunting black bears; and to protect human life and property in human/bear interactions.

Distribution and Habitat Use

Southcentral. The highest concentrations of black bears in GMU 6 occur in Subunit 6D, which includes Valdez Arm (Griese, 1989c). During the non-denning period, black bears use coniferous forest and alder-dominated mountain slopes. Where black bear distributions overlap those of brown bears, black bear densities are lower than in areas where only black bears occur (Griese, 1989c). Nowlin (1996b) indicated that relatively high hunting pressure has probably reduced bear numbers near population centers. APSC (1993) identified black-bear concentration areas near the ROW in GMU 6.

In GMU 13, Tobey (1989) indicated that black bears were numerous in those areas with suitable forest habitats and that habitat had probably increased in the unit since the 1950s because of extensive fire-suppression policies. Bears use forested habitats during the summer, and during spring and fall move into shrub zones to feed on berries and succulent vegetation (Miller, 1987; Tobey, 1996e). Habitats along the Susitna River are marginal for black bears and are not considered representative of the unit (Miller, 1987; Tobey, 1989). In relation to TAPS, black bears are most numerous in Subunit 13D, and APSC (1993) identified black-bear concentration areas near the ROW in GMU 13.

Interior. In GMU 20, black bears are at the northern limit of their range in Alaska. They are distributed throughout the entire unit, including those areas in the vicinity of the TAPS ROW and highways. During spring, bears use moist lowlands, where early-growing vegetation is the bulk of their diet (Hatler, 1967, cited in Boudreau, 1996). In the fall, bears feed primarily on berries found in open meadows or alpine areas. In GMU 20D, black bears are essentially absent from the most heavily populated areas and treeless alpine habitat (DuBois, 1996c). APSC (1993) identified black-bear concentration areas near the ROW in GMU 20.

3.2.5.10 Wolf

Wolves are present in all GMUs that the TAPS ROW crosses (Figure 3.2-20). The following is organized into three sections based on geography and state GMU boundaries: Southcentral (GMUs 6 and 13), Interior (GMUs 20A, 20B, 20C, 20F, and 24), and Northern (GMU 26B).

Population History and Status

Southcentral. Wolves have existed in low numbers in GMU 6 since the turn of the century (Griese, 1989d). The numbers have gradually increased since the early 1950s, most likely in response to increased ungulate prey (i.e., deer translocated to islands in Prince William Sound; see Section 3.2.5.6) and cessation of federal wolf-poisoning efforts (ca. 1940s and 1950s) (Nowlin, 1997). There are approximately 47 to 61 wolves in eight packs in GMU 6 (McDonald, 1998e), and although little is known about the wolf population in GMU 6D (specifically Valdez Arm), Nowlin (1997) suggested that it contained 10 to 15 wolves in 3 packs.

Ballard et al. (1987) reviewed the history of wolves in GMU 13 through 1982. During the late 1940s and early 1950s, extensive wolf control by the federal government reduced wolf populations to extremely low levels, with an estimated 12 wolves in GMU 13 in 1953. Following cessation of wolf control, numbers increased quickly and reached a high of 350 to 450 by 1965. In 1967, the population declined to less than 300 wolves in response to hunting pressure and low moose numbers. Wolves increased quickly between 1968 and 1975, reaching a second peak of 426. In 1982, numbers were again reduced to 109 wolves during spring due to harvest management policies designed to reduce wolf predation on moose and caribou. These policies included wolf control and intensive hunting and trapping pressure, including same-day airborne hunting (Ballard et al., 1987) (Figure 3.2-21).

Warren Ballard

Photo 3.2-19. *Wolf.*

After 1982, wolf numbers increased in GMU 13 in response to changes in hunting and trapping seasons and bag limits, methods of allowable harvest, and mild weather conditions. By autumn, wolf numbers were estimated at 400 (Tobey, 1991b). Since the early 1990s, autumn pre-harvest wolf numbers have ranged from 310 to 472, while spring post-harvest numbers ranged from 160 to 260 (Tobey, 1997) (Figure 3.2-21). The fall 1997 wolf population in GMU 13 was estimated to be 360 to 400 wolves in 45 to 55 packs (McDonald, 1998e). Wolves in GMU 13 are not limited by prey availability because "moose numbers are moderate and caribou numbers are high" (McDonald, 1998e, p. 8). Hunting is the primary cause of mortality in GMU 13, although ADF&G is unable to "reduce the wolf population

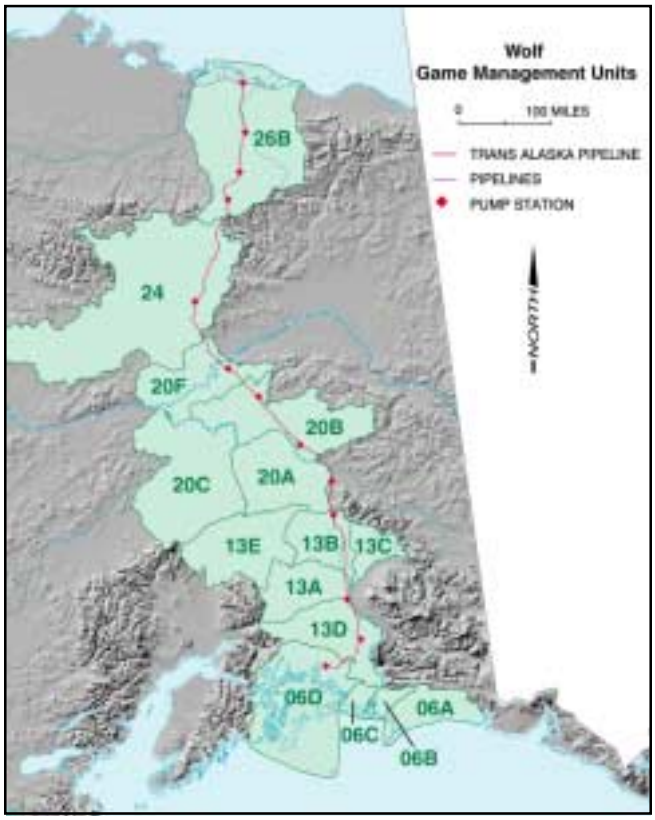


Figure 3.2-20. *Game management unit map for wolves along TAPS.*

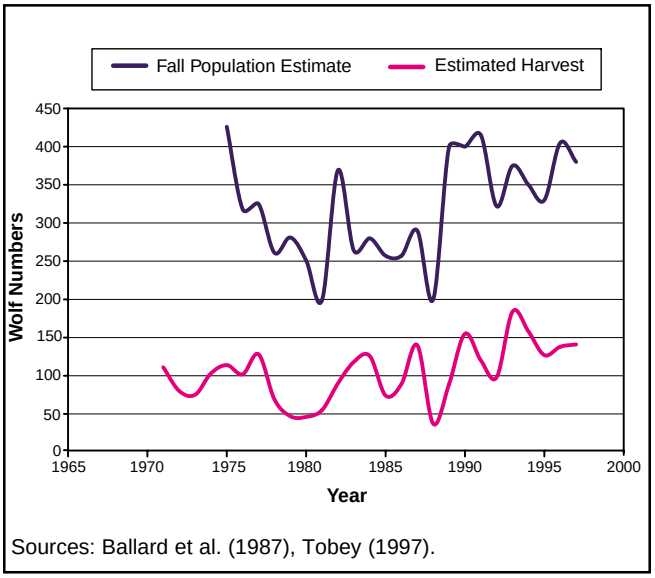


Figure 3.2-21. *Fall wolf-population estimates/harvests, GMU 13.*

to meet wolf management objectives for intensive management" (Tobey, 1997, p. 67). Other sources of wolf mortality include predation by other wolves, accidents, injuries, starvation, and drowning (Ballard et al., 1987; Tobey, 1997)

Interior. Wolves in Interior Alaska, as in most other parts of the state, were numerous in the late 1940s and early 1950s, but by the late 1950s were reduced to low numbers due to federal wolf-control programs (Gasaway et al., 1983). Wolf control ended in 1960, and numbers increased through the 1960s, peaking in the early 1970s. Gasaway et al. (1983) estimated 170 to 260 wolves in GMU 20A between 1963 and 1975. Wolf control was again initiated in autumn 1975 in an effort to increase moose and caribou populations. During the next five years, wolf numbers in GMU 20A were reduced by 70 to 80 percent, and by 55 to 60 percent for an additional two years (Boertje et al., 1996). After control efforts ended in the spring of 1982, wolf populations in the unit increased to pre-control levels (Boertje et al., 1996). In 1993, there were an estimated 250 to 275 wolves in GMU 20A in 30 to 34 packs (Dale, 1997b). During this time, the Delta Caribou Herd declined from 10,700 to 3,600 due to unfavorable weather and predation, precipitating the wolf-control program from October 1993 through November 1994 (Dale, 1997b). In fall 1995, there were an estimated 180 to 210 wolves in GMU 20A in 25 to 35 packs, and 750 to 1,070 wolves in 85 to 144 packs in the lower Tanana Valley (Dale, 1997b). Wolves in GMU 20A are not limited by prey availability (Stephenson et al., 1995).

Wolf populations in GMU 24 have fluctuated over time in response to the availability of prey and to wolf-control activities (Woolington and McNay, 1997). Wolf numbers were historically low in the Brooks Range because ungulate densities were low (Campbell, 1974 cited in Woolington and McNay, 1997). As prey numbers increased during the 1950s, wolf populations in GMU 24 also increased, peaking during the mid-1950s. Federal wolf-control efforts subsequently reduced wolf numbers in the unit, reducing the effect of wolf predation on local moose populations and thus increasing the available prey base. With the cessation of predator control in April 1982 and increased prey abundance, wolves in GMU 24 increased. Between 1988 and 1996, annual wolf-population estimates ranged from 390 to 540 animals in 50 to 70 packs (Woolington and McNay, 1997). In the southern portions of GMU 24, wolf numbers "are as high as at any known time" (Woolington and McNay, 1997, p. 164).

Northern. Wolves are present throughout the Brooks Range and in those areas of the Arctic Coastal Plain where resident prey abundance is sufficient to support their numbers (Stephenson, 1997). ADF&G and FWS personnel have intermittently surveyed wolf populations in GMU 26. In fall 1995, 150 to 215 wolves in 22 to 32 packs were estimated to be in GMUs 26B and 26C, and this population is currently stable (Stephenson, 1997). Factors limiting wolf population growth in GMU 26B include availability of ungulate prey, predation by other wolves, and rabies (Zarnke and Ballard, 1987; Ballard and Krausman, 1997).

Harvest by Humans and Population Management

Southcentral. Before 1982, hunting and trapping seasons were liberal, and same-day airborne hunting was permitted for wolves in GMU 13 (Ballard et al., 1987). After 1982, bag limits and hunting and trapping regulations were restricted (same-day airborne hunting was eliminated in 1988). In the early 1990s, regulations and harvest methods were again liberalized to achieve the GMU 13 wolf-management objective of maintaining a post-hunting and -trapping spring wolf population of 175 to 225 (Tobey, 1997). In 1995, GMU 13 was designated an intensive management area, with the primary objective of increasing harvest of moose and caribou by humans (Tobey, 1997). The spring wolf-population objective was reduced to 135 to 165 wolves. In 1997 there was no bag limit on wolf harvests by hunting and trapping in GMU 13, and same-day airborne hunting was allowed with a registration permit (Stephenson et al., 1995; Tobey, 1997).

Annual wolf harvests from 1971 to 1998 have ranged from a low of 37 during 1988-89 when methods of harvest were greatly restricted, to a high of 184 during 1993-94 when deep snows provided excellent wolf-tracking conditions for same-day airborne hunters (Figure 3.2-21).

Interior. During the 1970s, the ADF&G wolf management objectives for the Interior GMUs including 20A were to reduce wolf numbers to allow increases in moose and caribou populations. Between 1975 and 1981, total wolf harvest in GMU 20A from public hunters and ADF&G control efforts averaged 48 per year (range 13 to 145) (Boertje et al., 1996). After wolf control in 1982-92, the public harvested an average of 36 wolves per year (range 14 to 67), with highest harvests occurring during periods of severe winter weather (1990-92). Renewed ADF&G wolf control increased the annual harvest to 162 wolves during 1993-94 and 66 during 1994-95 (Boertje et al., 1996). Since that time, wolf harvests have remained stable at approximately 50 per year (Dale, 1997b). The number of hunters and trappers has also remained relatively stable.

Between 1988 and 1995, reported wolf harvests in GMU 24 averaged 76 animals each year (range 30 to 119). Most wolves harvested in this unit are probably taken from

the southern portion (Woolington and McNay, 1997).

Northern. Wolf harvests by hunting and trapping in GMU 26B averaged 16 animals per year (range 3 to 31) between 1987 and 1997. Peak harvests occurred in 1992 and 1993, but are currently stable at less than 10 wolves per year (Stephenson, 1997; James, 1997b). In GMU 26B, wolves are harvested from various locations near TAPS from the Atigun River north to Sagwon (Stephenson, 1997). Wolf hunting is permitted only with bow and arrow in the Dalton Highway Corridor Management Area; trapping is allowed in the DHCMA. Actual harvests are probably higher than reported harvests because local hunters do not consistently comply with sealing requirements (Ballard et al., 1997).

Distribution and Habitat Use

Southcentral. Ballard et al. (1987) studied radio-collared wolves during the 1970s and 1980s in GMU 13. They determined that distribution and movement patterns of wolves in GMU 13 were dependent on prey availability. They also found that wolf territory size was primarily a function of moose density and that wolves do not follow migrating caribou out of pack territory. Many of the wolf territories described by Ballard et al. (1987) were bisected by the TAPS ROW and the Richardson Highway.

Interior. Gasaway et al. (1983) documented and described wolf distribution in GMU 20A. In 1976, 5 of 23 packs in the unit had territories directly adjacent to the Richardson Highway and TAPS ROW between Fairbanks and Big Delta. Although migratory moose in the study area crossed the ROW and highway during seasonal movements, Gasaway et al. (1983) did not say if wolves followed them. Ballard and Gipson (2000) also illustrated wolf pack distribution in GMU 20A, with several packs maintaining territories near the TAPS ROW.

Wolves are found throughout GMU 24 in all habitat types and near human settlements (Woolington and McNay, 1997). Their distribution is also dependent on the availability of prey. Highest wolf densities are found in the northern and southern portions of the unit rather than in the central area, which has the lowest density of resident ungulates (Woolington and McNay, 1997).

Northern. Wolves are present throughout GMU 26B in areas where the densities of resident ungulate prey will support their numbers (Stephenson, 1997). Highest wolf densities are found in the Brooks Range and its foothills. Garner and Reynolds (1986) monitored radio-collared wolves in ANWR and as far west as GMU 26B. They determined that these wolves did not follow caribou to winter range, but remained in the same pack territories all year. Radio-collared wolves on the coastal plain seasonally preyed on the most available ungulate species: caribou during spring and summer, and moose and Dall sheep during winter (Garner and Reynolds, 1986). Little is known about wolf habitat use in the foothills of the Brooks Range and on the coastal plain. APSC (1993) documented two wolf-den sites near TAPS — one at Atigun Pass and the other just north of Pump Station 3. Both sites are mapped in river drainages adjacent to TAPS and the Dalton Highway.

3.2.5.11 Furbearers and Small Mammals

Excluding introduced rodents, 39 species of furbearers and small mammals occur along the TAPS ROW: 7 species of shrews, little brown bat, snowshoe hare, collared pika, 6 species of squirrels and marmots, beaver, 11 species of voles and mice, porcupine, 2 species of foxes, coyote, 6 species of weasels, and lynx (Table 3.2-17). Small mammals are ecologically important as primary consumers of vegetation and as prey of larger mammals and raptorial birds. Several species — including the Alaska tiny shrew (Dokuchaev, 1997), the water shrew (Cook et al., 1997), and the long-tailed vole — are rare or little studied. The Alaska tiny shrew, Alaska marmot, and the collared pika are species endemic to Alaska or the North.

No terrestrial mammals in Alaska are listed as threatened or endangered. However, the lynx is a sensitive species (formerly a C2 species and listed as a threatened species in the contiguous 48 states; 65 FR 16052). Along with the river otter, the lynx is listed in Appendix II of the Convention on International Trade in Endangered Species (CITES).

In general, the species of greatest relevance to this project are those that are harvested by humans for fur or food. Therefore, the remainder of this section focuses on 12 species of furbearers that are regularly harvested or that potentially would be affected by specific management activities or impacts other than harvest: beaver, muskrat, coyote, arctic fox, red fox, marten, short-tailed weasel, least weasel, mink, wolverine, river otter, and lynx.

Abundance and harvest statistics are available, primarily from ADF&G survey and inventory reports, for six species of furbearers (including wolves) whose harvested furs must be sealed. Population information is lacking for the other species. The TAPS ROW passes through portions of seven game management units: GMU 26 (North Slope), GMU 25 (Upper Yukon), GMU 24 (Koyukuk River), GMU 20 (Tanana Valley), GMU 13 (Nelchina Basin), GMU 11 (Wrangell Mountains), and GMU 6 (Prince William Sound). ADF&G manages the harvest of furbearers with both hunting and trapping regulations. Beaver, coyote, arc-

Table 3.2-17. *Furbearers and small mammals that have been recorded in Alaska, including the TAPS ROW, North Slope oil fields, and shipping corridor (within Alaska) in which they are known to occur regularly. This list is based on University of Alaska Museum checklist (Jarrell et al., 1998), which includes indigenous, feral, and accidentally introduced species based on refereed literature or specimens at the University of Alaska Museum. Except where noted, names are from Wilson and Reeder (1993). "x" indicates species present; "*" indicates species documented but presently rare (or absent) in range indicated; "?" indicates species possibly present but status unknown.*

Common Name	Scientific Name	TAPS ROUTE								North Slope Oil Fields	Shipping Corridor
		Arctic Coastal Plain	Arctic Foothills	Brooks Range	Interior Forest	Alaska Range	Copper Plateau	Pacific Coastal Mts.	Western Hemlock-Sitka Spruce Forest		
Common, or Masked, Shrew	*Sorex cinereus*	x	x	x	x	x	x	x	x	x	
Barrenground Shrew	*Sorex ugyunak*	x	x							x	
Dusky, or Wandering, Shrew	*Sorex monticolus*			x	x	x	x	x	x		
Water Shrew	*Sorex palustris*				x	x	x	x	x		
Tundra Shrew	*Sorex tundrensis*	x	x	x	x	x	x	?	?	x	
Pygmy Shrew	*Sorex hoyi*				x	x	x	x			
Alaska Tiny Shrew	*Sorex yukonicus*		?	?	x	?	x	?	?		
Little Brown Bat	*Myotis lucifugus*				x	x	x	x	x		
Collared Pika	*Ochotona collaris*			x	x	x	x				
Snowshoe Hare	*Lepus americanus*	x	x	x	x	x	x	x	x	x	
Woodchuck	*Marmota monax*				x						
Alaska Marmot	*Marmota broweri*		x	x							
Hoary Marmot	*Marmota caligata*				x	x	x	x	x		
Arctic Ground Squirrel	*Spermophilus parryii*	x	x	x	x	x	x	x		x	
Red Squirrel	*Tamiasciurus hudsonicus*			x	x	x	x	x	x		
Northern Flying Squirrel	*Glaucomys sabrinus*				x	x	x				
Beaver	*Castor canadensis*				x	x	x	x	x		
Northern Red-Backed Vole	*Clethrionomys rutilus*	x	x	x	x	x	x	x	x	x	
Meadow Vole	*Microtus pennsylvanicus*			x	x	x	x	x	x		
Tundra Vole	*Microtus oeconomus*	x	x	x	x	x	x	x	x	x	
Long-Tailed Vole	*Microtus longicaudus*				x	?					
Yellow-Cheeked, or Taiga, Vole	*Microtus xanthognathus*				x	x	?				
Singing Vole	*Microtus miurus*	x	x	x		x	x	x	x	x	
Muskrat	*Ondatra zibethicus*				x	x	x	x	x		
Brown Lemming	*Lemmus trimucronatus*	x	x	x	x	x				x	
Northern Bog Lemming	*Synaptomys borealis*				x	x	x	x	x		
Collared Lemming	*Dicrostonyx groenlandicus*	x	x	x	*	*				x	
Meadow Jumping Mouse	*Zapus hudsonius*				x	x	x	x	x		
Porcupine	*Erethizon dorsatum*	*	x	x	x	x	x	x	x		
Coyote	*Canis latrans*	x	x	x	x	x	x	x	x	x	
Arctic Fox	*Alopex lagopus*	x	x	*						x	
Red Fox	*Vulpes vulpes*	x	x	x	x	x	x	x	x	x	
Marten	*Martes americana*			x	x	x	x	x	x		
Short-Tailed Weasel, or Ermine	*Mustela erminea*	x	x	x	x	x	x	x	x	x	
Least Weasel	*Mustela nivalis*	x	x	x	x	x	x	x	x	x	
Mink	*Mustela vison*	*	*	x	x	x	x	x	x	*	x
Wolverine	*Gulo gulo*	x	x	x	x	x	x	x	x	x	
River Otter	*Lontra canadensis*		*	*	x	x	x	x	x		x
Lynx	*Lynx canadensis*		*	x	x	x	x	x	x		

tic and red fox, lynx, wolverine, river otter, marten, mink, weasels, muskrat, squirrels and marmots, and hare (all classified as "furbearers" in Alaska Trapping Regulations, No. 40, for 1999-2000 season) may be harvested with a trapping license. Furbearers may be taken with traps or snares, or shot with a firearm, unless specifically prohibited. Coyote, arctic and red foxes, lynx, squirrels and marmots, and hares (all classified as "fur animals" in Alaska Trapping Regulations) may also be harvested with a hunting license. Individual bag limits are cumulative if both harvest methods (hunting and trapping) and licenses (hunting and trapping) are used.

An ADF&G representative must seal pelts of species considered sensitive to overharvest: lynx, beaver, river otter, wolverine, and wolf taken anywhere in Alaska, and marten trapped in certain GMUs or subunits. The primary purpose of sealing is to gather more detailed information about the harvest.

ADF&G manages harvest through bag limits and manipulation of the legal seasons for each species in each GMU or subunit (Table 3.2-18). Current bag limits with a hunting license for coyote, foxes, and lynx are either 2 or 10, depending on the GMU. With a trapping license, there are no bag limits for these three species. Along the pipeline, beaver harvest is controlled by bag limits in GMU 26 (bag limit 0); GMU 25 (bag limit 50, except in Subunit 25C); portions of GMU 20 (bag limit 0 in Subunit 20B, bag limit 25 in Subunits 20D and 20E); and GMU 11 (bag limit 30). For all other species except lynx and wolverine, there are no bag limits along the ROW and the trapping season is more than 100 days long. Trapping and hunting seasons are less than 100 days for lynx in GMUs 6, 11, 13, and 20 (hunting only) and for wolverine in GMUs 11 and 13.

Beaver

Beavers are the largest native rodents in North America (Hall, 1981) and are found in suitable habitats throughout Alaska, except on the Arctic Coastal Plain (Jenkins and Busher, 1979). Beavers occur exclusively in association with woody vegetation and fresh water — including streams and large rivers, impoundments, and lakes — from sea level to the alpine zone where aspen is available. Beavers are generally crepuscular and nocturnal. They eat a variety of woody and herbaceous plants, but their distribution appears to be limited by the winter availability of woody plant species, particularly cottonwood, aspen, willows, and alders.

Beaver are monogamous and produce one litter per year, typically 3 or 4 young (range 1 to 9). Beaver live in extended family groups (colonies) that typically contain 4 to 6 animals in mid-winter, comprising an adult pair with their kits from the previous spring, plus yearlings and occasionally young adults. In most areas, trapping is the main factor limiting the number of beavers per colony (Hill, 1982). Members of a colony contribute to the construction and maintenance of the lodge, dams, and food caches that sustain them through winter. The most common problems associated with beavers and their dams are flooding of roads and fields and raising of water tables, damage to timber by flooding and cutting, and damage to dikes, ditches, and dams. The beaver is an ecologically important species that dramatically alters drainage patterns and enhances aquatic productivity. Beavers may cause problems with TAPS, including flooding and washouts (Trudgen, 1999, pers. comm.)

Muskrat

Muskrats are found in suitable aquatic habitats throughout Alaska south of the Brooks Range (Hall, 1981). Muskrats are associated with standing or slowly flowing aquatic habitats containing vegetation, including coastal marshes and freshwater marshes near lakes, sloughs, streams, and rivers (Perry, 1982). They eat shoots, roots, bulbs, tubers, stems, and leaves of aquatic plants. Muskrats do not store large quantities of food, and in cold environments they require access to plant parts beneath the ice. Water levels and ice thickness greatly influence habitat availability, and changes in food availability caused by fluctuation in water or ice can force muskrats to move. Muskrats live in bank dens or in ponds with constant water level and abundant construction materials, and build houses of pond vegetation (Willner et al., 1980). An elaborate system of canals leads from the house to feeding sites known as "feeders" and "push-ups."

Muskrat populations fluctuate widely and often appear cyclic over periods of 6 to 14 years (Perry, 1982). Muskrats have a high reproductive potential and generally a short life span. Populations are strongly affected by disease and predation, although climatic factors (particularly changes in water levels and ice thickness) and food availability may cause the most conspicuous changes in population size. During periods of high population, muskrats may consume vegetation until both food and cover are destroyed and dispersal and death by starvation result (Perry, 1982).

Coyote

Coyotes are thought to have arrived in Alaska during historic times, and their range in the state is expanding (Manville and Young, 1965; Bekoff, 1977; Cornelius, 1978). They are not abundant in Alaska and occur mainly

Table 3.2-18. *Alaska hunting and trapping seasons for furbearers and small mammals.*

	GMU 26 (North Slope)			GMU 25 (Upper Yukon)		
	Bag Limit	Season	No. Days	Bag Limit	Season	No. Days
Trapping						
Beaver	0	No open season		50a	Nov 1 - Apr 15	227
Coyote	No limit	Nov 1 - Apr 15	227	No limit	Nov 1 - Mar 31	212
Arctic Fox	No limit	Nov 1 - Apr 15	227			
Red Fox	No limit	Nov 1 - Apr 15	227	No limit	Nov 1 - Feb 28	181
Lynx	No limit	Nov 1 - Apr 15	227	No limit	Nov 1 - Feb 28	181
Marten	No limit	Nov 1 - Apr 15	227	No limit	Nov 1 - Feb 28	181
Mink and Weasels	No limit	Nov 1 - Jan 31	92	No limit	Nov 1 - Feb 28	181
Muskrat	No limit	Nov 1 - Jun 10	222	No limit	Nov 1 - Jun 10	222
River Otter	No limit	Nov 1 - Apr 15	227	No limit	Nov 1 - Apr 15	227
Squirrels and Marmots	No limit	No closed season	365	No limit	No closed season	365
Wolverine	No limit	Nov 1 - Apr 15	227	No limit	Nov 1 - Mar 31c	212
Hare	No limit	No closed season	365	No limit	No closed season	365
Hunting						
Coyote	2	Sep 1 - Apr 30	242	10	Sep 1 - Apr 30	242
Arctic Fox	2	Sep 1 - Apr 30	242			
Red Fox	10	Sep 1 - Mar 15	196	10	Sep 1 - Mar 15	196
Lynx	2	Nov 1 - Apr 15	227	2	Nov 1 - Feb 28b	181
Squirrels and Marmots	No limit	No closed season	365	No limit	No closed season	365
Hare	No limit	No closed season	365	No limit	No closed season	365

	GMU 24 (Koyukuk River)			GMU 20 (Tanana Valley)		
	Bag Limit	Season	No. Days	Bag Limit	Season	No. Days
Trapping						
Beaver	No limit	Nov 1 - Jun 10	191	No limitd	Nov 1 - Apr 15	227
Coyote	No limit	Nov 1 - Mar 31	212	No limit	Nov 1 - Mar 31	212
Arctic Fox						
Red Fox	No limit	Nov 1 - Feb 28	181	No limit	Nov 1 - Feb 28	181
Lynx	No limit	Nov 1 - Feb 28	181	No limit	Nov 1 - Feb 28e	181
Marten	No limit	Nov 1 - Feb 28	181	No limit	Nov 1 - Feb 28	181
Mink and Weasels	No limit	Nov 1 - Feb 28	181	No limit	Nov 1 - Feb 28	181
Muskrat	No limit	Nov 1 - Jun 10	222	No limit	Nov 1 - Jun 10g	222
River Otter	No limit	Nov 1 - Apr 15	227	No limit	Nov 1 - Apr 15	227
Squirrels and Marmots	No limit	No closed season	365	No limit	No closed season	365
Wolverine	No limit	Nov 1 - Mar 31	212	No limit	Nov 1 - Feb 28	181
Hare	No limit	No closed season	365	No limit	No closed season	365
Hunting						
Coyote	10	Sep 1 - Apr 30	242	10	Sep 1 - Apr 30	242
Arctic Fox						
Red Fox	10	Sep 1 - Mar 15	196	2	Sep 1 - Mar 15	196
Lynx	2	Nov 1 - Feb 28	181	2	Dec 1 - Jan 31f	31
Squirrels and Marmots	No limit	No closed season	365	No limit	No closed season	365
Hare	No limit	No closed season	365	No limit	No closed season	365

Table 3.2-18 (Cont'd). *Alaska hunting and trapping seasons for furbearers and small mammals.*

	GMU 13 - Glennallen			GMU 11 - Wrangell Mts.		
	Bag Limit	Season	No. Days	Bag Limit	Season	No. Days
Trapping						
Beaver	No limit	Oct 10 - May 15	217	30	Nov 10 - Apr 30	171
Coyote	No limit	Nov 10 - Mar 31	141	No limit	Nov 10 - Mar 31	141
Arctic Fox		No season			No season	
Red Fox	No limit	Nov 10 - Feb 28	110	No limit	Nov 10 - Feb 28	110
Lynx	No limit	Dec 1 - Feb 15	77	No limit	Dec 1 - Feb 15	77
Marten	No limit	Nov 10 - Feb 28h	110	No limit	Nov 10 - Feb 28	110
Mink and Weasels	No limit	Nov 10 - Feb 28	110	No limit	Nov 10 - Feb 28	110
Muskrat	No limit	Nov 10 - Jun 10	212	No limit	Nov 10 - Jun 10	212
River Otter	No limit	Nov 10 - Mar 31	141	No limit	Nov 10 - Mar 31	141
Squirrels and Marmots	No limit	No closed season	365	No limit	No closed season	365
Wolverine	No limit	Nov 10 - Jan 31	82	No limit	Nov 10 - Jan 31	82
Hare	No limit	No closed season	365	No limit	No closed season	365
Hunting						
Coyote	2	Sep 1 - Apr 30	242	2	Sep 1 - Apr 30	242
Arctic Fox		No season			No season	
Red Fox	2	Sep 1 - Feb 15	168	2	Sep 1 - Feb 15	168
Lynx	2	Nov 10 - Jan 31	82	2	Nov 10 - Jan 31	82
Squirrels and Marmots	No limit	No closed season	365	No limit	No closed season	365
Hare	No limit	No closed season	365	No limit	No closed season	365

	GMU 6 - PWS		
	Bag Limit	Season	No. Days
Trapping			
Beaver	No limit	Dec 1 - Apr 30	151
Coyote	No limit	Nov 10 - Mar 31i	141
Arctic Fox		No season	
Red Fox	No limit	Nov 10 - Feb 28	110
Lynx	No limit	Jan 1 - Feb 15	46
Marten	No limit	Nov 10 - Feb 28	110
Mink and Weasels	No limit	Nov 10 - Jan 31	82
Muskrat	No limit	Nov 10 - Jun 10	212
River Otter	No limit	Nov 10 - Mar 31	141
Squirrels and Marmots	No limit	No closed season	365
Wolverine	No limit	Nov 10 - Feb 28	110
Hare	No limit	No closed season	365
Hunting			
Coyote	2	Sep 1 - Apr 30	242
Arctic Fox		No season	
Red Fox	0	No open season	0
Lynx	0	No open season	0
Squirrels and Marmots	No limit	No closed season	365
Hare	No limit	No closed season	365

NOTES

a. Except 25C, no limit
b. Except 25C, December 1 - January 31
c. Except 25C, November 1 - February 28
d. Except closed in some of 20B and limit 25 in 20D and 20E.
e. Except December 1 - February 28 in 20A, 20B, 20D, 20E, and part of 20C.
f. Except November 1 - March 15 in 20E.
g. Except September 20 - June 10 in 20E.
h. Except November 10 - December 31 in 13E.
i. Except November 10 - Apr 30 in 6C

in the southern portions of the state in areas where wolves have been reduced or eliminated. However, they have been observed along the entire length of the TAPS ROW (Bee and Hall, 1956; Manville and Young, 1965; Hall, 1981). Coyotes are most abundant in the most populated areas of Alaska — i.e., Kenai Peninsula, Southcentral Alaska, Copper River Basin (Cornelius, 1978). Coyotes are highly adaptable, denning in a variety of habitats and eating a wide variety of animals and plants (Bekoff, 1982). The basic social unit is the mated pair, although packs do occur. Breeding pairs use dens.

Arctic Fox

Arctic foxes occur throughout arctic tundra habitats in western and northern Alaska (Underwood and Mosher, 1982). Along the TAPS ROW, they occur regularly only on the North Slope of the Brooks Range (Bee and Hall, 1956; Hall, 1981). In this area, arctic foxes feed primarily on lemmings and voles. Arctic fox populations are cyclic and highly variable seasonally (Chesemore, 1975). Populations decline during periods of low microtine-rodent abundance. Arctic foxes feed heavily on carrion in winter and on nesting birds and their eggs during the short avian breeding season. When food is scarce (annually during winter in most areas), arctic foxes wander widely. Dense aggregations can occur in winter at large marine-mammal carcasses and at village dumps, where garbage is available (Chesemore, 1975). Arctic foxes are highly adaptable and readily habituate to human activities when not harassed. They readily consume human foods or garbage and quickly learn to exploit these resources (Burgess, Rose et al., 1993).

Warren Ballard

Photo 3.2-20. *Arctic fox.*

Arctic foxes are monogamous and monestrous. Dens are occupied by a single breeding pair and used for pup-rearing. Dens are typically excavated into low mounds on the tundra, and arctic foxes prefer sites that have a history of use. However, they are capable of denning under skirted buildings, in abandoned human structures and utilidors, and even in abandoned vehicles (Burgess, 2000). The density of arctic fox dens in the Prudhoe Bay area (1 den/12-13 km^2) is higher than adjacent areas on the North Slope (about 1 den/30-40 km^2) (Burgess, 2000). Litter sizes are large, typically 6 to 12 pups, but the number of young produced varies considerably from year to year and is highly correlated with lemming density. Arctic foxes are the main vector of rabies in the Arctic (Winkler, 1975; Crandell, 1975). Although Cowan (1949) suggested otherwise, rabies does not appear to regulate population size in foxes (Elton, 1942; Rausch, 1958; Follmann et al., 1988; Artois et al., 1991) but rather is a symptom of inadequate food availability in a reservoir species. Rabies outbreaks are often associated with periods of high-density arctic fox populations.

Red Fox

Red foxes occur throughout Alaska and along TAPS, except south of the Chugach Mountains in the Prince William Sound area (Hall, 1981). However, they are uncommon on the North Slope except near major rivers and river deltas (Eberhardt, 1977). Small mammals, birds, berries, and insects comprise the bulk of the diet of the red fox (Samuel and Nelson, 1982; Eberhardt, 1977). Red foxes are monogamous and monestrous, and typically both the male and female remain in one area and cooperate in raising the pups. Dens are excavated into low mounds or stream banks.

Weasels

Six species in the family Mustelidae (weasels) occur along the TAPS ROW. Four species of commercial value in the fur industry are discussed here: wolverine, river otter, marten, and mink. Ermine (short-tailed weasels) and least weasels, which are common along all of TAPS (Hall, 1981), feed primarily on microtines and generally are not sought by trappers because of their small size and low commercial demand.

Wolverines are wide-ranging carnivores that occupy forests and tundra along TAPS (Manville and Young, 1965; Pasitschniak-Arts and Larivière, 1995). Pelts of wolverine are prized for parka trim and cold-weather clothing. Prey include small and large mammals, carrion, birds, eggs, and insects (Magoun, 1985; Pasitschniak-Arts and Larivière, 1995). Population densities of wolverines generally are low. On the Arctic Coastal Plain, wolverines have larger home ranges (average 626 km^2 for males; Magoun, 1985) and are more dispersed than in forested areas in Southcentral Alaska (average 535 km^2 for males; Whitman et al., 1986), probably as a result of differing prey availability. Wolverines tend to inhabit remote areas and may be more impacted by habitat loss and human predation than other furbearer species (Hornocker and Hash, 1981).

River otters are restricted to aquatic and marine shoreline habitats and generally decline in numbers with increasing latitude (Larivière and Walton, 1998). Nonetheless, otters are found in low numbers along streams on the Arctic Coastal Plain (Magoun and Valkenberg, 1977) and are present along the TAPS ROW. River otters are listed in Ap-

pendix II of the Convention on International Trade in Endangered Species, which requires permits for international sale of pelts, principally because of low populations in the contiguous 48 states. River otters feed on a variety of fish and marine invertebrates. Small mammals, birds, and eggs are also occasionally used for food (Larsen, 1983).

Marten are restricted to forested areas throughout Alaska (Clark et al., 1987), including the TAPS ROW. They generally require coarse woody debris or trees to provide shelter and pathways under snow (Buskirk, 1983; Paragi et al., 1996). Dens and resting sites are made in hollow trees, squirrel nests and middens, and under tree roots, logs, rocks, and snow. Marten are relatively easy to trap and depending on pelt prices, are heavily exploited by trappers. Marten primarily eat small mammals, but also use birds, fish, carrion, insects, fruits, and human food when available (Buskirk and MacDonald, 1984; Ben-David et al., 1997).

Mink inhabit the shores of streams, lakes, and coastlines of the boreal forest in Alaska (Larivière, 1999). They are uncommon to rare along streams on the Arctic Coastal Plain (Bee and Hall, 1956) but occur throughout the TAPS ROW. Mink prey primarily on animals associated with water, including fish, terrestrial and marine invertebrates, birds, and to a lesser degree, small mammals (Harbo, 1958; Johnson, 1985). Mink attain their highest densities on marine coastlines such as those in Southeast Alaska (20/linear mi; Harbo, 1958), compared with Interior streams, which support lower densities (2.2/mi^2; Harbo, 1958).

Lynx

Lynx occur throughout the boreal region of North America, including Alaska (Tumlison, 1987), and occur along the TAPS ROW from the Brooks Range south. They are very rare on the North Slope (Rausch, 1953; Bee and Hall, 1956). Lynx are found most often in forested habitats (mixed spruce-hardwood forests, open spruce muskegs, and aspen-spruce woodlands); occasionally in shrub habitats; and rarely in open habitats (Berrie, 1973; Stephenson, 1986; Perham, 1995).

The primary prey of lynx is the snowshoe hare, which fluctuates in abundance on an approximate 10-year cycle in Interior Alaska (Wolff, 1980; Mowat et al., 1999). When hares are not abundant, lynx select alternate prey including grouse, ptarmigan, red squirrels, and microtine rodents (Kesterson, 1988; Perham, 1995). The reproductive success and thus population size of lynx are tied closely to the population size and density of snowshoe hares (O'Connor, 1984; Mowat et al., 1999).

Lynx may be susceptible to overharvest because they are fairly easy to trap and their populations decline to low levels during periods of prey scarcity (e.g., Bailey et al., 1986). Lynx populations are managed closely by ADF&G to restrict harvest when populations are low, thereby enhancing population recovery as hare numbers rise. The lynx was formerly a federal Category 2 candidate species, primarily due to its scarcity in historical range in the contiguous 48 states, where it was listed (50 CFR 17) as of March, 2000 as a threatened species under the Endangered Species Act. However, there is no indication that the population is threatened in Alaska or northern Canada. Currently, snowshoe hares are relatively abundant in Interior Alaska, and lynx numbers have grown in the mid- to late 1990s, based on the increasing proportion of young animals taken by trappers (Taylor, 1993a, 1994b, 1995, 1996; James, 1996). Home-range size varies between the sexes (males tend to have larger ranges), as well as seasonally and with changes in prey abundance (Berrie, 1973; Stephenson, 1986; Perham, 1995). In favorable habitat in eastern Interior Alaska, home ranges of male lynx average 139 km^2 (range = 13 to 242 km^2; n = 6), overlapping the ranges of several females, whose home ranges average 56 km^2 (n = 3) (Perham, 1995). Lynx are known to disperse widely when hare populations decline (Mowat et al., 1999).

3.2.6 Marine Mammals

By J. Burns, C.B. Johnson, and S.R. Johnson

3.2.6.1 North Slope/Beaufort Sea

Most of the marine mammals that occur regularly in the Beaufort Sea have a holarctic distribution that includes multiple geographic stocks (Table 3.2-19). Those with stocks present in the Beaufort include the polar bear, ringed and bearded seals, and bowhead and belukha whales. Gray whales were also in this category, but the two Atlantic stocks are now extinct and the western Pacific one is nearly so. The eastern Pacific stock is no longer listed as threatened or endangered. In Alaskan waters, several marine mammals reach the northern limit of their summer distribution in the northeastern Chukchi Sea, occurring irregularly and in low numbers in the Beaufort Sea. Usually, such species are noted in the extreme western part near Point Barrow. Their occasional presence farther east is more on the order of infrequent extra-limital occurrences. These species include the harbor porpoise, killer whale, and gray whale. Others such as the walrus and spotted seal occur regularly in the western Beaufort and decrease markedly farther east, the former mainly as individual stragglers east of Pitt Point and the latter as stragglers east of Oliktok Point. Ringed

Table 3.2-19. *Marine mammal species (in taxonomic order) of the Beaufort Sea and Prince William Sound, including their status under the Marine Mammal Protection Act (MMPA), and the Endangered Species Act (ESA).*

Order	Common Name	Scientific Name	Abundance (a)	Seasonal Residency	Status under MMPA (b)	Status under ESA
BEAUFORT SEA						
Cetaceans	Bowhead whale	*Balaena mysticetus*	Abundant	Seasonal	Depleted	Endangered
	Gray whale	*Eschrichtius robustus*	Occasional	Seasonal	Protected	Delisted
	Fin whale	*Balenoptera physalus*	Occasional	Seasonal	Depleted	Endangered
	Killer whale	*Orcinus orca*	Occasional	Seasonal	Protected	—
	Belukha whale	*Delphinapterus leucas*	Abundant	Seasonal	Protected	—
Pinnipeds	Walrus	*Odobenus rosmarus divergens*	Occasional	Seasonal	Protected	—
	Spotted seal	*Phoca largha*	Common	Seasonal	Protected	—
	Ringed seal	*Phoca hispida*	Abundant	Year round	Protected	—
	Ribbon seal	*Phoca fasciata*	Occasional	Seasonal	Protected	—
	Bearded seal	*Erignathus barbatus*	Abundant	Year round	Protected	—
Carnivores	Polar bear	*Ursus maritimus*	Abundant	Year round	Protected	—
PRINCE WILLIAM SOUND						
Cetaceans	Northern right whale	*Eubalaena glacialis*	Unknown	—	Depleted	Endangered
	Gray whale	*Eschrichtius robustus*	Occasional	Seasonal	Protected	Delisted
	Blue whale	*Balenoptera musculus*	Occasional	Seasonal	Depleted	Endangered
	Fin whale	*Balenoptera physalus*	Common	Seasonal	Depleted	Endangered
	Sei whale	*Balenoptera borealis*	Occasional	Seasonal	Protected	—
	Minke whale	*Balenoptera acutorostrata*	Common	Year round (c)	Protected	—
	Humpback whale	*Megaptera novaeangliae*	Common	Seasonal	Depleted	Endangered
	Sperm whale	*Physeter macrocephalus*	Unknown	—	Depleted	Endangered
	Belukha whale	*Delphinapterus leucas*	Occasional	Seasonal	Depleted	—
	Short finned pilot whale	*Globicephala macrorhynchus*	Rare	—	Protected	—
	Rissos dolphin	*Grampus griseus*	Rare	—	Protected	—
	Baird's beaked whale	*Bararclius bairdii*	Unknown	—	Protected	—
	Cuvier's beaked whale	*Ziphius cavirostris*	Unknown	—	Protected	—
	Stejneger's beaked whale	*Mesoplodon stefnegari*	Unknown	—	Protected	—
	Killer whale	*Orcinus orca*	Abundant	Year round (c)	Protected	—
	Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	Occasional	Seasonal	Protected	—
	Harbor porpoise	*Phocoena phocoeno*	Abundant	Year round (c)	Protected	—
	Dall's porpoise	*Phocoenoides dalli*	Abundant	Year round (c)	Protected	—
Pinnipeds	Steller's sea lion	*Eumetopial jubatus*	Common	Year round (c)	Depleted	Endangered (d)
	Northern fur seal	*Callorhinus ursinus*	Occasional	Seasonal	Depleted	—
	Harbor seal	*Phoca vitulina richardsi*	Abundant	Year round	Protected	—
Carnivores	Sea otter	*Enhydra lutris*	Abundant	Year round	Protected	—

a. Modified from Morris et al. (1983) and Calkins (1986).
b. Marine Mammal Protection Act. Endangered species are classified automatically as depleted; all stocks of depleted species are strategic stocks.
c. Reduced numbers in winter.
d. Population segment west of 144° west longitude (Cape Suckling); segment east of there is listed as threatened.

seals, bearded seals, and polar bears, all of which move extensively, are present year-round. Bowhead and belukha whales are normally present from late April to mid-October. Bowhead whales, bearded seals, ringed seals, and polar bears are important subsistence species for hunters from Barrow, Nuiqsut, and Kaktovik. Belukha whales are taken sporadically when available.

Pacific Walrus

Walruses are obligate benthic feeders that periodically haul out on sea-ice or land to rest. Their distribution is restricted to continental-shelf waters, where they feed at depths of 110 m or less (Fay and Burns, 1988). Essentially the entire population, estimated to number at least 201,000 in 1990 (Gilbert et al., 1992), winters in the Bering Sea. Some animals, mainly males, remain there during summer and use land haulouts on the Russian and Alaskan coasts. The largest segment of the population migrates north in spring and early summer, and reaches the northern Chukchi Sea usually in mid-July to early August, depending on the

severity of ice conditions. One component summers in the eastern Chukchi Sea. The eastern distribution of these animals is normally considered to be in the vicinity of Point Barrow (Brooks, 1954), though it is now known that small numbers move beyond there into the Beaufort Sea (Burns, pers. obs.). In occasional years when sea-ice remains close to shore, small herds occur as far east as Cape Simpson. Beyond that, they occur as individual stragglers and as beach-cast remains as far east as Canada's Yukon Territory (Bee and Hall, 1956; Harington, 1966; Youngman, 1975). A single animal that had apparently overwintered near Banks Island was reported by Stirling (1974).

In most years relatively few walruses enter the Beaufort Sea, and their residence time is short because the pack ice recedes north, well beyond the narrow continental shelf on which they forage. In the central Beaufort, they are beyond the margin of their normal range and are present only occasionally and usually as singletons.

Spotted Seal

The primary sources of information about spotted seals in the Beaufort Sea are J. Burns (pers. obs.); T. Bendock (1985, pers. comm.); H. Brower, Sr. (numerous pers. comms.); J. Helmericks (1990, 1999, pers. comm.); local knowledge; Porsild (1945); Bee and Hall (1956); Youngman (1975); BLM and MMS (1998); and USACE (1999). Spotted seals occur in the coastal zone of the Beaufort Sea every summer. They are a component of a much larger population that is abundant but for which the population size is unknown (Small and DeMaster, 1995). Spotted seals winter in the Bering Sea, and many migrate north in the summer. These seals appear in the northern Chukchi in July, and a small number, now estimated at about 1,000 (BLM and MMS, 1998), move east past Point Barrow. The basis for that estimate is not clear. Most of the spotted seals occur in the western and west-central Beaufort.

The Harrison Bay/Colville River region is probably the eastern boundary of their normal summer range, though a few are encountered as far east as Herschel Island, Canada. In the 1960s and early 1970s, about 200 to 300 spotted seals hauled out at several locations in the eastern Colville Delta. Currently, the numbers there are on the order of 25 to 30. The reduction has been attributed to increased access and harvests by local subsistence hunters (J. Helmericks, 1999, pers. comm.; H. Helmericks, 2000, pers. comm.). It is more likely, however, that dynamics of the spotted-seal population have been negatively affected by the significant decline in primary productivity of the Bering Sea, found by Schell (1998) to have been on the order of 30 to 40 percent since 1965.

Spotted seals arrive in the Beaufort after ice has cleared from the bays, and they depart with the onset of freezeup in early October. These far-ranging seals feed at sea, in coastal bays and lagoons, and in rivers during periods of high fish concentrations. They haul out on islands and sandbars. Only a few haulouts are known to be used regularly, and these include Oarlock Island in Dease Inlet, where the highest numbers are encountered; in Smith Bay near the mouth of the Ikpikpuk River; and in the Colville River delta. A few regularly ascend the Colville River as far upstream as the confluence of the Itkillik River, and there are occasional reports of seals to Ocean Point and beyond. When spotted seals are hauled out, even minor disturbances cause them to flee into the water. The few seals that use haulouts on the Colville River delta are probably those most frequently subjected to anthropogenic disturbances.

Ringed Seal

Ringed seals are abundant and present year-round in the Beaufort Sea. They are most evident when floating sea ice is present. Floating ice includes both landfast and pack-ice habitats. Ringed seals make and maintain holes through the ice by abrading it with the strong claws of their fore-flippers. During autumn to early summer, highest densities of these seals occur in the fast ice habitat. As snow accumulates, they enlarge breathing holes to haul out and make lairs in snowdrifts and pressure ridges. In winter the lairs are for resting, while more complex pupping lairs are made starting in about mid-March. The white-coated pups are born in these complex lairs from late March to May, and are nursed for 4 to 6 weeks (Smith and Stirling, 1975; Smith and Hammill, 1981; Kelly, 1988). Starting in late April, seals of all ages begin to haul out on top of the ice and snow to bask during the annual molt. Basking seals are most numerous in late May-June.

The first areawide aerial survey of molting ringed seals on the fast ice between Point Barrow and Barter Island was done in June 1970. Intermittent surveys have continued to the present. Compared to other areas in Alaska, the density of seals on fast ice of the Beaufort is low and annually variable. In 1970, the observed densities were: 0.88/km^2 between Point Barrow and Lonely, 0.41 between Lonely and Oliktok, 0.53 between Oliktok and Flaxman Island, and 0.94 in the area between Flaxman and Barter islands (Burns and Harbo, 1972). In comparison, surveys in 1996-98 found 0.57 to 0.83 basking seals/km^2 between Oliktok and Flaxman Island, and 0.67 to 1.17/km^2 between Flaxman and Barter islands. These values were within the range of those from surveys in the mid-1980s (Frost and Lowry, 1999). More limited surveys in the central Beaufort in

1997-99 near proposed development projects produced estimates of 0.39 to 0.65 seals/km^2 on fast ice overlying water depths of 3 m or more (Moulton and Elliott, 1999). The "countable" seals represent an as-yet unknown proportion of the overwintering population.

In Alaska, ringed seals rarely haul out on shore. During the ice-free season, relatively few are seen at sea because of low sightability in all but calm or nearly calm winds. They are, however, present in the coastal zone, in open water, and in pack-ice habitats. Treacy (1988-98) reported incidental sightings in all years of his bowhead whale surveys and noted that they are broadly distributed throughout the open-water habitat. He commented (Treacy, 1999, pers. comm.) that it was not uncommon to encounter active feeding aggregations of 10 to 25 seals.

Though ringed seals are an important subsistence resource in the Beaufort Sea region, current hunting effort, especially in winter, is much reduced compared to former times. Winter hunting success is traditionally greatest during late autumn-early winter and steadily declines during February to mid-April, as the seals become more sedentary. It increases again in late spring-early summer when they begin to haul out during the molt, migrate, and become more easily accessible to hunters using small boats in the deteriorating ice.

Bearded Seal

Bearded seals are present year-round in the Beaufort Sea. Though quantitative estimates are lacking, they are considered common though not abundant during late spring-early autumn, and common but few during the months of heavy, comparatively stable ice cover. These seals are strongly associated with the more labile ice of subarctic and arctic regions, where it overlies waters less than about 500 to 650 ft deep (150 to 200 m). In Alaska they occur very infrequently in the winter fast-ice zone. Bearded seals are benthic feeders, and their diet includes many items also consumed by walruses — such as bivalve molluscs. The population in Alaskan waters is largely migratory, with the center of winter abundance in the Bering Sea. Farther north, they are restricted to areas within the pack ice where environmental conditions produce persistent openings (leads, polynyas, flaw zones, etc.). Such conditions become progressively more limited north of Bering Strait, and especially in the Beaufort Sea (Burns, 1967; Burns and Frost, 1983; Kelly, 1988).

Bearded seals are the largest of the phocid seals, with adults weighing up to 800 pounds (lb) [360 kilograms (kg)]. The high yield of meat, utility of their large durable hides, and good availability during spring breakup make them the preferred seal taken by subsistence hunters. Relatively few are taken in the Beaufort Sea, except near Point Barrow.

Bearded seals are rarely found or seen on fast ice of the Beaufort Sea before spring breakup (Burns and Harbo, 1972; Frost et al., 1989; Frost and Lowry, 1999). Reported sightings of 13 bearded seals on the fast ice between Long and Stockton islands during surveys on 4-8 June 1999 (Moulton and Elliott, 1999) are unusual, perhaps questionable, and at variance with their absence during replicate surveys of the same transects on subsequent days.

During the open-water season, these seals are broadly distributed from shore seaward in open water and into the pack ice. They do not normally haul out on land unless debilitated. In early autumn, juveniles occasionally occur in river mouths and lagoons where low-salinity water freezes before the more salty waters of other nearshore areas.

Polar Bear

State of Alaska

Photo 3.2-21. *Polar bear.*

In the Beaufort Sea, polar bears are present year-round, though with major seasonal shifts in distribution. These animals form a separate stock that occurs in the area from Point Hope (east-central Chukchi Sea) to Cape Bathurst (western Amundsen Gulf). This stock has increased at an estimated annual rate of 2 percent or more during the past three decades. It now numbers perhaps 2,000+ animals and is thought to be at or near carrying capacity (Amstrup, 1995; FWS, 1995b). The average density in the region from Point Barrow to Cape Bathurst was estimated to be 1 per 141 to 269 km^2 in 1986 (Amstrup et al., 1986).

During late autumn to spring, polar bears are widely distributed, occurring on land, on the fast ice, and on the pack ice. However, they are most abundant in the active flaw zone, where their principal prey, ringed seals, are most available. During open water, they are mainly associated with the distant pack-ice, though they are occasionally seen on land or swimming in open water at a considerable distance from the ice. In autumn, as the ice comes closer to the coast, some commonly swim ashore and scavenge beachcast carcasses or the remains of bowhead whales taken by subsistence hunters — a relatively common occurrence at Kaktovik. Polar bears can be a safety hazard as they enter settlements and occasionally destroy property

and kill people.

Unlike other bears, polar bears do not aestivate, but are active all winter. The exceptions are pregnant females, which make maternal dens in deep snowdrifts during late October-November. Of 90 dens in the Beaufort Sea region reported by Amstrup (1995), 48 were on drifting pack-ice, 38 were on land, and 4 were on landfast ice. The distribution of dens is illustrated in Amstrup (1995, p. 259).

Cubs, usually two, are born in December to January. The mothers and cubs emerge from maternal dens in late March-early April, and those that were on land go to sea. There has been continuing concern about the effects of anthropogenic disturbances on bears in maternity dens. Amstrup (1995) noted that disturbances resulting from opening dens, capture, examination, marking, and radio-tracking of maternal bears did not affect litter sizes or the growth and condition of cubs. Also, 10 of 12 bears in dens tolerated exceptional levels of human activity. He believed that because of the high tolerance threshold, the imposition of short-term spatial and temporal restrictions on human activities near dens could prevent undue disturbance of bears in dens (Amstrup, 1995, p. 262).

Gray Whale

Gray whales feed primarily on benthos. Their summer distribution is mainly limited to shallow waters of the continental shelf. Gray whales are abundant in the northeastern Chukchi and occur irregularly in the Beaufort. During annual whale surveys in autumn from 1987 to 1997, Treacy (1988-98) saw these whales in only two years. In 1988, a beachcast carcass was seen east of Deadhorse, and three animals were entrapped in newly formed shore ice at Point Barrow. On October 2, 1997, three groups totaling nine whales were seen near Point Barrow. On occasion they occur farther east. One was taken by Eskimo hunters near Cross Island in 1933; 30 were seen near Cooper Island 33 km east of Point Barrow on October 5, 1972; one was seen near Barter Island in September 1975; and three were reported off Tuktoyaktuk, Canada, in August 1980 (Maher, 1960; Marquette and Braham, 1982). Interestingly, they were not mentioned by Porsild (1945) or Youngman (1975) as occurring in waters of the Mackenzie Delta or the Yukon Territory. Presumably the more recent sightings reflect the increase and recovery of this once-depleted species, now estimated to number 23,000 (Small and DeMaster, 1995).

In the central Beaufort, gray whales occur infrequently. It is not known if more of these whales may go into the Beaufort Sea if annual summer ice conditions continue to ameliorate. They are not an important subsistence species, though they may be taken occasionally.

Belukha Whale

Belukha whales occur in the Beaufort from mid- to late April through late October-early November. Rarely, some may overwinter. Like bowhead whales, they migrate north from wintering areas, mainly in the Bering Sea, starting in early spring. Usually some are seen at Point Barrow by mid-April, often travelling with or in proximity to bowheads. Also like bowheads, most travel through offshore leads to the eastern Beaufort Sea and Amundsen Gulf, where they summer. During early summer they are common in the warm waters of Mackenzie (primarily), Kugmallit, and Liverpool bays. Others occur in open water and in the distant summer pack-ice (largest component) (Harwood et al., 1996), probably moving among the three habitats. Young are born mainly during mid-June to mid-July and nurse for 12 to 18 months (Burns and Seaman, 1985).

The Beaufort Sea stock, recognized on the basis of where they spend the summer, is estimated to number more than 41,000. Belukhas of the eastern Chukchi stock, estimated at perhaps 3,700 animals (Small and DeMaster, 1995), now summer mainly in and near the 170-km-long Kasegaluk Lagoon system near the settlement of Point Lay (Frost et al., 1993). At least some, and perhaps all of them, move north into the Beaufort during late July-early August (Burns and Seaman, 1985; R. Suydam, 1999, pers. comm.), at about the same time animals of the Beaufort Sea stock begin migrating west. Though most belukhas in the Beaufort during summer are in the east, some are present in low numbers across the entire region. The late summer/autumn return migration from Canadian waters is protracted. Most belukhas travel in and near the front zone of the pack ice, but also through open water from the offshore ice margin to the coast (Burns and Seaman, 1985; Treacy, 1988-98).

The responses of belukhas to noise and disturbance are highly variable and range from habituation to flight at long distances from approaching large vessels. Responses are probably related to a number of factors including experiences of the whales, time and nature of habitat use, activities of the whales, type of disturbance, and with respect to vessels, their characteristics and maneuvers. In Cook Inlet, before the serious population reduction [thought to be due primarily due to overharvest (NMFS, 2000)], they frequented the area of the City of Anchorage port facilities and several rivers in which small boat traffic was heavy. They still use the remaining primary estuary in which they have been intensively hunted for many years. In Bristol Bay they feed among the salmon fishing boats. In other areas they continue to return to favored bays and river mouths in spite of extensive hunting pressure. Conversely, in deep ice-cov-

ered waters of the Canadian High Arctic, during spring, they swam away from large ships and icebreakers as far away as 35 to 50 km. In general, belukhas are more tolerant of disturbance in open water than when their movements are constrained by sea ice (Burns, pers. obs.; Burns and Seaman, 1985; Cosens and Dueck, 1993; Richardson, Greene et al., 1995).

Bowhead Whale

The Bering Sea (western arctic) stock is the largest of the five that occur in the holarctic range of this species. Size of the Bering Sea stock was estimated at 10,400 to 23,000 before decimation by the commercial whaling industry in the last half of the nineteenth century, and perhaps 3,000 when whaling ended in 1914 (Woodby and Botkin, 1993). This stock has slowly increased since then and in 1993 was estimated at 8,000, with a 95 percent confidence interval from 6,900 to 9,200 (Zeh et al., 1994). The estimated rate of increase from 1978 to 1993 was 3.2 percent (Zeh et al., 1996) and occurred in the face of harvesting, other sources of mortality, and industrial activity in the Beaufort Sea. In spite of its current population size and trend, the Bering Sea stock is still classified as endangered (ESA designation) and depleted (MMPA designation).

Bowheads winter in the Bering Sea, migrate north in spring, and summer in a broad area from Amundsen Gulf and the eastern Beaufort Sea to the eastern part of the East Siberian Sea. The spring migration begins in late March-early April, depending on ice conditions. From April to June, most are distributed along a migration corridor that extends from the Bering Sea wintering grounds to feeding grounds in the eastern Beaufort (Moore and Reeves, 1993). Usually the first migrants are seen at Barrow in mid-April, though in the extreme heavy ice year of 1980, they did not appear until late May (Krogman et al., 1989). After rounding Point Barrow, bowheads (and belukhas) travel through offshore leads in the continuous pack-ice to the eastern Beaufort Sea, where they spend the summer feeding on abundant zooplankton. An unknown but variable part of the population migrates along the Russian coast to feeding grounds in the western Chukchi Sea (Bogoslovskaya et al., 1982). Whales that summered in the eastern Beaufort begin the first part of the fall migration in late August/September and are usually out of the Beaufort by late October (Treacy, 1988-98; Moore and Reeves, 1993). If food is abundant, they feed en route, sometimes close to shore.

Other than during the spring and autumn migrations, the number of bowheads in the Alaskan sector of the Beaufort is low. Successful harvesting of this very important subsistence resource occurs during both the spring and autumn near Point Barrow, but is restricted to the autumn near Kaktovik and Nuiqsut. Near Barrow, the spring migration through leads next to the landfast ice provides hunters with access to the whales, as does their westward passage in open water past Point Barrow in autumn. The autumn migration provides the only opportunity for whalers near Kaktovik and Nuiqsut. From 1990 to 1999, Barrow hunters landed 207 whales, of which 110 were taken during autumn. During that same period, 26 were landed by whalers from Kaktovik (range 1 to 4/yr) and 20 by hunters from Nuiqsut (range 0 to 4/yr) (George, 1999, pers. comm.; Alaska Eskimo Whaling Commission harvest records). Several variables contribute to whaling effort and success in autumn — notably weather, proximity of migrating whales, sea-ice conditions, and at Barrow, success of the spring whaling season. Miller et al. (1996) and Treacy (1988-98) reported that proximity of the pack ice during autumn influences the migration, with a tendency for bowheads to migrate farther offshore during years of extensive ice cover.

There has been ongoing concern about the effects of disturbance on bowhead migration and feeding during autumn, particularly from low-flying aircraft, marine shipping, vessel-based seismic exploration, and stationary exploration and production facilities. Richardson, Greene et al. (1995) reported available information about these issues. In summary, whale responses to low-level aircraft were highly variable depending on activities of the whales and the habitat in which they were encountered. When responses were elicited, they included diving, turning away from the aircraft, or dispersal away from the area being circled. The effects were transitory. Responses to ships and boats were also highly variable, mainly depending on what the vessels were doing. Bowheads greater than 500 m to the side or behind a small ship seemed unaffected. Whales approached within 100 to 500 m when a ship was stationary or not maneuvering toward them. In other instances whales attempted to avoid approaching vessels at distances of 4 km or more. Bowheads can be displaced by as much as a few kilometers while fleeing, but stop doing so when a vessel is a few kilometers past.

Little is known about disturbance by icebreakers actively involved in ice-breaking, which produces the highest noise levels. In one instance, migrating whales apparently avoided such activity at a distance of 25+ km, though they responded similarly to a drillship and nearby support vessels operating in open water. In other instances of stationary offshore activities, bowheads showed no overt responses unless the broadband received sound levels were about 20 decibels (dB) or more above ambient levels.

Reactions of bowheads to airgun arrays and single airguns were studied in Beaufort Sea during the 1980s, and again in 1996-98. The earlier work, based on small sample sizes, showed that bowheads often avoided strongly when an operating airgun array approached within ~7.5 km (~160 dB re 1 µPa rms) (Richardson et al., 1986; Ljungblad et al., 1988). However, subtle behavioral effects extended to greater distances (Richardson et al., 1986). Also, Eskimo hunters reported that migrating bowheads avoided seismic boats at much greater distances (MMS, 1997a). During 1996-98, aerial surveys near Prudhoe Bay showed that most migrating bowheads avoided the area within 20 km of an active airgun array (Richardson et al., 1999). Some avoided the 20- to 30-km area as well. The seismic operation was close to shore, and westbound bowheads deflected offshore to avoid it. Broadband received levels of pulses 20 km from the array were typically 120 to 130 dB re 1 µPa (rms) — notably lower than previously demonstrated to cause avoidance of airgun arrays by baleen whales. The avoidance distances were large even though the airgun array was rather small: 560 to 1,500 cubic inches (in^3) and 6 to 16 guns, with only one array operating at any one time. Bowheads re-occupied the 20-km avoidance zone within 12 to 24 hours after airgun operations ended. The recent work shows that studies in the 1980s underestimated the distances where bowheads begin to avoid an approaching airgun array, and overestimated the received sound levels necessary to elicit avoidance.

To date, no indications exist that industry-related anthropogenic disturbance has adversely affected the population of whales or the success of subsistence whaling in the Beaufort Sea. Whaling has been and is the single activity that has had the greatest impact on this stock of bowheads.

3.2.6.2 Prince William Sound Tanker Routes

Nine species of marine mammals are abundant or common in Prince William Sound; other species are uncommon, rare, or unknown in occurrence (Table 3.2-19) and will not be discussed here. All marine mammals are protected by the Marine Mammal Protection Act (1972), some are protected by the Endangered Species Act (1973), and great whales are further regulated by the International Whaling Commission. The status, abundance, and residency of each species are listed in Table 3.2-19.

In Prince William Sound, six species of cetaceans, two species of pinnipeds, and one species of carnivore are common to abundant. Killer whales are found worldwide in all major oceans but favor the colder waters of both the North and South Hemispheres (Matkin et al., 1997). Of four species of whales common to Prince William Sound, the killer whale is the only toothed whale and primarily feeds on marine mammals and fish (Calkins, 1986). Killer whales are abundant and present year-round, but the migratory pattern in and out of the Sound probably varies among pods (Dahlheim and Matkin, 1994). Of more than 14 pods identified in Prince William Sound, eight are regularly found there (Matkin et al., 1994).

Four baleen whales occur seasonally in Prince William Sound. Fin, humpback, and gray whales are the largest species to visit the Sound and are migratory; minke whales are small migratory whales that might occur there year-round (Calkins, 1986). Fin and humpback whales are endangered species, whereas the gray whale has been delisted. Numbers of large baleen whales using Prince William Sound are not readily available, but humpback whales probably are most abundant, with 60 to 100 individuals feeding there during summer (von Ziegesar et al., 1994). Humpbacks feed on euphausiids and fish (Kawamura, 1980). Fin whales occur in Prince William Sound during April-June, when they are migrating to the Bering Sea (Hall, 1979). Gray whales also are migrating to and from the Bering and Chukchi seas when they occur in the Sound in late spring and early fall (Calkins, 1986). Gray whales feed primarily on benthic amphipods but also take other benthic and pelagic invertebrates (Rice and Wolman, 1971; Nerini, 1984). Minke whales summer in the Gulf of Alaska and mostly are seen between the 200-m depth contour and shore (Consiglieri and Braham, 1982). Minke whales generally feed on euphausiids and fish (Tamura et al., 1998).

Dall's and harbor porpoises both are abundant and widespread in Prince William Sound, with Dall's being the more common (Calkins, 1986; Harvey and Dahlheim, 1994). Both species feed on fish and crustaceans, but generally on different species (Calkins, 1986). Dall's porpoises occur on the continental shelf and slope and prefer straits, passes between islands, and areas of merging currents (Scheffer, 1949; Cowan, 1944), while harbor porpoises frequent bays, harbors, and river mouths (Tomilin, 1957 cited in Calkins, 1986). Both species are more abundant in Prince William Sound in summer than winter (Hall, 1979).

Of three species of pinnipeds that can occur in Prince William Sound, Steller sea lions and harbor seals are year-round residents, and northern fur seals are occasional visitors (Calkins, 1986). Steller sea lions use terrestrial haulouts as resting areas, but gather at traditional rookeries during May-July to pup and breed; the nearest rookery to Prince William Sound is at Seal Rocks, on the eastern side of Montague Island (Calkins et al., 1994). Sea lions feed on fish (primarily pollock), cephalapods (squid and octopus),

and crustaceans (Hoover, 1988a). Sea lions from the central Gulf of Alaska (including Prince William Sound) have declined in number since the late 1980s (Loughlin et al., 1992) and were listed as an endangered species in 1990. Harbor seals are one of the two most abundant marine mammals breeding in the Sound and are year-round residents there; however, they also have undergone substantial population declines since the 1980s (Frost, Lowry et al., 1994). Nearshore areas within 20 km of the coast are the primary habitat of harbor seals (Hoover, 1988a), which prey on fish, crustaceans, and cephalopods (Calkins, 1986; Hoover, 1988b). Harbor seals use terrestrial haulouts throughout the year, but more so in early and late summer to pup and molt, respectively (Frost, Lowry et al., 1994).

Steller Sea Lion

Steller sea lions, which are endangered in the area of concern, occur in Prince William Sound year-round, though their numbers are low compared to other areas in the Gulf of Alaska. According to Calkins et al. (1994), there are no rookeries in the Sound, but there are five haulouts, two of which are used year-round and three seasonally. There is some ambiguity with respect to categorization of haulouts within the Sound and those at and near the southern entrances. Those in the Sound include Glacier Island, Perry Island, Point Eleanor, The Needle, and nominally, Point Elrington. Those at the southern entrances include the Wooded Islands (a rookery and haulout), Seal Rocks (rookery and haulout) in Hinchinbrook Entrance, Danger Island, and Procession Rocks. There have been no surveys of all of these sites in a single year.

Based on fragmentary data from these sites in different years, there are now perhaps 3,500 to 4,000 sea lions in and near the Sound. In June-July 1990, there were 1,232 on the Wooded Islands, 1,471 on Seal Rocks, 926 on The Needle, and 382 at Pt. Elrington (Merrick et al., 1991). Seal Rocks is the only rookery/haulout in close proximity to the tanker traffic area. In August 1994, there were 116 sea lions on The Needle, 151 on Procession Rocks, and 17 on Danger Island (Burns, unpubl. data). A correction factor of 1.31 is used to expand counts of non-pups obtained in June-July. On rookeries censused in June-July, the counts are divided by 2.63 to estimate the number of pups (Small and DeMaster, 1995).

Sea lions have undergone a major population decline in parts of their range: on the order of 63 percent from 1986 to 1989 in the area from the central Gulf of Alaska, including Prince William Sound, to the central Aleutian Islands (NMFS, 1992). At Sugarloaf Island, one of the Barren Islands group (near the Sound), the decline from 1956-57 to

Warren Ballard

Photo 3.2-22. *Steller sea lions with pups.*

1990 was from 11,963 to between 1,319 and 1,513 animals, or 87 to 89 percent (Merrick et al., 1991).

According to Pitcher and Calkins (1981), sexual maturity in females — defined as the age of first pregnancy — occurs at ages 3 to 8 years (average 4.8). Some males become sexually mature as early as age 3, but usually between 5 and 7. Normally, males do not successfully breed (defend territories) until 9 to 13 years. A single pup is born during mid-May to mid-July, with the peak in mid-June. A high incidence of reproductive failures has been noted (Calkins and Pitcher, 1982; Calkins and Goodwin, 1988). Breeding occurs, on average, 12 days after parturition. There is a period of delayed embryonic implantation which lasts until mid-October. The maternal bond is maintained for slightly less than a year, though 1- to 3-year-old animals have been observed to nurse along with a newborn pup. Mothers periodically leave their pups on the rookery and go to sea on feeding forays. Pups first enter the water when about 2 weeks old. They travel at sea with their mothers starting between ages 24 to 32 days and are proficient swimmers by 36 to 41 days. As summarized by Hoover (1988a), sea lions consume a wide range of food items including many different kinds of fish, cephalopods, decapods, gastropods, and occasionally the pups of other marine mammals.

According to Calkins et al. (1994), there was little evidence of a population-level effect of the *Exxon Valdez* oil spill on sea lions within or beyond Prince William Sound, in part because the rookeries and haulouts are on high, steep-sided islands subjected to strong surf activity, and because crude oil did not persist on their pelage. They found that in 1989 the predicted numbers of pups and to-

tal sea lions on rookeries and haulouts were not significantly different from the actual counts. Sea lions were, however, exposed to oil. Hydrocarbon compounds were incorporated into tissue and were being metabolized, as shown by several biochemical indicators.

Harbor Seal

Harbor seals are ubiquitous and abundant in Prince William Sound and are present year-round. There is considerable movement into and out of the Sound and among haulouts within it. For these seals, most rookeries also serve as haulouts, and the latter term will be used in this discussion. Haulout sites are close to the water's edge — usually within the tide zone — and occur on the mainland, in river deltas, on ice calved from tidewater glaciers, and on myriad reefs, ledges, rocks, islets, and islands. Man-made structures such as docks or rafted logs are also used. The substrates of terrestrial haulouts vary from mud and sand to solid rock. Seals use haulouts throughout the year, with the highest numbers occurring on them during pupping (mainly May-June) and molting (mainly August-September). Aerial surveys of harbor seals are done during these two seasons of maximal haulout activity, but primarily during the molt. At some important haulouts, ground-based observations over weeks or months have been made. The largest concentrations of seals occur at haulouts around the perimeter of the Sound, including the Copper River Delta and the mainland glacial fjords of the northern and western parts.

In the Gulf of Alaska region, including Prince William Sound, there has been a significant and prolonged population decline. One of the longest and most intensively studied haulouts is on Tugidak Island near Kodiak, where seals declined by about 85 percent between 1976 and 1988 (most rapidly during the late 1970s) (Pitcher, 1990). Trend count surveys in Prince William Sound were initiated in 1983. The first survey route (Route A) flown during the molting season included 25 land sites in the central and southeastern parts of the Sound. This route did not include any of the major haulouts around the perimeter. From 1984 to 1988, the decline at those 25 sites was about 42 percent (Pitcher, 1989). When the decline in the Sound actually began is not known. However, in view of the Tugidak Island studies and the emerging information about a major North Pacific regime shift that occurred in about 1976 (Ebbesmeyer et al., 1991), it seems likely that it was already occurring during the late 1970s. Based on a longer time series of Route A surveys, Frost et al. (1999) found that the decline was approximately 63 percent from 1984 to 1997, with at an annual rate of 4.6 percent from 1990 to 1997.

In actuality the picture is not so clear-cut. Starting in 1991, a second survey route (Route B), which includes 26 index sites in the northern, western, and southwestern Sound, was established (Hoover-Miller et al., 2001). Six of those sites are in glacial fjords where seals are abundant. The combined data from both survey routes indicate that while the decline continued at most sites on Route A, numbers in the glacial fjords steadily increased. Considered together, data from both routes indicate that the "population" of seals in the Sound has been stable or increasing since about 1992-93. The ongoing trend of a warming climate has resulted in major retreat and shrinking of the glaciers, perhaps producing more favorable ice (haulout) and feeding conditions in the fjords. Regional shifts in the distribution of seals in different parts of the Sound are evident.

With respect to actual numbers, the summary data presented by Small and DeMaster (1995) indicate that the average of counts at all 51 sites was 2,394, based on surveys during the molting seasons in 1991-92. An additional 3,491 seals were on haulouts in the Copper River Delta. The accepted correction factor for unseen seals is 1.61. Therefore, the minimum number of seals in this region was about 9,500, though the actual population size remains unknown.

Pitcher and Calkins (1979) conducted the most detailed biological studies of harbor seals in the Gulf of Alaska/Prince William Sound region, and the following information is from that report, unless otherwise noted. The sex ratio in this population was found to be 1:1 in age groups 0 to 21, but strongly skewed in favor of females after that. The oldest seal they examined was 31. The age at sexual maturity has apparently changed over time, probably in response to changed environmental conditions. Bishop (1967) reported that in his samples obtained from Tugidak Island in 1963-64, females reached sexual maturity at ages 3 to 4 before the decline. In the late 1970s, females became sexually mature at about age 5, and males at 5 or 6.

Pups are born in May through early July, with a marked peak in early to mid June. A single pup is born and nursed for 3 to 4 weeks. The pups can swim from birth and usually do so within an hour (often the birth site is inundated by the next rising tide). During the nursing period, pups travel with their dams. Breeding occurs again at about the time that pups are weaned and is followed by a period of delayed embryonic implantation that lasts until about mid-October. Pregnancy rates in 6, 7 and ≥8 year-olds were, respectively, 88 percent, 89 percent and 92 percent. Natural mortality is high: 74 percent for females and 79 percent for males in age groups 0 to 4 years. It was much lower in older seals: 11 percent for females ages 4 to 19 and 13 percent in males ages 4 to 17. In both sexes, mortality increased again after age 18.

There is considerable variation in the prey items eaten by harbor seals in the Gulf of Alaska/Prince William Sound region, probably due to the variety of vastly different habitats in which the seals occur. Fishes (a minimum of 27 species) comprised 73 percent, cephalopods (mainly octopus) 22 percent, and decapods (shrimps and crabs) 4.1 percent of stomach contents. In descending order, the top four food items were pollock, cephalopods, capelin, and flatfish.

In 1989, an estimated 302 seals were "missing" from haulouts in the Sound that were oiled by the *Exxon Valdez* oil spill. That estimate was based primarily on statistical analyses of counts from surveys of Route A done during August-September 1988-92. The missing seals were presumed to have died from the spill (Frost, Lowry et al., 1994).

Indeed, many seals were exposed to the oil (Lowry et al., 1994) and to the massive influx of people and equipment that ensued. Haulouts were oiled, treated, inspected, and studied. Seals were coated with oil, incorporated volatile hydrocarbon compounds into their tissues, and metabolized them, as shown by biochemical indicators (Frost, Manen et al., 1994). The problem of evaluating mortality, however, involves the contentious issue of distinguishing between sublethal exposure to oil and spill-caused deaths.

Fourteen dead seals were recovered in the Sound, 11 of which were premature or newborn pups (Williams et al., 1994). There was also an ongoing population decline, natural morality of young animals is high, the seals are highly mobile, and they are often displaced by disturbance. The survey-based impact study reported by Frost, Lowry et al. (1994a) was based on assumptions that molting seals have 100 percent fidelity to sampled haulouts, that cleanup and other human activities did not displace seals, and that a state of dynamic equilibrium prevails among Route A sites. A review of that study by Hoover-Miller et al. (2001) indicates that the single-year reduction in seals at oiled haulouts cannot be used as an estimator of spill-caused mortality. Indeed, it was found that:

- The surveys in 1989 were inadequate and not done at the proper time;
- Statistical tests applied to data from "treatment" and "control" sites were not appropriate;
- Seals showed considerably less than 100 percent site fidelity;
- A condition of dynamic equilibrium among haulouts does not exist; and
- Both short and long-term shifts occur in the distribution of seals in the Sound, even absent disturbance.

The strength of evidence does not support the claim that 302 seals died from the *Exxon Valdez* oil spill.

Sea Otter

More than 90 percent of the world's sea otters inhabit Alaska (Rotterman and Simon-Jackson, 1988). Alaska's marine waters contain an estimated 100,000 to 150,000 sea otters (Calkins and Schneider, 1985), of which 14,352 (1994 estimate, USFWS, unpubl. data) reside year-round and breed in Prince William Sound. Although the southern sea otter is listed as endangered, the Alaska stock has no special protection beyond that accorded other marine mammals by the Marine Mammal Protection Act. The Alaska sea-otter population generally has grown and expanded since harvesting stopped in 1911, but that growth in Prince William Sound was disrupted by an earthquake in 1964 and the *Exxon Valdez* oil spill in 1989 (Estes, 1991; Johnson and Garshelis, 1995; Garshelis and Johnson, in press). Sea otters occupy shallow areas (<54 m deep; Kenyon, 1969) along coastlines where they can find protection from wind and storm-driven waves. In Prince William Sound, they feed on a variety of bivalves, crustaceans, and other invertebrates in the nearshore area (Calkins, 1978; Garshelis, 1983; Doroff and Bodkin, 1994; Johnson and Garshelis, 1995)

The *Exxon Valdez* oil spill in western Prince William Sound resulted in the death of hundreds of sea otters. The otter mortality was not over the entire western Prince William Sound, but concentrated in heavily oiled areas. The overall population in western Prince William Sound has increased over the 1990s (Monson et al., 2000), and various indicators suggest the sea otter population in spill-affected areas was recovering a few years after the spill (Johnson and Garshelis, 1995). There are continuing concerns over demographic effects from the initial oil exposure to the spill and over the toxicological effects of residual oil several years after the spill (Monson et al., 2000; Dean et al., 2000) in areas that were heavily oiled. However, as cautioned by Johnson and Garshelis (1995), other environmental factors may affect the sea otter population in western Prince William Sound. For example, the sea otter population in the Aleutian Islands has declined by about 90 percent during the 1990s without any oil spill impacts. Predation by killer whales is implicated in this decline and may also affect the sea otters in Prince William Sound. Harvest by humans may also impact populations in the sound. Subsistence harvest records show hundreds of sea otters killed each year from locations in the sound, including 424 otters in 1998, 195 otters in 1999, and 330 otters in 2000 (U.S. Fish and Wildlife Service, unpublished data). The harvest numbers are underestimates because it is not known how many otters are harvested but unreported. Conclusions about the spill's impact on the sea otter population are con-

founded by the failure to relate killer-whale predation, human harvest, and other mortality sources (e.g., winter die-offs), combined with poor understanding of major changes in population dynamics (e.g., pre-1911 fur harvest and the 1964 earthquake), which still affect the distribution of sea otters and their prey.

Additional species of marine mammals inhabit marine waters outside Prince William Sound along the tanker routes. These include blue whale, right whale, sei whale, sperm whale, and fur seal (USACE, 1999). Most of these additional species of whales and the southern sea otter are considered threatened or endangered.

3.2.7 Threatened and Endangered Species

By R. Ritchie, D. Troy, and J. Kidd

Three species of animals listed as threatened or endangered in Alaska under the Endangered Species Act (ESA) may occur along the TAPS ROW: Spectacled and Steller's eiders, both listed as threatened, and the Eskimo Curlew, listed as endangered. Also occurring along TAPS, the Arctic subspecies (*tundrius*) and American subspecies (*anatum*) of Peregrine Falcon were delisted from the ESA in 1994 and 1999, respectively. The Short-tailed Albatross, also considered endangered, occurs in the shipping lanes adjacent to Prince William Sound. Seventeen species of terrestrial and freshwater aquatic vertebrates were formerly Category 2 candidate species in Alaska (FWS, 1996a).

Although no federally listed threatened or endangered plant species occur along the TAPS ROW, at least one species, formerly considered a candidate species — the Yukon aster, *Aster yukonensis* — may occur along TAPS (Table 3.2-20; FWS 1996a). Habitat for this species includes gravelly slopes, road cuts, and lakeshores (Welsh, 1974), and it has been found in the Koyukuk River basin (Murray and Lipkin, 1987). In addition, the Alaska Natural Heritage Program maintains a list of rare vascular plants found in the state (Alaska Natural Heritage Program, 2000). At least one of these species — Muir's fleabane, *Erigeron muirri* — occurs along TAPS (specimens collected from Toolik Lake and Sagwon uplands; Lipkin and Murray, 1997). These plant species are not formally protected by federal statutes and are not discussed further below.

The following describes only those species currently protected by provisions of the ESA or recently delisted as protected ESA species. In addition to the federal ESA list, the State of Alaska maintains a list of species of special concern (ADF&G, 1998). Table 3.2-20 contains a complete list of endangered and threatened species and species of concern recognized or formerly recognized by federal and state statutes.

3.2.7.1 Birds

Short-tailed Albatross

The Short-tailed Albatross is listed as endangered in the U.S. (65 FR 46643). The Short-tailed Albatross formerly ranged throughout much of the northern North Pacific Ocean as far south as Mexico and bred on numerous islands off Japan and Taiwan. Presently, it breeds only on Torishima Island and on Minami-kojima off southwestern Japan. This restricted breeding distribution makes the species vulnerable to extinction. The most recent data suggest a total world population of about 1,000 birds (Michaelson et al., 1999). Research suggests that the species concentrates near the shelf-break of the outer continental shelf in Alaska in the North Pacific Ocean (Sherburne, 1993).

Spectacled Eider

BP Exploration

Photo 3.2-23. *Spectacled Eider.*

The Spectacled Eider is a seaduck that nests in arctic Russia and western and northern Alaska and winters in the Bering Sea. This species is listed under the ESA as threatened throughout its range (58 FR 27474) and FWS recently proposed to designate most of the Alaska North Slope and the nearshore Beaufort Sea as critical habitat for this species (65 FR 6114). When the original TAPS environmental impact statement (BLM, 1972) was written, the North Slope of Alaska was thought to harbor only a small proportion of the world's population of Spectacled Eiders, and most of those birds were thought to occur west of the Colville River, especially in the vicinity of Teshekpuk Lake (Dau and Kistchinski, 1977). Since then, the primary Alaska breeding population (Yukon-Kuskokwim Delta) has declined markedly (Stehn et al., 1993). Subsequent research has revealed a larger population and more widespread distribution of Spectacled Eiders on the North Slope than formerly acknowledged (Larned et al., 1999). The North Slope is now the most important breeding area in Alaska for Spectacled Eiders. This is the ESA-listed species most likely to be encountered along the TAPS ROW, albeit only along the northernmost segment on the Arctic Coastal Plain.

Abundance of Spectacled Eiders decreases from west to

Table 3.2-20. *Status and distribution of threatened and endangered species in Alaska. The list of species excludes marine mammals (see Table 3.2-19) and was modified from FWS (1999a) and ADF&G (1998). [E = endangered, T = threatened, D = delisted (*proposed for delisting), SOSC = state species of special concern; NL = no listing].*

Common Name / Group	Species	Federal	State	Range in Alaska	TAPS & Marine Transportation System
Aleutian Canada Goose	*Branta canadensis leucopareia*	T, D*	SOSC	Aleutian Islands, Semidi Island	No
Spectacled Eider	*Somateria fischeri*	T	SOSC	Western, Northern (coastal)	Yes
Steller's Eider	*Polysticta stelleri*	T	SOSC	Southwestern, Northern, Western (coastal)	Yes
Eskimo Curlew	*Numenius borealis*	E	NL	Probably extirpated	Yes
Short-tailed Albatross	*Phoebastria albatrus*	E	E	North Pacific, Bering Sea	Yes
American Peregrine Falcon	*Falco peregrinus anatum*	D	SOSC	Interior	Yes
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	D	SOSC	Northern, Western	Yes
Northern (Queen Charlotte) Goshawk	*Accipiter gentilis laingi*	NL	SOSC	Southeast	No
Olive-sided Flycatcher	*Contopus borealis*	NL	SOSC	Central, Southern, Southeast	Yes
Gray-cheeked Thrush	*Catharus minimus*	NL	SOSC	Interior, Southern, Southeast	Yes
Townshend's Warbler	*Dendroica townshendi*	NL	SOSC	Interior, Southern, Southeast	Yes
Blackpoll Warbler	*Dendroica striata*	NL	SOSC	Interior, Southern	Yes
Aleutian shield fern	*Polystichum aleuticum*	E	NL	Adak Island	No
Yukon aster	*Aster yukonensis*	NL	SOSC	Disjunct through the Brooks Range	Possible
Green sea turtle	*Chelonia mydas* (incl. *agassizi)*	T	NL	Pacific Ocean	Possible
Leatherback sea turtle	*Dermochelys coriacea*	E	NL	Pacific Ocean	Possible
Loggerhead sea turtle	*Caretta caretta*	T	NL	Pacific Ocean	Possible
Olive (Pacific) Ridley sea turtle	*Lepidochelys olivacea*	T	NL	Pacific Ocean	Possible
Snake River sockeye salmon	*Oncorhynchus nerka*	E	NL	Pacific Ocean	Possible
Snake River spring/summer chinook salmon	*Oncorhynchus tshawytscha*	T	NL	Pacific Ocean	
Snake River fall chinook salmon	*Oncorhynchus tshawytscha*	T	NL	Pacific Ocean	Possible
Puget Sound chinook salmon	*Oncorhynchus tshawytscha*	T	NL	Pacific Ocean	Possible
Lower Columbia River chinook salmon	*Oncorhynchus tshawytscha*	T	NL	Pacific Ocean	
Upper Willamette River chinook salmon	*Oncorhynchus tshawytscha*	T	NL	Pacific Ocean	Possible
Upper Columbia R. spring chinook salmon	*Oncorhynchus tshawytscha*	E	NL	Pacific Ocean	Possible
Upper Columbia River steelhead	*Oncorhynchus mykiss*	E	NL	Pacific Ocean	Possible
Snake River Basin steelhead	*Oncorhynchus mykiss*	T	NL	Pacific Ocean	Possible
Lower Columbia River steelhead	*Oncorhynchus mykiss*	T	NL	Pacific Ocean	Possible
Upper Willamette River steelhead	*Oncorhynchus mykiss*	T	NL	Pacific Ocean	Possible
Middle Columbia River steelhead	*Oncorhynchus mykiss*	T	NL	Pacific Ocean	Possible

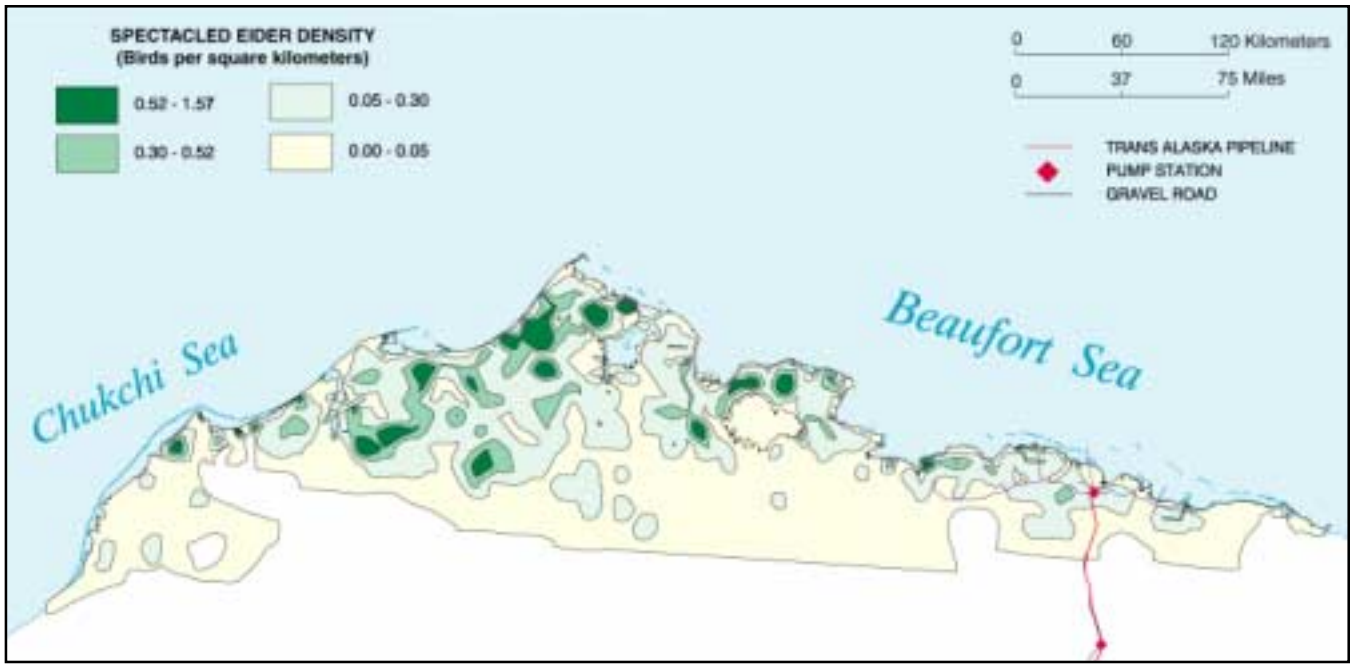


Figure 3.2-22. *Abundance patterns of Spectacled Eiders across the North Slope (modified from Larned et al., 1999).*

east across the Arctic Coastal Plain. Most high-density areas are west of Harrison Bay, and relatively few pairs are found east of the Shaviovik River (Larned et al., 1999) (Figure 3.2-22). About 100 pairs of Spectacled Eiders occur in the Prudhoe Bay area (TERA, 1997). Larned et al. (1999) summarized four classes of Spectacled Eider abundance across the Arctic Coastal Plain (Figure 3.2-22). Approximately 40 miles of the TAPS ROW is in the region surveyed, and Spectacled Eider abundance in the ROW is entirely within the lowest two categories: below average to no birds (Larned et al., 1999). This classification indicates that the best habitats for Spectacled Eiders along TAPS are at the northernmost end, near Pump Station 1. More intensive surveys of most of this region south to approximately TAPS MP 7 from 1991 to 1997 (TERA, 1996b, 1997) found a few Spectacled Eiders near TAPS but none within 1 km of the ROW. Spectacled Eiders may occur farther south than the areas covered by current surveys, although densities probably are low. Along TAPS, the southernmost report of Spectacled Eider is from MP 12 (Hohenberger et al., 1981).

Spectacled Eiders may occur along the northern end of TAPS from late May through mid-September. Spectacled Eiders return from wintering grounds in the Bering Sea to the Arctic Coastal Plain in late May or early June. Male Spectacled Eiders depart during mid- to late June at the onset of nesting, while females leave from late June through mid-September, depending on their breeding success (failed breeders depart earliest). After leaving the coastal plain, Spectacled Eiders molt in a few locations in arctic and eastern Russia or Ledyard Bay in northwestern Alaska before continuing on to staging areas near St. Lawrence Island and wintering areas in the central Bering Sea (Petersen et al., 1999; TERA, 1999). Additional information on breeding biology and status of the Spectacled Eider is summarized in FWS (1996b).

Critical habitat has been proposed for Spectacled Eiders on the North Slope by FWS (65 FR 6114). Under the proposal for critical habitat, the northern section of the TAPS ROW and Pump Station 1 are included within the area designated as critical habitat for the North Slope Nesting Unit. Within that area, specific "primary constituent elements" of critical habitat have been defined as "...those physical and biological features that are essential to the conservation of the species (primary constituent elements) and that may require special management considerations or protection..." (65 FR 6117). For the North Slope Nesting Unit, five primary constituent elements have been described: all deep waterbodies; all waterbodies that are part of basin wetland complexes; all permanently flooded wetlands and waterbodies containing either *Carex aquatilis, Arctophila fulva*, or both; all habitat immediately adjacent to these habitat types; and all marine water out to 25 miles from shore, its associated aquatic flora and fauna in the water column, and the underlying benthic community. These habitats occur along the ROW and around Pump Station 1.

Steller's Eider

R. Lanctot

Photo 3.2-24. *Steller's Eider.*

The Alaska breeding population of Steller's Eider was listed as threatened (59 FR 35896) in 1997 because of a substantial population decline in recent years (Kertell, 1991; Quakenbush and Cochrane, 1993). During summer, Steller's Eiders are likely to occur only at the northernmost end of TAPS, but in winter, small groups regularly occur in Cook Inlet, near Kodiak Island, and occasionally in the Gulf of Alaska and Prince William Sound (FWS, 1998a). Most Steller's Eiders wintering in Alaska are from the larger (nonlisted) Russian breeding population. Winter distribution of the Alaska breeding birds is poorly documented.

Steller's Eiders historically nested in a discontinuous distribution on the Aleutian Islands, the Alaska Peninsula, the Yukon-Kuskokwim Delta, and the Seward Peninsula; from the vicinity of Point Lay to Barrow in northwestern Alaska; across most or all of the Arctic Coastal Plain of northern Alaska; and across most of arctic Russia from the Kheta River (west of the Lena River) eastward nearly to the tip of the Chukchi Peninsula (Kertell, 1991; Quakenbush and Cochrane, 1993). Currently, Steller's Eiders nest in Alaska only on the Yukon-Kuskokwim Delta and on the Arctic Coastal Plain, and in Russia on the arctic coast (Quakenbush and Cochrane, 1993).

On the Yukon-Kuskokwim Delta, this species has almost disappeared as a breeding bird, with only a few pairs nesting there since 1994 (Flint and Herzog, 1999). On the Arctic Coastal Plain of Alaska, Steller's Eiders nest primarily near Barrow, but the total breeding range probably extends from Point Lay to near the Colville River Delta (Day et al., 1995; Quakenbush et al., 1995). Non-breeding and post-breeding birds use nearshore waters of the northeastern Chukchi Sea and large lakes around Barrow for molting and summering, and they also rarely occur in summer as single birds along the coast as far east as the border with the Yukon. The Steller's Eider has been recorded periodically in the Prudhoe Bay area, and at least one pair apparently nested there in 1993 (FWS, 1998a).

Information on habitat use by breeding Steller's Eiders is sparse. On the Yukon-Kuskokwim Delta, they formerly nested in what is described as the "vegetated intertidal zone" (i.e., salt marshes) of the central delta, where the coastal habitat is irregularly flooded (King and Dau, 1981). In arctic Alaska, they nest and raise broods in areas dominated by low-centered polygons and shallow ponds with emergent grasses and sedges, flooded tundra (i.e., wet meadows), lakes, and drained lake basins. The presence of emergent plants seems to be important to brood-rearing Steller's Eiders (Quakenbush and Cochrane, 1993). A recent study in the Barrow area found that waterbodies with *Arctophila fulva* (pendant grass) had considerable use (greater than their availability) during the pre-nesting, nesting, and brood-rearing periods (Quakenbush et al., 1995). Suitable habitats for Steller's Eiders occur near Pump Station 1 and along the north end of TAPS, but no Steller's Eiders have been reported there.

Critical habitat has been proposed for Steller's Eiders on the North Slope by FWS (65 FR 13262). The eastern channel of the Colville River forms the eastern boundary of the area designated as critical habitat for the North Slope breeding population of Steller's Eiders. Thus, the ROW and facilities are not in critical habitat proposed for this species.

Eskimo Curlew

The Eskimo Curlew is perhaps the only endangered species whose range overlaps the TAPS ROW. Once numerous, this species is now on the verge of extinction, if not already extinct (Page and Gill, 1994). This arctic-nesting shorebird declined to low numbers before its distribution or much of its breeding biology was described (Gollop et al., 1986). This species has been recorded numerous times in northern Alaska, but nesting was never documented (Gabrielson and Lincoln, 1959). Potential breeding habitat occurs in a narrow band along the northern foothills of the Brooks Range (Gill et al., 1998). The cause of the Eskimo Curlew's decline is unknown, but over-hunting, habitat change through conversion of wintering and staging areas to agriculture, changes in prey availability, and climate change have been suggested as factors (Faanes and Senner, 1991). The only factor that may have operated on the breeding grounds was climate change, including colder conditions (perhaps resulting in poor reproduction) during the period of decline.

Arctic Peregrine Falcon

The Arctic Peregrine Falcon, formerly listed as endangered and then reclassified as threatened, was delisted from the ESA on 5 October 1994 (59 FR 50796). Under the provisions of the ESA, FWS monitored this species for 5 years following delisting and during the Section 7 consultation process, treated it as a Category 2 candidate species. With this 5-year monitoring period completed, protection of Arctic Peregrine Falcons is no longer mandated by the ESA. Instead, FWS will offer consultation to reduce development impacts on this species (Swem, 1999, pers. comm.).

Arctic Peregrine Falcons nest in northern and northwestern Alaska from the U.S.-Canada border to Norton Sound on the Bering Sea. Regionally, they occur along the TAPS ROW on the Sagavanirktok River and its tributaries between late April and mid-September. Incubation begins by late May, hatching occurs by early July, and young fledge by late August (Cade, 1960; Ritchie, 1987). Arctic Peregrine Falcons winter mainly in South America (Hickey and Anderson, 1969). Peregrines are primarily cliff-nesters and regularly use river bluffs and cliffs in the northern foothills of the Brooks Range (Cade, 1960). They prey mainly on birds. As Peregrine Falcons have recovered from substantial declines between the 1950s and 1970s (Ambrose et al., 1988), they occasionally have used habitats of lesser quality, including low coastal bluffs (Mauer, 1999, pers. comm.) and mud banks of lakes and rivers on the Arctic Coastal Plain (Ritchie, unpubl. data).

Skip Ambrose

Photo 3.2-25. *Arctic Peregrine Falcon.*

Nesting Peregrine Falcons have been recorded on the Sagavanirktok River within 1 mile of the TAPS ROW. The Colville River and its tributaries and the Sagavanirktok River are the core breeding areas for peregrines in northern Alaska. Traditional concentration areas for nesting peregrines in this area include Franklin and Sagwon bluffs, but nesting has been documented as far south as Slope Mountain (Wright and Bente, 1999; APSC, 1993). During the 1970s, peregrines in northern Alaska were reduced to about 35 percent of the breeding population known in the 1950s due to poor productivity linked to pesticides (Ambrose et al., 1988). The Sagavanirktok River corridor was no exception; fewer than five pairs occupied its cliffs in the mid-1970s (Roseneau et al., 1976). By 1988, at least 10 pairs occupied the area, and in 1998 more than 25 pairs occupied bluffs along the river (Wright and Bente, 1999).

American Peregrine Falcon

The American Peregrine Falcon, formerly listed as endangered and reclassified as threatened, was delisted from the ESA on 25 August 1999 (64 FR 46542). As with the Arctic subspecies, the FWS will treat it as a Category 2 candidate and monitor it for a 5-year period after delisting.

American Peregrine Falcons occur in Interior Alaska, possibly reaching the coast in western and Southcentral Alaska (Ambrose et al., 1988). Regionally, they occur along the TAPS ROW south of the Brooks Range divide and nest in the drainages of the Yukon River, including the Koyukuk, Tanana, and main Yukon, and their tributaries. Nests have not been located south of the Alaska Range along TAPS in the Copper River drainage (Swem, 1999, pers. comm.), although suitable habitat appears to be present (Cade, 1960). They feed primarily on birds and winter in the southern U.S. and in Mexico, and some birds migrate to Central and South America. As the population continues to recover, peregrines may use many of these unoccupied regions. In Interior Alaska, peregrines are present from late April to late September; they begin incubation as early as mid-May, and young hatch by late June and fledge in August. Peregrines nest on riparian cliffs and dirt bluffs, occasionally using more remote rock outcroppings in uplands adjacent to major rivers (Ritchie and Rose, 1999). Nesting has been recorded within 1 mile of TAPS at the Tanana River pipeline crossing and within 5 miles on the Salcha River and other locations along the Tanana River. Traditional nesting areas for peregrines along TAPS include the middle Yukon River, the Tanana River between Fairbanks and Delta Junction, and some tributaries in the Tanana-Yukon Uplands (White et al., 1977). Nesting habitat for peregrines and other raptors is also found at Grapefruit Rocks near the pipeline at MP 417-418 between Livengood and Fairbanks.

Between the late 1960s and 1985, the American Peregrine population in Interior Alaska declined to at least 55 percent of historical numbers (Ambrose et al., 1988). The lowest levels occurred in the 1970s, and numbers began to increase by the late 1970s paralleling increases of the Arctic subspecies in northern Alaska. The population has continued to increase and presently exceeds historical baselines established in the 1960s. For instance, 16 to 19 nest sites were known for the Tanana River from pre-1963 records (Haugh, 1976), but by 1998, pairs of falcons occupied 38 sites along the same section of river, including quarries along the Richardson Highway (Ritchie et al., 1998).

3.2.7.2 Plants

Currently no plants listed as threatened or endangered in Alaska occur along the TAPS and adjacent areas.

3.2.7.3 Mammals

No terrestrial mammals are listed as threatened or endangered in Alaska. Threatened or endangered marine mammals, including the bowhead whale, are discussed in Section 3.2.6.

3.3 Social Systems

This section provides relevant information about social systems in the affected environment, including:

- The economy (Section 3.3.1);
- Sociocultural systems (Section 3.3.2);
- Subsistence activities and patterns (Section 3.3.3);
- Cultural resources (Section 3.3.4);
- Land ownership and land uses (Section 3.3.5);
- Recreation and visual resources (Section 3.3.6);
- Wilderness (Section 3.3.7); and
- Transportation (Section 3.3.8).

3.3.1 Economy

By O.S. Goldsmith, L.D. Maxim, and R. Niebo

By the definition of the Trans Alaska Pipeline System (TAPS) in Stipulation 1.1.1.22 of the Federal Grant, the Alaska North Slope (ANS) fields and the marine transportation link are not parts of the pipeline system. However, these other systems are clearly linked to the pipeline in economic terms (none of these elements could "stand alone") and are conveniently discussed as a group, rather than as individual elements. Thus, both the ANS fields and the marine transportation link are included in the discussion of economics. Historical economic impacts, which are reflected in a description of the affected environment because the entire production/transportation system has been in operation since 1977, include *direct*, *indirect*, and *cumulative economic* effects of the pipeline system. [Because the system elements are in different geographic areas, it is possible to disaggregate effects in other parts (Sections 3.3.2 through 3.3.8) of this discussion.]

For the ROW renewal decision, however, the ANS fields, pipeline, and associated marine transportation link are an operating system. Historical economic impacts are discussed in this description of the affected environment. Future impacts associated with the recommended and no-action alternatives are examined in Section 4.

Except where noted, all dollar figures are stated in terms of money of the day (MOD). Figures adjusted to constant dollars are prefixed by the base year (e.g., 1998 dollars).

3.3.1.1 Importance of ANS/TAPS to the National Economy

The ANS oil fields have been termed "one of the...most important in the history of the domestic crude oil industry" (Cicchetti, 1972) and the largest in North America (GAO, 1999). Thus, these fields are sufficiently large to have national, as well as state and local, significance. This subsection provides facts and economic data to illustrate and quantify their national importance. The follow points summarize this subsection:

- From 1977 to 1988, ANS production grew from 7 to 25 percent of domestic crude output. Even in 1998, ten years after reaching maximum output, ANS output accounted for approximately 20 percent of U.S. crude production.
- ANS output reduced the balance-of-trade deficit in crude petroleum by approximately $268 billion from 1977 to 1999.
- ANS output contributed approximately $40.2 billion to the federal government in various taxes and royalties from 1977 to 1999.

BP Exploration (Alaska) Inc.

Photo 3.3-1. *Production facility at Prudhoe Bay for separating water and gas from crude oil.*

- ANS production has provided a market for U.S.-flagged tankers and jobs for U.S. seafarers. In 1999, for example, tankers in the ANS trade accounted for 37 percent of the tonnage of the total U.S. seagoing tanker fleet (20 percent on a ship-count basis).

ANS Production in Context

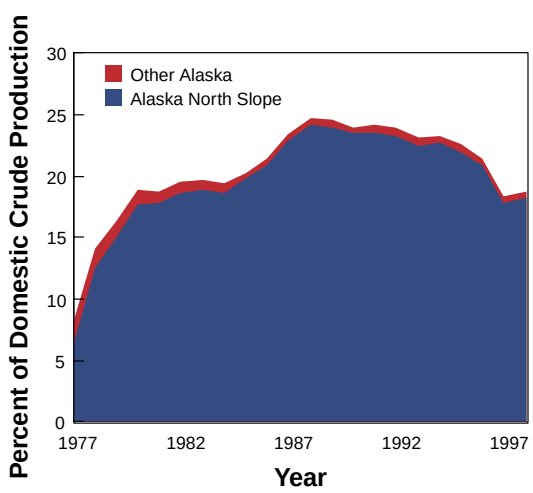
The first barrel of ANS crude reached the Valdez Marine Terminal at 11:02 p.m. on July 28, 1977, and was shipped to ARCO's Cherry Point, Washington refinery on the *ARCO Juneau* on August 1, 1977 (APSC, 1999c; Mead 1978). Total TAPS throughput in the first year of operation was 112.3 million bbl, which increased to a maximum of 744.1 million bbl in 1988 before beginning a gradual decline (APSC, 1999c). Even in the first calendar year of operation, this output accounted for a substantial proportion of domestic crude production. Figure 3.3-1 shows ANS and total Alaska crude oil production from 1977 to 1998 plotted as a percentage of total domestic crude production. As can be seen, ANS production dominates total Alaska production, and Alaska production has accounted for a significant proportion of total domestic crude production, rising to approximately 25 percent in 1988. In 1998, ten years after reaching maximum output, ANS production accounted for nearly 1 bbl out of every 5 produced domestically — a significant contribution to total domestic crude output.

ANS Output and Balance of Trade

The U.S. has substantial crude oil reserves. Until World War II, U.S. crude production was sufficient to satisfy domestic consumption. Since then, domestic demand has outstripped supply, and the U.S. has become a net oil importer, a fact that has geopolitical as well as economic implications. In 1950, net petroleum imports accounted for only 8.3 percent of domestic demand (API, 1991; Section IX, Table 1; Section X, Table 1). In 1999, crude oil imports supplied approximately 58 percent of domestic demand, and this figure is expected to grow (EIA, 1999e).

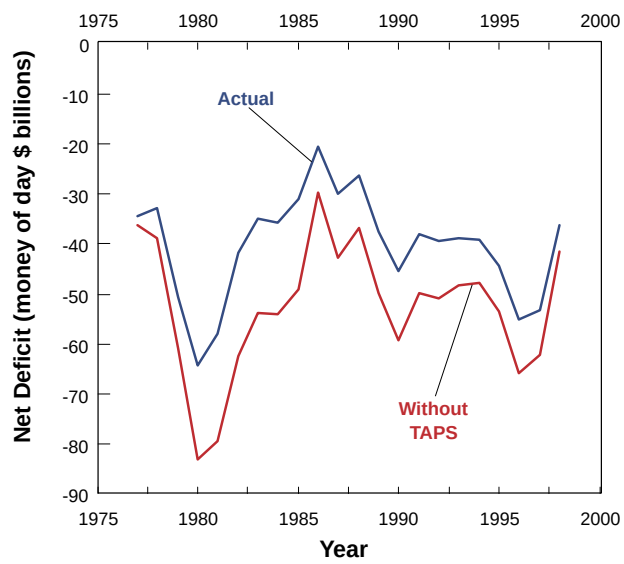
ANS production reduces U.S. dependence on foreign sources of oil. Crude oil is imported to the U.S. from many producing areas, including countries in the Western Hemisphere, Africa, and the Middle East. Because many oil-producing countries are politically unstable and/or have uneasy relations with the U.S., this dependence is problematic and creates challenges for military/foreign policy. Crude oil self-sufficiency is no longer feasible for the U.S. However, the U.S. National Energy Strategy that was articulated in 1991 established two objectives — expand U.S. production and reduce U.S. consumption — to enhance energy security (Thomas et al., 1993). ANS production contributes to the first of these objectives.

From a trade perspective, import dependence results in a negative balance of payments in the crude oil sector — a balance that has been improved historically because of ANS production. Figure 3.3-2, for example, provides a time series of the balance of payments in crude oil (i.e., the value of crude oil exports minus the value of crude oil imports in



Data Source: Energy Information Administration (EIA, various years) and Alaska Department of Revenue (ADOR, 1999a, b)

Figure 3.3-1. *ANS and other Alaska crude oil as a percentage of domestic crude production, 1977-1998.*



Data Sources: U.S. Department of Energy EIA (1999a, b, c, d); United Nations (various years); U.S. Department of Commerce Bureau of the Census (DOC, 1999a, 1994); and APSC (1999c)

Figure 3.3-2. *U.S. net balance-of-trade in crude oil as reported and estimated assuming no ANS/TAPS outputs.*

each year) for the 22-year period from 1977 to 1998. The blue line in Figure 3.3-2 shows the actual negative balance of payments and the red line the estimated balance of payments in each year that would have resulted if ANS production was not available and domestic demand was unchanged. As can be seen, the actual balance of payments was negative for all years, ranging from approximately -$20 billion to -$64 billion (in 1980 following the Iranian Revolution). If ANS production were not available, the trade deficit would have been even greater, by an aggregate amount of approximately $268 billion figured at the average domestic crude price over the 22-year period. Thus, the presence of ANS/TAPS output reduced but did not eliminate the balance-of-payments deficit in crude oil.

If ANS production did not occur and instead an equivalent quantity of crude oil was imported, the balance of trade in crude oil would have been more negative by an average of 23 percent. Because crude oil imports account for such a large fraction of the U.S. balance of trade, the contribution of ANS production is particularly important. From 1977 to 1998, the total balance of trade in goods and services (Council of Economic Advisors, 1998) would have been more negative by an average of nearly 14 percent without ANS production.

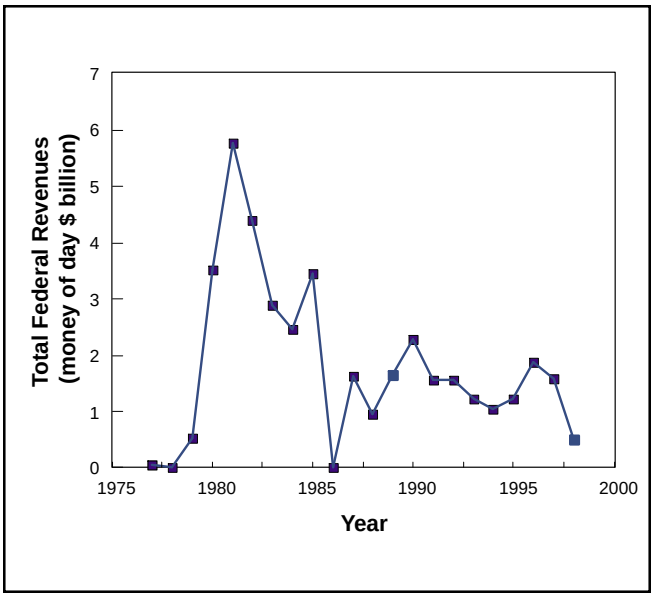


Figure 3.3-3. *Federal royalties and income taxes from Alaska North Slope and TAPS operations 1977-1998. Taxes, effective tax rates, and royalties all affect this revenue. The Crude Oil Windfall Profits Tax Act passed in 1980 and was in effect until 1988, although crude price declines rendered the effective amount of the tax at zero for years after 1985. The peak federal revenues in 1981 were largely the result of the runup in oil prices in that year and the effect of the windfall profits tax.*

Federal Revenues Derived from ANS Output

ANS production provides revenues directly to federal, state, and local governments. Federal government revenues are realized in the form of federal income taxes paid by ANS producers and TAPS owners, windfall profits taxes from 1980 to 1988 when the Crude Oil Windfall Profit Tax Act of 1980 was in effect, and federal royalties on onshore and offshore developments. Income taxes — including taxes on ANS production, windfall taxes, and TAPS operation — have been studied (Deakin, 1989) for the 11-year period from 1977 to 1987. A time series of federal royalties can be found in MMS (1993a, 1997b). From 1977 to 1987, federal revenues from ANS/TAPS operations totaled nearly $25 billion — an average annual revenue of approximately $2.25 billion.

The Deakin analysis has not been updated. However, Berman et al. (1984), and more recently Eppenbach (1993), have made projections of federal and state revenues for the period beyond that covered in the Deakin analysis. Although federal and state revenue projections differed in absolute or relative terms, both studies projected modest revenue declines for both federal and state revenues as ANS production decreases. The authors of this section of the Environmental Report used a regression model to update the estimates of federal income tax made in the Deakin analysis. The independent variables employed include ANS wellhead price and TAPS throughput. The regression is statistically significant, with an R^2 value of approximately 0.9. Figure 3.3-3 shows the estimated federal revenues (including windfall profits tax, federal income taxes on ANS producers, TAPS taxes, and federal royalties) from 1977 to 1998 based on the Deakin estimates through 1987 and the regression predictions for the years 1988 through 1998. On a cumulative basis, ANS/TAPS contributed approximately $40.2 billion to the federal government, an average of slightly more than $1.8 billion annually.

ANS Output and Federal Maritime Policy

Besides supporting the national objectives of fostering domestic crude production, limiting balance of payments deficits, and realizing revenue, ANS/TAPS output furthers U.S. maritime policy by providing opportunities for U.S. tankers, seafarers, and the domestic shipbuilding industry.

Under the Merchant Marine Act of 1920 (the so-called Jones Act), all shipments between U.S. ports must be carried on U.S.-flagged and -built vessels (built without construction differential subsidies and operated without operating differential subsidies) and crewed by U.S. merchant seamen (Committee on OPA 90, 1998). This law is designed to preserve an essential core of the American merchant fleet.

In the past 50 years the number of U.S.-flagged ships has declined precipitously. For example, the number of U.S. tankers alone totaled 951 in 1947 (API, 1991). By 1999, there were only about 100 U.S.-flagged tankers (depending on definitions, the number of tankers in the U.S. tanker fleet in 1999 varies from 93 to 126 according to estimates provided by the U.S. Maritime Administration [MARAD, 1999a, b, c, d]). Part of this decline is the result of replacing older, slower, smaller ships with larger, faster, more efficient ones (MARAD, 1998b), and part the result of changing shipment patterns and the declining competitiveness of U.S.-flagged vessels in comparison to those of other nations. (U.S. tankers remain relatively competitive [USDOE, 1994], but tanker construction cost differentials between U.S. and foreign shipyards are material [Committee on OPA 90, 1998].) The overall trend is not consistent with U.S. policy (MARAD, 1998a, b; 1999a) designed to "foster and maintain a United States Merchant Marine capable of meeting economic and national security requirements . . . reverse the precipitous decrease in the number of ships in the United States-flag fleet and the Nation's shipyard and repair capability . . . and stabilize and eventually increase the number of mariners available to crew the United States merchant vessels."

Shipments from the VMT to other U.S. ports beginning in 1977 provided impetus for construction of additional tankers to serve the ANS trade and created more jobs for seafarers and those who build and maintain "Jones Act tankers." A small number of foreign-flagged tankers was employed to ship ANS crude to the U.S. Virgin Islands under an exemption in the Jones Act. These shipments ended in 1997 (GAO, 1999).

In 1993, for example, about 32 full-time-equivalent Jones Act tankers were used to transport ANS crude oil (USDOE, 1994) — a significant proportion of the U.S. tanker fleet at that time (Labar, 1995). Although 32 full-time-equivalent tankers were required, some 45 tankers (USDOE, 1994) were engaged in the trade on a part-time basis. Figure 3.3-4 shows estimates of the required number of full-time-equivalent and total tankers based on a simplified, but conservative, mathematical model that considers the average haul distance, tanker size in deadweight tons (dwt), loading and unloading times, delays, and the ratio of total tankers to full-time equivalents. This figure also shows corresponding estimates for various years made by USDOE (1994) denoted by the individually plotted points. In the peak throughput year for TAPS of 1988, ANS tanker trade provided employment for about 2,600 full-time-equivalent seafarers, assuming 27 billets per tanker, and 2.36 crew/billet (USDOE, 1994 based on MARAD estimates).

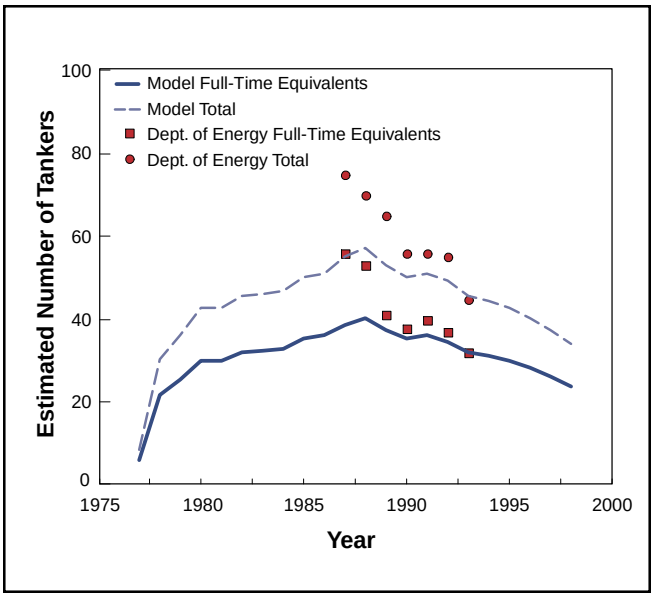


Figure 3.3-4. *Estimates of the full-time equivalent and total number of tankers engaged in the ANS trade based on conservative assumptions. Corresponding estimates for certain years made by USDOE (1994) are shown as individual points.*

According to U.S. General Accounting Office estimates (GAO, 1999), U.S. shipyards built over 50 tankers in the 1970s and 1980s to carry crude oil from Valdez to distant refineries. GAO (1999) cites estimates by shipbuilding officials that construction of a tanker generates approximately "1,000 U.S. shipyard jobs for the 18 months it takes to construct a tanker." Thus, construction of 50 tankers entailed approximately 900,000 person-months of labor. Additionally, tankers serving the ANS trade undergo major, scheduled dry-dock repairs about twice every five years at a cost of $1 million to over $10 million each (GAO, 1999), generating additional jobs at domestic ship-repair facilities. GAO (1999) estimated that about 10 to 15 such repairs have occurred annually for tankers serving the ANS trade, and the average annual number of overseas repairs of ANS tankers was 3.4 from 1989 to 1998 (GAO, 1999).

Generally, the decline in ANS output will require fewer tankers, although the actual number of tankers required at any given time will depend on the particular marketing and transportation patterns prevailing at the time. The ANS trade will still employ a substantial percentage of the Jones Act tanker fleet and therefore support U.S. maritime policy objectives. Moreover, despite future declines in the aggregate number of tankers in this trade, there will be new tanker construction associated with shipment of ANS crude (Committee on OPA 90, 1998). This is because many of the tankers now in this trade will need to be scrapped or sold to comply with the Oil Pollution Act of 1990 (OPA 1990), which mandates, with few exceptions, that all tank vessels

in U.S. waters be double-hulled by the year 2015. A phase-out schedule for U.S. tankers, including those engaged in the ANS trade, has been developed (Labar, 1995; GAO, 1999). Many of these will be replaced by new construction, generating revenues for domestic yards and continued employment for shipbuilders and seafarers. Section 4.3.3 presents estimates of the OPA 90-compliant tankers needed to support continued operation of ANS/TAPS.

Ship Escort/Response Vessel System Tugs

Finally, it should be noted that advances in tug design have evolved from TAPS operational needs. Two new tugs, called *enhanced tractor tugs*, were built by Dakota Creek Industries in Anacortes, Washington, at a cost of $15 million each to provide tanker escort service, ship handling, fire-fighting, and emergency response. Each tug is crewed by five people and can store up to 1,666 barrels (bbl) of oil. Both of the enhanced tractor tugs began working in the SERVS fleet in 1999 (APSC, 1999a, b, 1997a).

3.3.1.2 Importance of ANS/TAPS to the State Economy

This section discusses the characteristics of Alaska's economy including data on gross state product (GSP), diversity of economic activity, cyclical and seasonal fluctuations, personal income, population and employment, prices, sources of state funds, and economic regions. Salient data on the importance of ANS/TAPS to the state economy are highlighted.

Basic Industry

Petroleum production, transportation, and refining is the largest basic sector activity in Alaska. This industry accounted for 19 percent of the total GSP in 1998 (Table 3.3-1) according to estimates by the Institute of Social and Economic Research (ISER) of the University of Alaska, Anchorage (UAA). The share of GSP is heavily influenced by the price of oil and the level of production, both of

Table 3.3-1. *Alaska gross state product by sector (money of day $ million).*

	1961	1970	1980	1990	1998
Total	**$938**	**$2,165**	**$20,276**	**$25,787**	**$22,052**
Private Basic	**114**	**400**	**13,766**	**14,214**	**6,985**
Petroleum	6	207	12,807	11,930	4,280
Seafood	69	110	583	1,123	953
Mining	7	9	37	330	699
Tourism	11	21	169	411	658
Forest Products	22	53	171	370	230
Air Cargo	0	0	0	50	167
Public Basic	**355**	**606**	**1,279**	**2,403**	**2,778**
Military	183	326	599	1,231	1,233
Federal Civilian	172	281	681	1,172	1,545
Infrastructure	**195**	**401**	**1,647**	**2,309**	**3,100**
Construction	72	187	694	815	1,090
Transportation*	45	104	408	601	815
Public Utilities	78	110	546	893	1,195
Support	**211**	**524**	**2,383**	**4,574**	**6,483**
Services*	53	138	768	1,680	2,462
Trade*	92	220	787	1,540	2,098
Finance	52	138	720	1,205	1,730
Misc. Manufacturing	12	24	102	131	167
Agriculture	2	3	7	18	27
State and Local Government	**62**	**235**	**1,200**	**2,287**	**2,705**

*Net of tourism, air cargo, and oil pipeline.
Source: Goldsmith (1999a).

Alyeska Pipeline Service Company

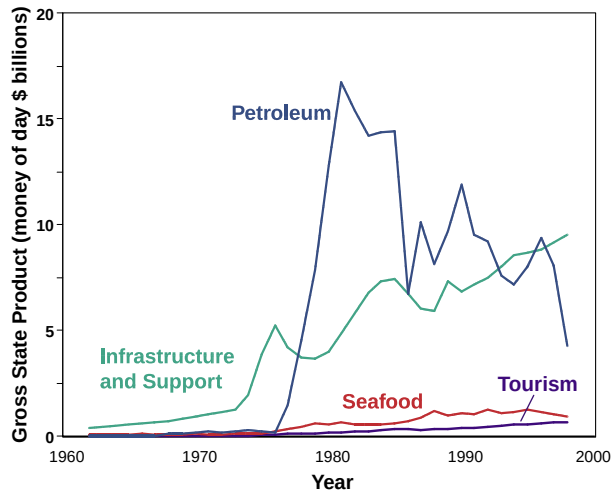
Photo 3.3-2. *Photo of tanker with escort vessels in Prince William Sound.*

which vary over time. In 1980, for example, it was 68 percent. Figure 3.3-5 shows a time trend of several key components of GSP demonstrating both the importance and volatility of the petroleum sector.

Most of the oil production comes from the Prudhoe Bay region on the North Slope. Most is transported through TAPS to Valdez in Southcentral Alaska and thence to market by tanker. Cumulative North Slope production from 1977 through calendar year 1998 was 12.521 billion bbl according to data from the Alaska Department of Natural Resources (ADNR, 1999c). (Through 1999, the total production has exceeded 13 billion bbl.) North Slope oil reserves developed and under development at the start of 1999 were 11.277 billion bbl, and production during 1998 was 450.834 million bbl. The large natural-gas reserves on the North Slope — approximately 30 trillion cubic feet — have not yet been commercially developed (CERA, 1999a; Sherwood and Craig, 2000). Two refineries at North Pole just outside Fairbanks, and one at Valdez process a small portion of North Slope production — about 21 million bbl in 1997 — primarily for consumption in the state (ADNR, 1999c). A fourth oil refinery at Nikiski processes Cook Inlet and imported crudes. (This refinery at one time processed ANS crude but ceased using it because the refinery had no market for the heavy residual refined products.)

The development of North Slope oil resources has contributed to the state economy through several mechanisms. Relevant statistics include:

- Through 1998, about $42.6 billion (1998 dollars) was invested in production facilities on the North Slope (Table 3.3-2) (BP, Annual; Deakin, 1989).
- Data on total in-state procurement spending by the industry are not available, but oil industry wages paid in Alaska attributable to North Slope activities through 1997 were $12.4 billion in 1998 dollars as shown in Figure 3.3-6 (ADOL, Annual Employment). Payroll associated with TAPS operation through 1998, excluding contractors, totaled nearly $1.7 billion in 1998 dollars (Table 3.3-3).
- Figure 3.3-6 also shows a time series of employment. After rapid growth in the early years, employment peaked in 1991 at slightly more than 9,000 workers and has been declining in recent years due to falling production and to cost-saving measures.
- Total annual expenditures for pipeline operations and maintenance, including special projects, have been several times as large as the annual payroll (Table 3.3-4).



Source: Goldsmith (1999a).

Figure 3.3-5. *Alaska gross state product by sector (money of day $ billion).*

Table 3.3-2*. Alaska North Slope investment through 1998 ($ million).*

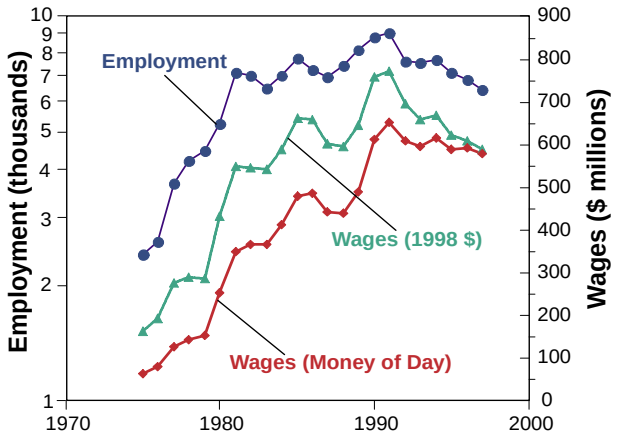
	Cost (money of day $ million)	Estimated Cost (1998 $ million)
Prudhoe	$17,500	—
Kuparuk	5,500	—
Endicott	1,236	—
Point McIntyre	750	—
Lisburne	1,800	—
Milne Point	781	—
Niakuk	154	—
Total	$27,721	$42,596

Note: Excludes investments in Badami, Northstar, Alpine, Point Thomson, and other nonproducing fields.
Sources: BP, Annual; Deakin (1989)

Table 3.3-3. *Pipeline-related employment and wages.*

Year	Employment	Alyeska Pipeline Service Company Payroll: Money of Day ($ million)	Alyeska Pipeline Service Company Payroll: 1998 ($ million)
1978	N/A	$27	$56
1979	N/A	30	56
1980	N/A	34	57
1981	N/A	37	58
1982	N/A	39	59
1983	N/A	40	60
1984	N/A	43	60
1985	N/A	44	61
1986	N/A	46	62
1987	1,439	47	63
1988	1,597	48	64
1989	1,922	53	70
1990	2,434	68	84
1992	3,047	110	126
1993	3,077	102	113
1994	3,639	127	138
1995	2,512	107	113
1996	2,173	90	93
1997	2,017	85	86
1998	2,074	81	81
1999	2,096		
Total		**$1,344**	**$1,662**

N/A: Not available.
Note: Employment includes workers under contract and special projects employment. In 1998 these categories totaled 854 and 411, respectively. Payroll estimated by author. Payroll excludes contract and special projects workers.
Source: APSC, Annual, Earnings; ADOL, Annual, Employment.



Note: Includes ANS plus Anchorage Standard Industrial Code (SIC) 13.
Sources: ADOL, Annual Employment; author (before 1986).

Figure 3.3-6. *Alaska North Slope oil employment (left axis) and wages in money of day and 1998 dollars (right axis).*

The total market value of North Slope oil production delivered to refineries through the end of fiscal year 1998 was $246 billion (MOD), or $330 billion in 1998 dollars (based on data from ADOR, 1999c). State revenues from North Slope oil for the same period were $54.2 billion, or $73.5 billion in 1998 dollars (Table 3.3-5). Revenues attributable to North Slope oil production totaled $51.3 billion, and revenues from TAPS pipeline operations were $2.9 billion. Most production revenues come from the severance tax and state royalties, while both production and transportation contribute to the state property tax and the corporate income tax. Most revenues have been deposited in the state General Fund, but a part of royalties and settlements has gone into the Alaska Permanent Fund and the Constitutional Budget Reserve, which were established to save part of the revenues from depleting assets such as petroleum.

Local governments have received $4.4 billion in revenues through 1998 — $5.6 billion in 1998 dollars — directly from production and transportation of North Slope oil (Table 3.3-6). This represents the portion of the state property tax on oil and gas production and transportation facilities that is shared with the local governments of the North Slope Borough (NSB), the Fairbanks North Star Borough, the City of Valdez, and Anchorage. Of total state property tax revenues collected since 1975 of $6.6 billion, 66 percent was passed directly to these local governments.

Employment in the petroleum industry is small in relation to GSP (Table 3.3-7) (ADOL, 1982b). The employment level is not closely related to the level of production (ADOL, 1989b). In recent years, oil and gas industry employment has declined as oil production has dropped. Nonetheless, because of the high cost of labor, the petroleum industry payroll is the largest of the private basic industries in the state, and wage rates in oil-related industries are the highest in the state (Figure 3.3-7). The industry in Alaska is unique in many other areas including public ownership of land, dominance of production in huge fields, high costs, and dominance by large corporations (ADOL, 1983b).

Other Basic Industries

Other major basic industries in Alaska include seafood, mining, tourism, forest products, international air cargo,

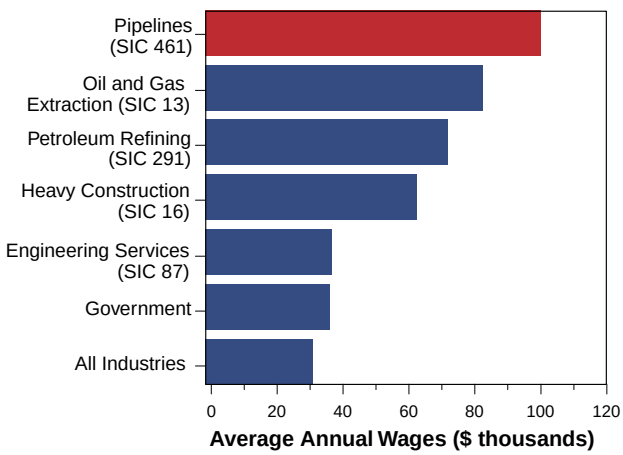
Table 3.3-4. *Alyeska Pipeline Service Company TAPS expenditures (1998 $ million).*

Year	Personnel	Outside Services	Equipment Supplies	Total Operations/ Maintenance	Projects	Total
1987	$98	$62	$134	$294	$49	$343
1988	98	70	155	323	63	386
1989	105	155	177	437	169	606
1990	124	179	218	521	368	889
1991	148	205	153	506	279	784
1992	182	217	121	519	183	702
1993	160	218	98	477	134	611
1994	192	220	98	511	369	880
1995	155	206	82	443	198	641
1996	125	199	82	406	138	544
1997	114	183	96	392	173	565
1998	108	177	90	375	116	491
1999	105	167	88	360	135	495
2000	116	163	81	360	152	512
Total 1987-2000	**$1,830**	**$2,421**	**$1,674**	**$5,924**	**$2,524**	**$8,448**
2001 (Estimated)	$124	$161	$78	$362	$202	$565

Note: Personnel expenditures include payroll, benefits, and other worker-related spending. For this reason, totals are greater than those shown for payroll alone in Table 3.3-3.
Source: APSC, Annual, Earnings.

and the federal government. Salient characteristics of these industries are briefly summarized below.

Seafood Industry. The seafood industry is the second largest private basic industry in Alaska measured by GSP. The larger part of the industry impacting the Alaska economy is the harvesting and processing of salmon, shellfish, and halibut, which together had an ex-vessel value of $881 million in 1995 (ADF&G, 1997). Fishermen in small boats with limited entry permits operate out of the coastal communities throughout the state, harvesting a variety of species in different locations at different seasons of the year. Processing facilities located in many of these communities prepare the harvest for market. For many coastal communities such as Kodiak, Homer, Cordova, Sitka, and Ketchikan, the income of resident fishermen and the processing facilities is one of the most important contributors to the local economy. This is in spite of the fact that a large share of permits to fish for these species are owned by non-Alaskans and many seasonal workers come to Alaska to



Source: ADOL, Annual; ADOL (1998b)

Figure 3.3-7. *Average annual wages by industry in Alaska, 1997.*

Table 3.3-5. State revenues North Slope oil production and pipeline operations, 1978-1998.

	Money of Day ($ million)	1998 ($ million)
Total	**$54,228**	**$73,471**
Share Attributable to North Slope	**51,309**	**69,198**
General Fund Revenues	40,538	56,274
Severance Tax	18,835	24,611
Royalties	4,365	19,020
Corporate Income Tax	3,608	5,076
Bonuses and Rents	1,530	4,080
Special Settlements	1,109	1,466
Property Tax	597	914
Reserves Tax	494	1,106
Constitutional Budget Reserve Revenues	4,931	5,266
Share Attributable to Pipeline	**2,919**	**4,273**
Corporate Income Tax	1,259	1,771
Property Tax	1,660	2,501
Item: Totals for Allocated Taxes		
Corporate Income Tax	4,867	6,848
Property Tax	2,257	3,415

Note: Includes property taxes starting in 1975. Includes North Slope Bonus in Fiscal Year 1970.
Source: ADOR, 1998; Alaska Permanent Fund Corporation, Annual.

crew on the fishing boats and work in the processing plants (McDowell Group, 1989; Knapp and Smith, 1991).

The income of these commercial fishermen is sensitive to world market conditions as well as fluctuations in the size of the annual harvest — for example, the ex-vessel value of the salmon harvest has ranged from $263 million to $789 million between 1988 and 1998 (ADF&G, 1999a). And because the number of harvesters is constrained by regulation, per-capita income from fish harvesting changes considerably from year to year, and fixed costs are high. In consequence, when fish prices are high and the harvest is good, per-capita fisherman income is high and the communities dependent on fishing are economically healthy. In years when prices and harvest are low, communities dependent on the fishery do poorly. Management of the resource has resulted in generally high harvests, and the resource is fully utilized. As a result, further expansion in this industry must come from adding value in processing. Increased competition from fish farming in recent years has put downward pressure on the market price of salmon.

The other part of the industry is the bottom fishery, which in contrast to salmon, shellfish, and halibut, is a low-value, high-volume fishery dominated by large operations in western Alaska. In 1995 the ex-vessel value of the harvest was $511 million (ADF&G, 1997). Large ships harvest the bottom fish and process it into surimi (fish paste) and other products or send the harvest to shore-based processors in Dutch Harbor and other western Alaska ports. The impact of the bottom fishery on the Alaska economy comes when these large ships are owned by Alaskans, when they use the services of Alaska ports, when they employ Alaska residents, and when processing occurs in shore facilities.

Employment in the seafood industry is relatively con-

Table 3.3-6. Property tax revenues, 1975-1998.

	Nominal (money of day $ million)			Constant (1998 $ million)		
	Total Collected	Local Share	State Share	Total Collected	Local Share	State Share
Jurisdiction						
North Slope Borough	$4,479	$3,888	$590	$5,837	$4,932	$904
Valdez	548	358	190	800	481	320
Fairbanks Northstar Borough	224	116	108	322	156	166
Anchorage	26	19	7	34	24	10
Unorganized Borough (a)	1,362	0	1,362	2,016	0	2,016
Total	6,638	4,381	2,257	9,009	5,593	3,415
Pipeline	2,134	474	1,660	3,138	637	2,501
North Slope	4,504	3,907	597	5,870	4,956	914

Note: (a) Retained by state government.
Source: ADCED, Annual.

stant from year to year. Most harvesters are self-employed, either as captains or crew members of boats, and their numbers are not reported in wage and salary employment statistics. Processor employment is the largest component of the manufacturing industry in Alaska. After processing, the wholesale value of all seafood produced in 1995 was $2.508 billion (ADF&G, 1997). The low wages in the fish processing sector account for the low average wage in manufacturing in the state.

Mining. The mining industry is the third largest contributor to private basic-sector gross product. It consists of a small number of world-scale hard-rock mines in the Southeast, Interior, and Northwest parts of the state; one coal mine serving both Alaska and export markets; and many smaller operations and exploration activities. Zinc production at the Red Dog Mine in Northwest Alaska contributes the largest share to the total value of production, followed by gold from the Fort Knox Mine in the Interior, and gold and silver from the Green's Creek Mine in Southeast Alaska. Smaller mines primarily produce gold and silver. The total value of mineral production in 1998 was $904 million — $505 million of zinc, $173 million of gold, $82 million of silver, $49 million of lead, and $95 million of all others (ADNR, 1999a).

Production from these mines is based on the most current technology, and this, together with the large scale of their operations, provides some stability to employment in spite of fluctuating world metal prices. Smaller operations are more vulnerable to world market conditions, as is the level of exploration and development of new prospects.

Employment in mining has been increasing but remains small and is confined to exploration, development, and primary production. Minerals are exported without processing because of the high cost of business in the state. Mining payrolls are important to the economies of the communities adjacent to the mines, although the Red Dog Mine draws workers who are residents of many communities throughout the state. Many people working in the mining sector are

Table 3.3-7. *Annual average employment (thousands).*

	1961	1970	1980	1990	1997
Total	**94.829**	**133.868**	**209.787**	**283.906**	**311.305**
Private Basic	11.101	16.248	34.227	47.936	50.063
Oil and Gas	0.599	2.692	7.955	11.908	10.096
Seafood	7.034	8.483	15.429	18.692	19.112
Mining	0.594	0.354	0.526	1.217	1.593
Tourism	1.045	1.536	5.794	10.474	15.068
Forest Products	1.829	2.759	3.953	4.712	2.376
Air Cargo	0.000	0.424	0.570	0.933	1.818
Public Basic	48.100	48.536	39.719	41.861	35.395
Military	32.500	31.425	22.003	23.132	18.054
Federal Civilian	15.600	17.111	17.716	18.729	17.341
Infrastructure	10.878	15.271	24.426	26.777	30.743
Construction	4.053	6.893	10.169	10.278	12.734
Transportation	4.150	5.707	8.515	10.760	11.718
Public Utilities	2.675	2.671	5.742	5.739	6.291
Support	16.550	35.374	75.125	116.332	141.496
Services	5.282	10.822	27.380	45.630	58.038
Trade	7.745	14.751	27.076	41.766	49.812
Finance	1.520	3.098	7.654	9.165	10.957
Misc. Manufacturing	0.694	1.340	2.655	3.364	3.492
Agriculture	0.022	0.076	0.224	.567	1.055
Proprietors	1.287	5.288	10.137	15.841	18.143
State and Local Government	8.200	18.439	36.290	51.000	53.607

Source: Goldsmith (2000b).

Oil and Gas: Exploration, production, transportation, refining
Seafood: Harvesting (including proprietors) and processing
Timber: Harvesting and processing
Mining: Wage and salary only (excludes proprietors)
Tourism: Transportation, trade, and services employees
Transportation: Net of pipelines, air cargo, and tourism
Trade: Net of tourism
Services: Net of tourism
Proprietors: Net of fish harvesters
Manufacturing: Net of seafood processing, petroleum refining, and forest products harvesting and processing

self-employed, and these workers are not reported in wage and salary employment statistics.

Tourism. The tourism industry consists of the share of business in the trade, services, and transportation sectors identified with nonresident pleasure visitors to the state. The number of pleasure visitors exceeds 1 million per year, bringing more than $800 million in tourist spending into the state (McDowell Group, 1999a). Activity is concentrated in Southeast Alaska, where tour ships have a large share of the market, and in Southcentral Alaska, where several large operators provide a variety of sightseeing package tours. Many visitors come to fish, hunt, and engage in other outdoor activities, and these visitors are more likely to be independent travelers. Small numbers of tourists visit the less accessible communities, mostly by air.

The number of tourists has grown rapidly in recent years, and virtually every sizable community has felt the effects. For some communities, such as Skagway, tourism is now the most important private basic sector of the economy. The industry is very seasonal, with most visitors arriving during summer. This leads to some transiency in the tourism workforce because Alaska community labor markets are not large enough to absorb the seasonal swings in demand for workers. As a result, nonresidents fill a large portion of jobs in tourist-driven industries (ADOL, 2000).

The industry employs a large number of people, particularly during the peak summer months. On an annual average basis, employment is comparable to the seafood industry, which is also quite seasonal. Because wage rates for most jobs are relatively low, the contribution to local economies from tourism payrolls appears low. Not included in the wage and salary employment statistics are a large number of self-employed who work in the industry. This includes many of the guides and other small operators that provide “Alaskan experiences” that the large tour operators are not equipped to do.

Forest Products. The forest products industry, centered in Southeast Alaska, consists of the harvesting and processing of Alaska timber. This industry is not only vulnerable to fluctuations in world market prices, but also dependent on political decisions on the use of publicly owned timber. Though the growth in harvest from Native lands resulted in a boom early in the 1990s, the decline in allowable harvests from public lands and other factors resulted in a severe decline in this industry through the 1990s.

Pulp mills in Sitka and Ketchikan, mainstays of the economies in both communities, closed in the mid-1990s, and several sawmills have also gone out of business. Alternate types of wood processing facilities are under consideration, but none has yet to move beyond planning.

Employment is now primarily limited to timber harvesting and milling. These activities are still important to many of the Southeast Alaska communities, but the contribution of the timber payroll is not as important as it once was. Several of these communities are struggling to find ways to diversify their economies, with the assistance of federal funds made available for that purpose.

Air Cargo. International air-cargo activity operating primarily from Anchorage International Airport is another important private-sector basic industry in Alaska. This industry grew rapidly in the 1990s in response to growth in the international air-cargo market, taking advantage of the location of Anchorage between the U.S. West Coast and important Pacific Rim markets (Goldsmith, 1998). Several of the largest international carriers have built freight transfer facilities at the airport, and many others use the services of the airport. The jobs in this industry pay relatively high wages, and the payroll is an important contributor to the strength of the Anchorage economy.

Military. Military spending is one of the largest nonpetroleum sources of basic economic activity in the state. Major Army and Air Force bases are located in Anchorage and Fairbanks, and a large Coast Guard base is at Kodiak. Smaller installations are located in other communities. The number of active duty personnel has declined in recent years with the closure of bases on Adak Island and at King Salmon in Southwest Alaska, as well as Delta and Galena in the Interior. Reductions of personnel at the remaining bases have also affected the total.

Rising pay and capital spending to upgrade facilities have partially offset the economic effect of the decline in the number of active duty personnel. Fairbanks and Kodiak are most dependent on military spending.

Federal Government. Federal (civilian) spending has always been an important element of the Alaska economy. The largest numbers of federal employees in the state are with the U.S. Departments of Interior, Transportation, Agriculture, and Health and Human Services, as well as the U.S. Postal Service (ADOL, 1996). Federal employees in these and other departments are located in virtually every community in the state, although they are concentrated in the urban centers of Anchorage, Fairbanks, and Juneau.

Direct federal spending for construction, as well as capital and operating grants to state and local governments and nonprofits, also contributes to the economy of the state and communities throughout the state. In recent years, Alaska has ranked near the top among states in per-capita federal grants (DOC, 1998). Many of these grants target the building of infrastructure such as roads, ports, water and sewer facilities, and other utilities, and the provision of services

in rural Alaska that were formerly provided directly by federal employees.

Other. Two other important sources of purchasing power supporting the Alaska economy are the Alaska Permanent Fund Dividend and miscellaneous nonwage personal income. The dividend is an annual cash payment to every Alaskan from the income earned by investing the saved portion of state royalties from petroleum production. The total dividend distribution in 1999 was about $1 billion, larger than the payroll of any of the basic industries of the state (Alaska Permanent Fund Corporation, Annual). The dividend is an important component of household income in every community in the state.

Although small compared to most other states, the share of the Alaska population over 65 is growing as more people choose to retire in the state. Retirees provide a source of personal income to support economic activity in communities throughout the state.

Total Employment

The majority of jobs in Alaska are in infrastructure, support, and state and local government. Transportation is the largest employer in the infrastructure sector — including pipeline workers and those whose jobs depend on tourism and international air cargo. Air and water transportation are both important because of the large part of the state that is inaccessible by road. These regions hold a small share of the population, but much of the basic economic activity occurs in remote locations. This also accounts for the importance of communications and public utilities, since the many small Alaskan communities distributed across the state require access to regional centers, as well as electric and water and sewer service. The construction industry is dependent on the investment decisions of both the private sector and government.

Jobs in the infrastructure sector are relatively high-paying and are sought after by many Alaska residents, and with the exception of construction, are relatively stable from year to year. Many are located in smaller communities and rural parts of the state, and some of these rural jobs are filled by urban residents who commute to rural or remote work sites for temporary assignments.

Support jobs are concentrated in trade, services, and finance, with a small number involved in manufacturing and agricultural production for the Alaska market. Wholesale trade serves the needs of the large retail sector as well as industry, and because of its distribution function, its jobs are primarily in the urban areas and regional centers. Retail trade is well-represented in the economy by a mix of large national chain stores that entered the Alaska market in the 1990s, as well as smaller, locally owned businesses. Retail sales are influenced not only by the household income of residents (including the Permanent Fund Dividend), but also by the large number of tourists and seasonal workers that come to the state. Furthermore, the young average age and transiency of the population contribute to a large retail-trade sector. Since shopping opportunities in smaller communities are more limited and because the available shopping options in urban areas have been increasing rapidly in recent years, retail trade sales tend to be concentrated in urban Alaska and regional centers. Rural residents travel to urban areas to shop or send to city stores “bush orders” that are delivered inexpensively through the bypass mail system of the U.S. Postal Service.

Service businesses also tend to be concentrated in urban areas. This is particularly true of business services, but is also the case for many types of personal services such as health care. Most hospital beds in the state are in the four hospitals in Anchorage. The level of activity in services is sensitive not only to household income and the needs of tourists and nonresident workers, but also the demands of businesses in the state, and public spending. Engineering services, for example, are very sensitive to the level of construction spending. Health services are sensitive to the level of Medicaid and Medicare spending.

Finance is concentrated in urban Alaska, where much of the business of the state takes place. Manufacturing for the Alaska market consists mostly of publishing and some food, while agriculture is mostly greenhouse production and some mariculture.

The support sector generates the largest number of jobs in the economy. Some have high wages, particularly in business and professional services, but more are at the lower end of the wage scale.

The concentration of state and local government workers in Alaska is 41 percent above the national average (DOC, 1997). This is partially due to the need to provide public services to a population scattered among over 200 communities, many of which are not connected to the limited road system. Furthermore, the public ownership of many of the natural resources in the state means that the government has an important management function absent in most other states. State government employment, including the University of Alaska, is concentrated in the urban centers of Anchorage, Fairbanks, and Juneau where it is an important component of the local economy. In contrast, local government employment is more evenly distributed across the communities of the state, and in smaller communities represents one of the largest sources of jobs in the schools and administration.

Government Expenditures

Figure 3.3-8 shows state and local government expenditures per capita in 1996 (the latest year available) for the top 20 states. Alaska spending per capita has been the highest among all states for many years. In 1996, Alaska's spending per capita of $11,745 was slightly more than 2.4 times the median of $4,870 among the states and 2.23 times the mean of total spending. This spending pattern for Alaska reflects not only differences in the costs of goods and services,[1] limited infrastructure, low population density, and other factors, but also the fact that Alaska provides more services than do other states. Alaska's proportionately large expenditures per capita have been financed by the infusion of oil and gas revenues, among other sources. (The contribution of the oil and gas industry to Alaska's unrestricted General Fund revenues is presented below.)

Alaska also has the highest level of state debt per capita. Figure 3.3-9 shows state-government debt per capita in 1996 (the latest year available) for the top 20 states. Alaska's debt per capita has been the highest among all states for many years (Mead, 1978). In 1996, Alaska's state debt per capita of $11,234 was nearly 2.9 times the median of $3,923 among the states. This statistic is not presented to claim that the state is insolvent or unwisely managed. However, it does show that the state has been more willing than all others on a per-capita basis to accept debt burdens.

The Geographic Diversity of Economic Activity

Great economic diversity exists among the three major regions of Alaska: the Railbelt, Maritime Alaska, and the Interior.

Railbelt. This region is named for the Alaska Railroad that runs from Seward, through Anchorage and the Matanuska Valley, and north to Fairbanks. This area, which contains 72 percent of the state population, includes the four borough census areas of Anchorage, Fairbanks, Matanuska-Susitna, and the Kenai Peninsula, (ADOL, 1999c). Its communities are linked by road, and it has the most diverse economy of the state. It serves as the headquarters and staging area for much of the economic activity (in particular, petroleum, mining, and construction) that takes place in the more remote parts of the Interior. It is the home for most of the workers who commute to jobs at remote sites (ADOL, 2000) and many commercial fishermen (ADF&G, 1999e). It is the trade and service center for smaller communities in the Interior and much of Maritime Alaska. The largest military installations are in the Railbelt, and most federal government workers are stationed here. Most tourist visitors to the state spend some time in the Railbelt, and most Alaskans who live in the Railbelt spend their recreation dollars there as well.

Labor force participation in the Railbelt is high, and the unemployment rate is relatively low (ADOL, 1999f). The large workforce and small senior population contribute to a high level of per-capita income relative to both the national average and the rest of the state. The size of the population is sensitive to employment opportunities. When employment opportunities are growing, the population increases with migration from other parts of the state and the rest of the U.S. When employment opportunities are falling, out-migration causes the population to grow more slowly (ADOL, 1998a). Although a large number of Alaska Natives[2] live in the Railbelt, they are under-represented as a percentage of the Railbelt population compared to the rest of the state (ADOL, 1999d).

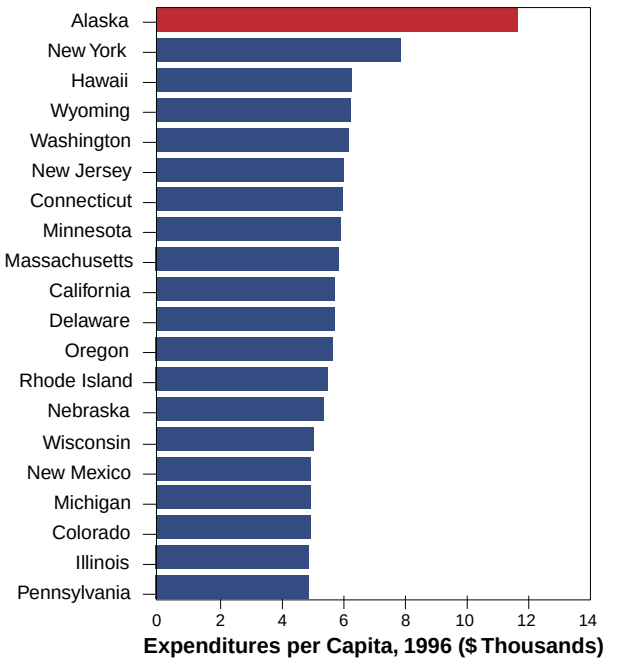
Maritime Alaska. This region consists of the smaller communities without road access along the Alaskan coast from Ketchikan in the south to Dutch Harbor far to the north and west.[3] About 16 percent of the state population lives in these communities. There are about a dozen communities with populations over 1,000 along this crescent; the largest community is Juneau, the state capital. Numerous smaller communities are interspersed among them. These communities grew up around the exploitation of natural resources, primarily fishing, and because of size, location, and other circumstances, are less economically diversified than the Railbelt communities. The larger communities such as Ketchikan and Juneau have the most economic diversity. Juneau, besides being the state capital, is the location of a large silver mine, the Greens Creek Mine; is a popular tourist destination for cruise ships; and is home to some commercial fishermen. Small communities such as Cordova and Dutch Harbor, which are almost completely dependent on commercial fishing, are less diverse.

Because of their more fragile economic base, the support economies of these communities are not as well-developed as in the Railbelt, although large retailers have moved into some of these markets. The relative lack of economic diversification also makes these communities more susceptible

[1] Adjusting for differences in the cost of living between Alaska and the other states, the average per-capita Alaska spending is approximately 1.9 times the average for the other states (Goldsmith, 2000a).

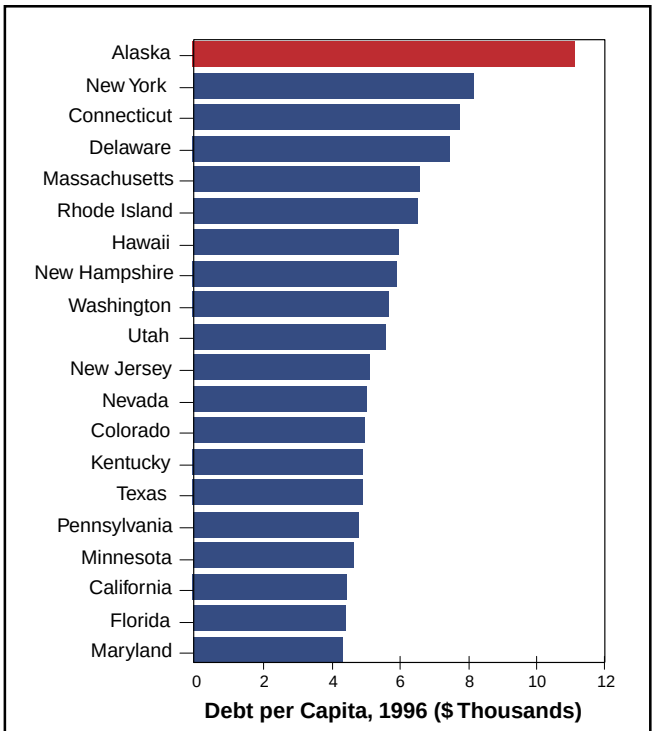
[2] "Native American" is an ethnic designation used by the U.S. Bureau of Census and the Alaska Department of Labor. It includes all Native Americans, as well as a small number of Natives belonging to tribal groups from other states. The terms "Alaska Native" or "Native" are more common and are used in the rest of this document.

[3] For this summary, "Maritime Alaska" is defined as the following census areas: Kodiak, Valdez-Cordova, Dillingham, and all census areas in Southeast Alaska.



Source: Bureau of Census (DOC, 1999b)

Figure 3.3-8. *Twenty states listed in descending order of combined state and local expenditures per capita, 1996.*



Source: Bureau of Census (DOC, 1999b)

Figure 3.3-9. *Twenty states listed in descending order of debt per capita, 1996.*

to a downturn in one natural resource market than is the case for the Railbelt. In recent years, growth in these communities has lagged behind the Railbelt.

Labor force participation in Maritime Alaska is not as high as in the Railbelt, and seasonal employment — in industries like fishing and tourism — is more important. Population growth is less directly tied to employment opportunities than the Railbelt as residents move in and out of the labor market in response to employment opportunities rather than migrate.

Household income is more variable, depending on the fishing season or other resource cycles. The Alaska Native population is under-represented in the larger Maritime communities compared to the state as a whole.

Interior Alaska. The remaining Alaskans (about 12 percent) live in this region, which consists of nearly 200 small communities mostly off the road system. Access is primarily by air or boat. These communities range in size from Bethel, Barrow, and Nome, with populations of 4,000 to 5,000 each, to places with a handful of families. The largest of these communities are regional centers for rural parts of the state. Petroleum production, mining, fishing, and tourism are the most important private basic industries in the Interior, but few communities receive much direct economic benefit from their proximity to these resources. Petroleum and mining are largely enclave-type developments from camps, the most productive fisheries are closer to the Maritime communities, and tourism is dominated by businesses located in the more urban parts of the state.

Most of these communities are cash-poor from the lack of a viable private-sector economic base, and their small size makes it difficult to support retail and service businesses. Much of the cash in many of these communities comes from the state and federal governments through a variety of programs providing grants and services to local residents and governments. These are administered by local governments, village corporations, tribal councils, and other quasi-government organizations. Per-capita personal income is below the Railbelt and the national average. At the same time, the cost of living, based on the cost of a standard marketbasket of goods and services, is considerably higher than in Anchorage because most food and manufactured goods must be shipped to Interior villages by air or water (University of Alaska, 1998).

The population is primarily Alaska Native, and most households engage in subsistence activities. Because of subsistence participation, the labor-force participation rate is relatively low. However, the unemployment rate in most places is quite high because the number of job opportunities is limited. In many communities most of the jobs pay-

ing a cash wage are with the government — the post office or school — or with the electric utility. In larger places there are more opportunities with the local government or other quasi-government organizations, and a limited number of jobs in small businesses. Publicly funded construction projects are another important source of wage income.

Considerable resources have been invested in providing public infrastructure in small Interior communities, and living conditions have improved considerably in terms of access to health care, education, and social services; electricity, communications, and other public utilities; and economic opportunities. Nevertheless, money to maintain infrastructure and programs is becoming more scarce, many communities still lack basic utilities, and economic opportunities are not growing fast enough to keep up with the growing working-age population. Many Interior residents choose to move to the Railbelt or Maritime communities because of the greater economic opportunities available in those places, but many choose the subsistence lifestyle of the Interior in spite of the limited opportunities for cash income which that choice entails.

Cyclical and Seasonal Fluctuations

Cyclical and seasonal instability of the economy is an important consequence of the dominance of natural-resource production in Alaska's economy. Natural-resource production tends to be both cyclical and seasonal. The cyclical nature of resource production is reflected in the ex-vessel value of the salmon harvest to commercial fishermen. In the last 10 years, it has ranged from $263 million to $789 million, depending on the size of the run and the market price (ADF&G, 1999d). This instability means the income for communities dependent on fishing can vary considerably from year to year, making planning difficult for households, businesses, and governments.

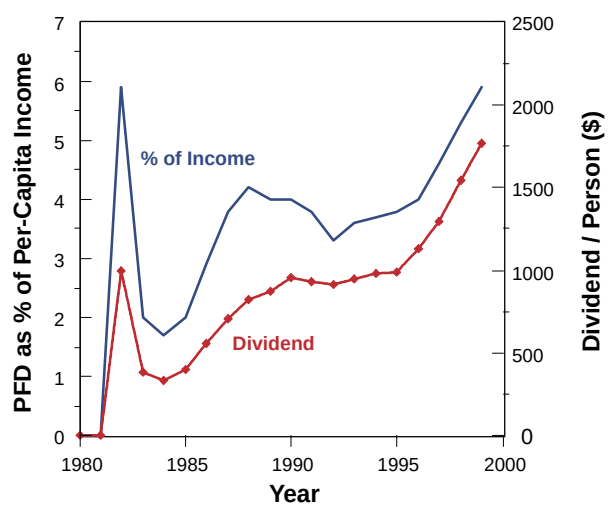
The seasonality of resource production is reflected in the employment in fish processing. For example, in 1997 in the Valdez-Cordova Census Area, monthly fish processing employment averaged 499, but it was 1,168 in the peak summer month of July and only 57 in December (ADOL, 1998b). The labor market in small communities, and for the state as a whole, is unable to absorb these seasonal swings. As a result, seasonal industries tend to have a large nonresident workforce, and the local economies cannot generate as large a support structure as places where income is more stable and remains within the community with residents.

Personal Income

An increasing share of personal income now comes from nonwage sources such as the Alaska Permanent Fund Dividend (PFD) (Goldsmith, 2000b). Figure 3.3-10 shows the dividend paid to each resident of Alaska in dollars and as a percentage of per-capita income from 1980 to 1999. The Permanent Fund Dividend Program was established in 1980. Court challenges required modification of this program, and the first checks were distributed at the end of 1982, which accounts for the spike in the curves shown in Figure 3.3-10. In subsequent years, the dividend has increased, as has the significance of this dividend relative to per-capita income. Because the dividend is paid on a per-person basis, the relative significance on a household basis is greater for large low-income families.

The PFD helps to insulate the economy from the fluctuations in income associated with natural-resource production. A portion of wages paid to workers in the state leaves when seasonal workers and nonresidents temporarily employed in Alaska leave the state at the end of their work assignments. This residence adjustment also helps to insulate the economy from seasonal variation, but the loss of purchasing power represented by this adjustment also takes away a source of growth for the economy.

There are large differences across the state in the importance and even direction of the residence adjustment (DOC, 1997). The largest outflow is from the North Slope Borough, where about three-quarters of all wages reported go to nonresidents of the borough — the oil field workers. In contrast, the Matanuska-Susitna Borough, adjacent to Anchorage to the north, has a net inflow of wages equal to



Source: ADOL (1999e); Alaska Permanent Fund Corp. (2000).

Figure 3.3-10. *Permanent Fund Dividend in dollars per person and as percent of per-capita income.*

nearly two-thirds of the wages paid to workers in the borough. Although much of this residence adjustment is due to the borough's location as a suburb of Anchorage, a portion comes from remote-site workers bringing their paychecks to their homes in the borough. This is substantiated by the fact that there is also a net inflow of wage income into the Kenai Peninsula Borough — equal to about 15 percent of the wages paid in the borough — even though the population centers in the borough are not close enough to Anchorage to be considered suburbs. Much of that inflow comes from wages paid on the North Slope. Table 3.3-8 shows that most North Slope oil workers live in the Railbelt and that few live in or near the oil fields.

Per-capita personal income in Alaska is no longer above the national average, as it was for many years, largely because the average annual wage is not growing. Most new jobs in recent years have been in lower-paying industries, while the economy has been losing high-paying jobs in industries such as petroleum and timber.

***Table 3.3-8**. Place of residence of North Slope oil workers (percent).*

	Residency Determination	
	Permanent Fund Dividend	**Driver's License**
Outside Alaska	29.8%	13.0%
Anchorage/Mat-Su	44.0	54.5
Gulf Coast	14.7	18.3
Interior	9.0	11.1
Northern	1.4	1.7
Southeast	0.5	0.6
Southwest	0.7	0.9
Total	100.0%	100.0%

Note: Gulf Coast includes the census areas of Valdez-Cordova, Kenai Peninsula, and Kodiak. Interior includes Fairbanks, Southeast Fairbanks, Yukon-Koyukuk, and Denali. Northern includes North Slope Borough, Northwest Arctic Borough, and Nome. "Oil workers" includes SIC 13, but excludes construction industry workers.
Source: ADOL (2000) and author's estimate.

Labor Market and Total Population

The population is 74 percent white, 17 percent Alaska Native, and 9 percent other (ADOL, 1999d). The average age is less than the national average, and Alaska Natives are younger than the state average (23 percent of the Alaska Native population is under 10). Only 5 percent of the population is over the age of 65. About 3 percent of the population is active-duty military.

The population is quite mobile, particularly in the Railbelt, but less so than in the past. As recently as the 1970 census, only 48 percent of males reported living in Alaska 5 years earlier. By 1990, the percentage had increased to 76 percent (DOC, 1972, 1982, 1993). Non-Natives are more likely to make their decisions about where to live based on the availability of jobs than are Natives, but the large Native population in the Railbelt suggests that a portion of Alaska Natives choose where to live on the basis of job opportunities.

Labor-force participation rates are higher for whites than Alaska Natives. In 1990, the rates were 88 percent for white males and 69 percent for Alaska Native males (DOC, 1993). This is partially a reflection of the desire of many Natives to pursue a subsistence lifestyle while living in the Interior and also reflects the absence of job opportunities in many Interior communities. Participation rates are also high for females, with 68 percent of white and 51 percent of Alaska Native women reporting to be in the labor force.

Unemployment rates in Alaska are generally higher than the national average for a number of reasons:

- First, in many smaller communities the availability of cash wage jobs is very limited. In many instances, particularly in the Interior, the published unemployment rates under-represent the extent of the unemployment because job seekers become discouraged and stop looking for work.
- Second, the seasonality of many jobs in construction, seafood, timber, and tourism means that the typical worker may spend more time unemployed than elsewhere.
- Third, competition for jobs from nonresident temporary workers may keep residents from obtaining jobs.

The percentage of nonresident workers in some industries is quite large, reflecting an easy flow of workers into and out of the state in response to the changing availability of jobs. One result is that the unemployment rate tends to be pro-cyclical, at least during expansions. When the number of jobs increases rapidly, the number of migrant job-seekers who come to Alaska increases more rapidly, causing the amount and rate of unemployment initially to increase (ADOL, 1977). Out-migration of these workers depends on their expectations of continuing job opportunities in the state. For example, the Out-migration after the construction of TAPS in the late 1970s was modest because of the expectation at the time that construction of a gas pipeline would commence in a year.

Public Sector

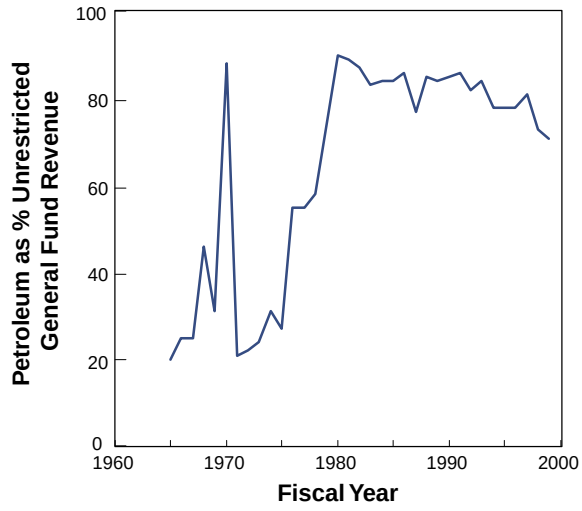
Much of Alaska is divided into organized boroughs, similar to counties in most states, but a part of the state is in the unorganized borough. Borough governments are required by law to provide certain public services, while the

state provides those services directly to the residents of the unorganized borough. Communities both within and outside the organized boroughs are incorporated into cities that provide additional local services. Three areawide boroughs combine a city and borough government into a single entity. Because of the existence of the unorganized borough, the modest tax base in many cities and boroughs, and the evolution of public service delivery in the state, state government provides a larger share of the public services in Alaska than in most states. For example, the state provides public education in the unorganized borough and provides most of the funding for public education in the cities and boroughs through foundation grants.

The largest source of general-purpose (General Fund) revenues for the state is petroleum production and transportation. Figure 3.3-11 shows a time series of the percentage of unrestricted General-Fund state revenues accounted for by the petroleum industry (1965-99). From 1988 to 1998, oil and gas revenues accounted for an average of 82 percent of such revenues. Taxes are levied on property, income, and production. Since the state owns the land from which most petroleum is produced, it also receives a royalty on production, as well as bonuses and lease payments. The remaining general-purpose revenues come primarily from a corporate income tax and various fees and licenses. The state currently has neither a statewide sales tax nor a personal income tax. Revenues from natural resources other than petroleum account for a small part of the total (ADOR, 1999c).

State revenues have consistently been less than general-purpose expenditures during the 1990s, and the deficit has been covered by drawing down the state's cash balances accumulated from oil revenues collected in earlier years. At the same time, the revenues collected from petroleum production and transportation have been falling due to declining production. The practice of relying on petroleum revenues and cash balances to cover the cost of general government can continue for only a few more years before large new revenue sources will be required, or the state general-purpose budget will need to be cut by about 50 percent (Goldsmith, 1999b). This assumes continuation of ANS production. If this revenue source were not available, the budget situation would be much more serious.

The second largest source of state revenues is federal grants for both capital spending and operations. These funds are restricted for use in specific programs and cannot be used to reduce the deficit in the General Fund. A sizable portion of these grants is to build the physical infrastructure of the state up to a level comparable to other states and foster economic development.



Source: ADOR (1999c)

Figure 3.3-11. *State revenues from the petroleum industry as a percentage of unrestricted General Fund revenues, 1965-1999.*[4]

The third major source of state revenues is the Alaska Permanent Fund. This fund was established in 1976 as a permanent savings account for a portion of the royalties paid to the state from petroleum production on state lands. Since the flow of these revenues was temporary, the rationale was to convert a depleting natural-resource asset into a sustainable financial asset. Deposits also served to prevent spending all the petroleum revenues when received. This reduced unnecessary expenditures and overheating the economy from a large and unsustainable cash infusion.

The Permanent Fund has grown to the point where at an oil price of $16/bbl, the annual earnings are as large as the declining revenues from oil. The balance in the fund ($26.7 billion on October 24, 2000) is constitutionally protected from being spent, but the earnings are appropriated by the state legislature each year. The largest portion of these earnings is distributed to Alaska residents as an annual cash dividend (the PFD). The rest of the earnings have up to now been saved through deposits into the balance of the fund, where they are then protected from being spent.

Local government revenues come primarily from a combination of sales taxes, property taxes, and transfers from state government and revenue sharing of locally generated taxes; assistance for specific programs like primary and

[4]The approximately 65 percent increase in petroleum revenues in Fiscal Year 1970 was due to oil lease sales that increased Alaskan state revenue by about $900 million (MOD) (Roderick, 1997).

secondary education; and general aid. Most of the smaller communities have a very limited tax base and rely heavily on the state to finance their operations. This results from the uneven geographic distribution of marketable natural resources in the state, the absence of manufacturing that is not directly related to resource production, and the concentration of most business activity in the Railbelt and larger communities in Maritime Alaska. The notable exceptions are the North Slope Borough and Valdez, which are able to collect sizable revenues from property taxes on petroleum property in their jurisdictions, and the Northwest Arctic Borough, where the large Red Dog Mine is located. Table 3.3-9 shows that oil and gas property taxes account for 98 percent and 78 percent of the property tax collections of the North Slope Borough and the City of Valdez, respectively. Each of these local governments has a permanent fund that provides another source of revenue not available to most communities in the state. Thus, oil property-tax revenues are 66 percent and 63 percent of total revenues for the North Slope Borough and the City of Valdez, respectively.

Although several factors mentioned above explain why public spending per capita has always been higher than the national average (Figure 3.3-8), the large oil revenues collected by the state since the mid-1970s account for an increase in spending in the early 1980s and a gradual decline since that time. Oil revenues allowed the state to extend programs and services to more communities and residents, to expand the scope of programs, to add new programs, and to build basic physical infrastructure lacking in many communities. The result is a level of public service delivery in the Railbelt and many Maritime communities that is generally comparable to communities in the rest of the U.S. The level of public service delivery in the Interior has improved, but the absence of adequate water and sewer systems in many villages shows that is still not comparable to communities in the rest of the U.S. (ISER, 1999). The General Fund deficit and declining petroleum revenues represent a challenge to state and local government to maintain the current level of public service delivery.

Price Level

The Anchorage cost of living is between 5 and 20 percent above the national average (ACCRA, 1999; ADOL, 1999a; Goldsmith, 2000b). The primary reasons are the necessity of importing virtually all consumer and producer goods from the contiguous 48 states, the absence of competition in the supply of many goods and services, the small scale of operations in many industries in the state, government dominance of labor markets, and “sticky” prices that go up easily during a boom but take longer to come down afterward. The differential is narrowing, based on the rates of annual inflation in Anchorage compared to the U.S. average. Since 1960, the Anchorage consumer price index has increased faster than the U.S. average only in one out of every four years (Goldsmith, 2000b).

Outside Anchorage in the rest of the Railbelt, the Maritime region, and particularly the Interior, the cost of living — measured by pricing an Anchorage market basket in different locations — is higher by a margin that varies with the size and accessibility of the community. The cost of getting goods and services to communities accessible only by air, the small scale of business operations, and the absence of competition all play a role in keeping prices and the cost of living high. Harsh climate, logistical problems, and shortages of trained manpower create additional problems that add to the cost of doing business in the Interior (University of Alaska, 1998).

The Alaska Permanent Fund Dividend and the absence of a personal income tax reduce the income required to purchase a market basket of goods and services. This tends to hold wage rates down relative to the measured price differential compared to other locations (ADOL, 1999a).

Table 3.3-9. *Local government for 1998 ($ millions).*

	Oil and Gas Property Tax	Total Property Tax	Total Revenues	Oil and Gas Percent of		Government Debt	Cash Reserves
				Property Tax	Total Revenues		
North Slope Borough	$207.190	$211.675	$313.370	97.9%	66.1%	$777.459	$423.848
Fairbanks North Star Borough	4.553	58.111	63.885	7.8	7.1	94.215	11.690
City of Valdez	13.777	17.581	21.931	78.4	62.8	3.280	62.000
Anchorage	1.033	227.061	324.902	0.5	0.3	616.305	50.689

Note: “Cash reserves” excludes proceeds of the sale of Anchorage Telephone Utility in 1999, and cash reserves of the City of Fairbanks.
Source: ADCED (1998 and 1999).

3.3.1.3 Importance of ANS/TAPS to Regional Economies in Alaska

Regions in the Study Area

North Slope Borough. The population of 9,632 is divided among seven small communities and Barrow, the regional center where 60 percent of the population lives. Separate from these Alaska Native communities is the North Slope petroleum complex, where several thousand oil and construction workers live in camps and run the North Slope oil fields. With few exceptions, these workers are not residents of the borough but commute from homes in other parts of the state and nation (ADOL, 2000, 1988b; Marshall, 1993; North Slope Borough, 1999).

The cash economy of the borough is largely dependent on North Slope oil production. Although only a small share of residents work in the oil fields, the borough imposes a property tax on the production and transportation facilities in its jurisdiction. Since its imposition, this tax has produced $4.932 billion (1998 dollars) for the borough, allowing it to undertake a large capital-improvement program and to institute public services previously unavailable in the borough. This is reflected in the fact that excluding the petroleum enclave at Prudhoe Bay, 39 percent of employment in the borough is in local government, mostly with the borough and the school district (Table 3.3-10). Furthermore, a share of services employment reflects the delivery of public services by quasi-governmental agencies like the tribal councils and nonprofit affiliates of the Arctic Slope Regional Corporation (ASRC), the Native corporation headquartered on the North Slope. The construction industry is still a major employer, but the capital improvement program peaked in the 1980s, and public capital spending is much less than previously.

The borough receives about two-thirds of its revenues from petroleum property taxes and a large share of the rest as income on its permanent fund, funded by tax revenues saved from former years. As the value of these assets depreciates, tax revenues have also been falling, and the borough budget is smaller today than in previous years. The borough does have a large outstanding debt (Table 3.3-9) which is being repaid by property tax revenues. As of 1999, this debt was approximately $777 million, or $80,716 per capita, based on a population of 9,632.

The ASRC is another important source of employment and income for the region. It is estimated that about 40 percent of its revenues, approaching $1 billion annually, come from subsidiaries providing construction, fabrication, environmental, and engineering services to the petroleum industry *(Alaska Business Monthly,* 1999). It is also actively involved in the refining industry in the state, as well as other activities that provide employment and dividends for shareholders both within and outside the borough.

As evident in Table 3.3-11, the pattern of personal income in the borough follows that of employment. Of total wages reported paid to workers in the borough of $533 million in 1997, at least $363 million left the region with enclave workers living in other parts of the state (DOC, 2000). Borough residents get a larger share of their income from wages and a smaller share from other sources than most other parts of the state. Wages are high, reflecting the high cost of living in the borough, but per-capita income is slightly below the state average.

Most borough residents participate in subsistence. This source of noncash income influences the labor-force participation rate for cash work.

Yukon-Koyukuk Census Area. In terms of area, the Yukon-Koyukuk Census Area is the largest in the state, covering much of the upper Yukon River basin, but it is one of the smallest in population with 6,372 people. They live in 42 communities, the largest of which, Fort Yukon, has about 600 people. McGrath and Galena, each with about 500 people, are the next largest communities. The communities in close proximity to the pipeline are all smaller. The population is 71 percent Alaska Native. In recent years, population growth in this census area has been the slowest in the entire state due to net out-migration.

Wage employment is limited in this census area because most of the population lives in remote locations in very small communities. There is a very limited private-sector economic base, and 42 percent of all jobs are directly provided by the state and local governments in the region. Many of the jobs in the service sector are funded through government grants to nonprofits, and most of the construction employment is based on public spending. Infrastructure and support jobs in retail trade are limited by the small amount of personal income in the region. Most residents participate in subsistence activities.

The local-government tax base in most communities is limited by the absence of private-sector economic activity. The sales tax is the primary method used to generate local income. Many communities are unincorporated and being in the unorganized borough, receive their services directly from the state government.

Less than half of personal income is from wages, and per-capita income is considerably below the state average.

Fairbanks North Star Borough. The population of the borough, 83,773, is centered in the City of Fairbanks and the surrounding communities of College and North Pole, with the remainder concentrated along the highways radi-

ating north and south from Fairbanks. Since it is a regional center for much of Interior Alaska, many Fairbanks residents work outside the borough on the North Slope, at remote construction sites, and at other jobs that bring income into the economy. There is some seasonality in employment due to the importance to the economy of mining and tourism, as well as arctic construction. Alaska Natives comprise approximately 6 percent of the population.

The main drivers of the Fairbanks economy are the military (Fort Wainwright and Eielson Air Force Base); the University of Alaska; mining (including the Fort Knox Gold Mine); tourism; regional transportation, construction, and other services to Interior businesses and households; petroleum refining; and TAPS (Huskey, 1995). It is headquarters for Doyon, Ltd., the Native corporation encompassing much of Interior Alaska, with the second largest number of shareholders.

The borough and the City of Fairbanks have a diversified revenue base. Seven percent of borough revenues come from the property tax on TAPS. As its assessed value declines, revenues from the pipeline have been falling.

Total personal income in 1997 was $1.8 billion. In spite of the residents bringing paychecks home from North Slope and other remote-site jobs, there is a net outflow of wages, largely due to nonresidents employed in seasonal jobs. Per-capita income is below the state average.

Southeast of Fairbanks. This census area stretches southeast from Fairbanks to the Canadian border along the Alaska Highway. About half of the population of 6,283 live in and around the two communities of Delta and Tok, both at highway junction points. The rest of the population is scattered among 12 communities, only one of which, Eagle, is much larger than 100 people. Although Alaska Natives are slightly under-represented in the total population, sev-

Table 3.3-10. *Full- and part-time employment by place of work, 1997.*

	North Slope Borough			Yukon-Koyukuk Census Area		Fairbanks North Star Borough		Southeast Fairbanks Census Area		Valdez-Cordova Census Area	
	Number	%	% Net Oil/Gas	Number	%	Number	%	Number	%	Number	%
Employment by place of work	8,609	100.0%		2,892	100.0%	48,979	100.0%	2,681	100.0%	7,076	100.0%
Mining (oil and gas)	3,271	38.0	0%	113	3.9	1,139	2.3	37	1.4	0	0.0
Construction	392	4.6	7.3	0	0.0	2,471	5.0	68	2.5	308	4.4
Transportation	483	5.6	9.0	207	7.2	3,091	6.3	221	8.2	1,094	15.5
Trade	618	7.2	11.6	349	12.1	9,090	18.6	570	21.3	855	12.1
Finance, services	1,559	18.1	29.2	716	24.8	14,194	29.0	630	23.5	1,851	26.2
Federal civilian and military	97	1.1	1.8	164	5.7	10,986	22.4	692	25.8	327	4.6
State government	50	0.6	0.9	117	4.0	3,792	7.7	124	4.6	399	5.6
Local government	2,088	24.3	39.1	898	31.1	2,635	5.4	242	9.0	707	10.0

Source: DOC (1998a). Includes wages and salary and proprietor employment.

Table 3.3-11. *Economic and demographic indicators.*

	North Slope Borough	Yukon-Koyukuk Census Area	Fairbanks North Star Borough	Southeast Fairbanks Census Area	Valdez-Cordova Census Area
Population - 1999	9,632	6,372	83,773	6,283	10,333
Percent Native Alaskan - 1998	56%	71%	70%	14%	14%
Earnings by place of work (million) - 1997	$533.3	$72.4	$1,444.3	$69.2	$230.2
Residence Adjustment (million)	($363.0)	($15.8)	($148.0)	$6.6	($24.8)
Earnings by place of residence	$131.2	$51.0	$1,196.2	$71.1	$188.6
Personal income (million)	$171.4	$106.7	$1,808.7	$111.5	$278.9
Per capita personal income	$23,725	$17,826	$21,417	$19,870	$26,743
Unemployment rate - 1997	5.5%	15.9%	7.6%	12.7%	11.1%

Sources: Population: ADOL (1999d); North Slope Borough population: ADCED (1999); Percent Alaska Native: ADOL (1998a); Personal income: DOC (1998b); Unemployment rate: ADOL (1998b).

eral of the smaller and more remote communities are largely composed of Natives.

The largest employer in the census area has been the Fort Greely Army Base adjacent to Delta. With state and government jobs included, 40 percent of all jobs are with the government. A share of the service jobs is supported by government grants to nonprofits for the delivery of public services, and a share of the construction employment is also based on government capital spending. Tourist activity and services to other highway travelers are the other main economic driver for the region. Infrastructure and support jobs in retail trade are limited by the small amount of personal income in the region. Many residents participate in subsistence activities.

The closure of Fort Greely, which is currently underway, will take away the biggest employer in the region. Local officials are looking at alternative uses for the facilities at the fort that would support jobs for Delta.

The local-government tax base in most communities is limited by the absence of private-sector economic activity. The sales tax is the primary method used to generate local income. Many communities are unincorporated and being in the unorganized borough, receive their services directly from the state government.

Sixty-four percent of personal income is from wages. Per-capita personal income is among the lowest in the state.

Valdez-Cordova Census Area. Valdez is home to about 40 percent of the 10,333 residents of this census division. The other sizable community is Cordova, about half the size of Valdez. The other communities over 200 are Copper Center, Tazlina, Glennallen, Kenny Lake, and Whittier. The rest of the population is scattered in smaller communities along the highway system and the coastline. The Alaska Native population is 14 percent of the total and concentrated in some of the smaller and more remote communities. The Native share of the population is less in the larger communities of Valdez and Cordova.

The main economic drivers for the census area are the TAPS pipeline and terminal, the refinery at Valdez, commercial fishing, tourism, and state government offices. Alyeska is the largest private employer in Valdez, and several contractors working for Alyeska in construction, transportation, environmental services, and security are also very important. The refinery is the other large private employer in Valdez, while seafood processing facilities are located in both Valdez and Cordova, which are also home to many commercial fish harvesters. People working in the tourist industry — for example, as charter fishing-boat operators — are sole proprietors (ADOL, 1999g).

The City of Valdez tax base is heavily dependent on the pipeline and terminal, with 63 percent of total revenues coming from property tax on oil-related facilities. As its assessed value declines, revenues from TAPS have been falling, necessitating reductions in the budget. The city has established a permanent fund to save a portion of the oil revenues collected in past years.

High wage rates in jobs related to TAPS are an important source of wage income, although proprietor income from fishing and tourism is also important. Per-capita income is above the state average.

Regions Outside the Study Area

Anchorage. This is the largest city in the state and with the adjoining Matanuska-Susitna Borough, the home to 308,381 — just over half the residents of the state. About 8 percent of the population is Alaska Native, but 20 percent of the entire Native population of the state lives here. Anchorage is a modern city with all the amenities found in cities of comparable size in the contiguous U.S. The Matanuska-Susitna Borough has in recent years become closely integrated with the Anchorage economy through an improved highway link. A large share of the residents of the borough commute daily to Anchorage to work. Many residents of both the borough and the city also work in the enclaves on the North Slope and elsewhere.

The main drivers of the Anchorage economy include the military (Fort Richardson and Elmendorf Air Force Base), federal civilian employment, state government including the University of Alaska, and much of the trade, business, transportation, and other infrastructure services for Interior and Maritime Alaska. Six Native corporations — Aleut Corporation, Bristol Bay Native Corporation, Calista Corporation, Chugach Alaska Corporation, Koniag Incorporated, and Cook Inlet Region Incorporated — have offices in Anchorage.

The stability of the economic base has resulted in the most highly developed support economy in the state. There is some seasonality related primarily to tourism and construction, and nonresidents do take out of the state some of the wages paid.

The local-government tax base depends primarily on the property tax. A small share of total revenues, 0.3 percent, comes directly from petroleum production and transportation property, although a much larger share is indirectly dependent on petroleum. Anchorage has no sales tax.

Nearly half of statewide personal income accrues to Anchorage residents. Because of a high labor-force participation rate combined with relatively high average wage rates, per-capita personal income is above the average for the state.

Kenai Peninsula Borough. Adjacent to Anchorage in the south and connected by road, this borough has a population of 48,952. The largest concentration of people is in the area surrounding the cities of Kenai and Soldotna. Homer and Seward are the other two communities with populations greater than 1,000. The rest of the residents are scattered primarily along the road system connecting these communities. Eight percent of the population is Alaska Native. Although the borough is adjacent to Anchorage, the distance by road of any of its four largest communities to Anchorage is more than 100 miles. As a result, its towns are not as closely integrated with Anchorage as those in the Matanuska-Susitna Borough. Many Kenai Peninsula residents now commute to the remote petroleum camps on the North Slope.

The main drivers of the Kenai Peninsula Borough economy include oil and gas production and processing, seafood, tourism, government employment, transportation services, and some timber production. The port of Nikiski near Kenai is home to the state's largest oil refinery, as well as two gas-processing facilities, one producing liquefied natural gas for export and the other manufacturing ammonia-urea. BP Amoco announced in June 2000 that it had selected Nikiski as the site for an $86 million facility to test gas-to-liquids technology. In recent years, Nikiski has also been the site of construction of modules for the North Slope oil fields. The Alaska Railroad runs through the borough and terminates at the port of Seward, where the Alaska state ferry and cruise ships call during summer.

The local-government tax base depends on a combination of property and sales taxes. A small share of total revenues comes directly from petroleum production and transportation property associated with Cook Inlet.

Like the Matanuska-Susitna Borough, there is a net inflow of wages from residents working outside the borough. Most of this comes from remote sites because daily commuting to Anchorage is not feasible by car. Nonwage income is high because of the many commercial fish harvesters and small businesses providing services to tourists and visitors from Anchorage. With these industries, the economy is seasonal and personal income can vary considerably from year to year depending on the fishing season. The per-capita income is below the state average despite high wage rates in petroleum.

Rest of State. The portions of Maritime Alaska and Interior Alaska not adjacent to TAPS comprise the rest of the state. The characteristics and diversity of this part of the state are described above in the discussion of geographic diversity of economic activity.

3.3.1.4 Alaska Native Community

Employment

A large share of employed Alaska Natives either work directly for the government or in jobs in industries such as services and construction that are supported by government funding (McDiarmed et al., 1998). Job opportunities in other industries are limited in the small communities where most Natives live. A small percentage of Natives are employed by the 12 Native corporations (Colt, 1991). Native corporations own approximately 93 percent (Hull and Leask, 2000) of all private land in Alaska. These corporations are developing natural resources and expanding into other economic sectors as diverse as catering and construction. Most Natives participate in subsistence.

Unemployment

Because there are few jobs that pay a cash wage in many smaller Native communities, unemployment is high, particularly during the winter. Official unemployment rates such as reported in the 1990 census (16 percent for all Alaska Natives) significantly underestimate the size of the problem in rural Alaska because of the discouraged-worker effect. Fifty-six percent of Native adults were reported as not working at the time of the census (McDiarmed et al., 1998).

Population

Seventeen percent of Alaskans, or 104,085, are Alaska Natives. While most live in the small rural communities in the Interior and Maritime Alaska, 26 percent now live in the Railbelt. The median age of the Native population is 23.

Income

Per-capita money income of Alaska Natives is below the state average because a smaller percent of the population works for money wages, and the average wage is below the state average (DOC, 1993). Transfers, including federal programs for Native Americans and the PFD, are important sources of money income in Native communities.

Public Resources

Federal programs supporting rural Alaska residents and communities, many of which are passed through state government, are the largest source of public resources for Alaska Natives. Many state programs also target rural Alaska, but declining revenues are reducing the state's ability to adequately fund these programs. Local sources of public resources are limited in most rural parts of the state.

Alaska Native Communities

The majority of smaller Alaska Native communities have fewer than 500 inhabitants and are accessible only by small aircraft or boat in the summer. The quality of housing is substandard by national standards, and imported fuel oil is used to generate electricity and provide space heating. Water and sewer utilities and solid waste management are primitive. Local health care is provided by health aides. Telecommunications and television are available, and the school is the largest public building in the community.

Pressure on Natural Resources

Growing Alaska Native and total Alaska populations are both putting increasing pressure on resources used by Alaska Natives for subsistence. Increasing accessibility to rural areas is also contributing to the increase in demand.

3.3.1.5 Other Historical TAPS/ANS Impacts

ANS production and TAPS throughput have had substantial and positive economic impacts since oil was first discovered on the North Slope. This subsection provides additional material on historical and cumulative impacts. (Cumulative impacts are discussed in more detail in Section 4.5.) This subsection covers three main topics: economic impacts of construction, economic impacts of pipeline operation and North Slope oil production, and economic impacts of the *Exxon Valdez* oil spill.

Construction

There are several different estimates of the total number of direct jobs attributable to construction of the pipeline (ADOL, 1978; Goldsmith and Huskey, 1978; Fairbanks North Star Borough, 1978). All exceed original employment projections by a considerable margin (Goldsmith and Huskey, 1978; GAO, 1978). As a result, the actual impact was greater than anticipated.

Construction occurred from 1974 through the summer of 1977, with 1975 and 1976 the years of greatest activity. According to the Fairbanks Community Information Center, employment was 8,155 in 1974, 20,371 in 1975, 20,162 in 1976, and 5,433 in 1977. The work was highly seasonal, with an estimated 28,072 working during the summer of 1975. Of this total, about 80 percent were construction workers, with the rest in managerial, professional, technical, and clerical positions.

These jobs directly increased wage and salary employment statewide nearly 20 percent above the 1973 level. The increase in wages and salaries was considerably greater because of the high average wage rate in the construction sector, the real increase in that wage rate, and the high number of hours of overtime paid to the average pipeline worker (Thomas et al., 1977). Statewide, wages in the construction sector grew from $154 million in 1973 to a peak of $1.466 billion in 1976, subsequently falling to $433 million in 1978 (Goldsmith, 2000b).

The multiplier effect of this infusion of employment and income was less than it might have been because a large share of the wages was paid to nonresident workers who left the state in the off-season and when the construction was completed. Nonetheless, the economy expanded significantly. Wage and salary employment increased from 110,000 in 1973 to 171,000 in 1976 — an increase of 55 percent in three years. Wages and salaries increased over the same period from $1.326 billion to $3.972 billion, an increase of 200 percent. Per-capita income grew from $6,493 to $11,500, an increase of 77 percent (Goldsmith, 2000b).

Project completion did not result in a significant drop in either employment or wages. From the peak in 1976, employment fell 5 percent over a two-year period, wages fell 17 percent, and per-capita income increased by 2 percent. The modest drop is attributable to the large share of nonresidents in the construction workforce, the pent-up demand created by the high construction wages paid to residents, government spending from oil revenues, oil patch spending, and spending in anticipation of the construction of a gas pipeline.

The small Alaska labor market was unable to supply all the workers needed for TAPS, particularly because many required special skills which Alaska workers did not have. As a result, many of the jobs were taken by workers from outside the state, some of whom stayed only as long as their job tenure, and some who made permanent moves to the state. The State of Alaska worked to minimize the flow of migrant job seekers in order to minimize their impact on public services as well as competition for the jobs (Thomas et al., 1997). This effort was partially successful. In 1975 during the early construction phase, the statewide unemployment rate fell from the year before, indicating a tightening of the labor market. This was particularly significant because the U.S. unemployment rate in 1975 was 8.5 percent, the only time it has been above the Alaska rate since 1970. When construction was complete, the unemployment rate rose, but many of the workers left the state and were able to find jobs elsewhere (ADOL, 1976).

The unemployment rate was influenced by the false boom which occurred in 1970 when workers moved to Alaska in anticipation of an early start date for pipeline construction which did not materialize. In the summer of

Photo 3.3-3. *Pipe is wrapped and placed in trench during TAPS construction.*

1970, the unemployment rate in Anchorage climbed from 8.8 to 11.2 percent, a reversal of the usual summer drop. This false boom impacted many businesses that invested in anticipation of an expansion of business that never materialized. In addition, the public resources in Anchorage and other communities were strained by these migrants (ASHA, 1971). During this time, the state mobilized to minimize some of the anticipated adverse effects of rapid population growth associated with construction.

Population increased 24 percent between 1973 and 1977, when it peaked at 418,000 before dropping back to 412,000 the following year. The number of people actually in the state during the peak construction periods was higher, but no estimates of this peak have been made. The population growth put a strain on the infrastructure of the state and the economy.

The housing shortage was reflected in high rents and low vacancy rates for apartments. In Anchorage, the winter vacancy rate for apartments was 1.4 percent in 1975. The situation was self-correcting as high rents led to a housing construction boom which peaked in 1977 just as pipeline construction finished. The apartment vacancy rate peaked at 32 percent in 1979 (Municipality of Anchorage, 1991). Public utilities, roads, hospitals, and other public facilities suffered from overcrowding, and private business demand grew rapidly. Construction of public facilities and commercial buildings responded but generally, like housing, only with a lag.

One impact felt by everyone was the inflation resulting from the rapid growth in demand for housing and other consumer goods as well as labor. Inflation in Anchorage as measured by the Consumer Price Index was usually below the national average, but it was higher from 1974 through 1976. Afterward, Anchorage inflation returned to its pre-pipeline-construction trend, but the Anchorage cost of living, compared to the U.S. average, remained above the pre-pipeline level until 1980 (Goldsmith, 2000b).

For businesses and government, the demand for labor created by TAPS caused a serious employee turnover and recruitment problem, both for those that could afford to pay higher wages to keep or hire employees and for those who could not (ADCRA, 1976). Wage rates tend to be “sticky,” particularly in industries where the workforce is highly unionized, and businesses and governments that bid up wages to hold employees found themselves with higher wage bills long after completion of the pipeline.

The population increase led to an increase in the demand for public services. The increase in school enrollments was much less than anticipated, largely because pipeline workers chose to leave their families behind when moving temporarily to work on the pipeline. Reported incidents of crime increased. Although public and private facilities providing welfare assistance were strained, it was less than anticipated (Thomas et al., 1977).

Neither the cost to state and local governments of providing impact assistance nor the revenues generated by pipeline construction have been calculated. Such an exercise is complicated by the problem of determining which effects to attribute to pipeline construction and which to other factors such as population growth in anticipation of gas pipeline construction. Costs included the per-capita expenditures associated with an increase in the population, those associated with increases in per-capita requirements for services, and those associated with an increase in labor and other costs for service delivery. In many instances, the growth in expenditures could not keep pace with growth in demand, and in others, the cost associated with the congestion and temporary deterioration in the quality of services was probably less than the expenditures that would have been required to avoid the loss.

State revenues increased between 1973 and 1977 from $208 million to $874 million, mostly from the petroleum property tax and the petroleum reserves tax. However, a large part of the increase was also due to the personal income tax, which peaked at $210 million in 1977 compared to $43 million in 1973. Local revenues increased from $216 million in 1973 to $500 million in 1977, mostly from increased transfers from the state and petroleum property taxes (Goldsmith, 2000b).

The economic effects of construction were felt throughout the state, but the direct effects primarily affected communities such as Fairbanks and Valdez along the pipeline route, as well as Anchorage. Resident workers came from throughout the state to work on the pipeline, and the inflation it caused was felt by all households, businesses, and

governments. The job, income, and population growth, as well as the dislocations associated with the rapid change, were more concentrated in the pipeline communities.

A study after construction calculated that 5,770 Alaska Natives were hired to work on the pipeline (Naylor and Gooding, 1978), including trainees. Accurate data are not available to compare this figure to either the total number of persons hired to work on the project or the Native population. Shareholders of each of the 12 in-state Native regional corporations were represented, with Doyon, Ltd., the corporation headquartered in Fairbanks, having the largest share of the total, 27 percent. Half of the Natives hired worked eight weeks or less, and 25 percent worked for two weeks or less. The majority of the jobs held by Natives were in the low-skill or unskilled categories. Much of the employment was directly tied to training, either by the government or on the job. Data on the length of tenure and job characteristics of the overall workforce are not available for comparison.

Pipeline Operation and North Slope Oil Production. The operation of TAPS and the production and sale of North Slope oil which the pipeline has made possible have made petroleum the most important basic industry in the state, and the growth it has produced has transformed the economy (ADOL, 1981). The economic importance of oil is based on three components: spending in the oil patch, public spending funded by petroleum revenues, and spending from the earnings of financial assets accumulated from petroleum revenues (Alaska Permanent Fund Corporation, Annual Report).

More than half of the 200,000 new jobs in Alaska since 1963 can be attributed to petroleum (Goldsmith, 1997; ADOL, 1986). During this period, the rate of job growth in the state averaged twice that of the U.S. as a whole. Today, petroleum accounts for between 110,000 and 120,000 total jobs, including activity associated with Cook Inlet (Goldsmith, 1997). This represents 38 percent of all jobs — divided among spending in the oil patch (10 percent), spending of petroleum revenues (25 percent), and spending from the earnings of the Permanent Fund (3 percent). Numerous other studies have documented the importance of petroleum for the economy (ADOL, 1999b; Huskey, 1995; AOGA, 1984; Tuck, 1982; McDowell Group, 1999b, 2000; Goldsmith, 1985; Kresge, Morehouse et al., 1977; Kresge, Seiver, et al., 1984; Tussing, 1984; Reaume, 1999).

When Alaska became a state, the economy was dominated by federal government employment, with a very thin veneer of infrastructure and support employment. Economic dependence on marginal, seasonal, and cyclical natural-resource industries contributed to an economy with a seasonal and transient workforce. Petroleum added a strong and stable new industry to the economic base of the state. In addition, the sheer magnitude of the private and public income generated by petroleum helped the Alaska economy to mature and stabilize through growth and diversification of its infrastructure, support, and government sectors. Most of the jobs attributable to petroleum are in these sectors other than the oil industry. This growth and maturity in turn have led to a reduction in the cost of living and doing business in the state, making it more attractive to many people as a place to live and to many businesses as a place to operate.

Job growth has been accompanied by growth in the real per-capita personal income of Alaska residents through high wages, business profits, PFDs, and other state and local government transfer and subsidy programs dependent on oil revenues — such as subsidies to offset the high cost of electricity in the Interior, the high private mortgage-interest rates of the early 1980s, and the high cost of higher education (Leask et al., 1987). From 1960 to 1973, real per-capita personal income was below the national average, after adjusting for the higher cost of living in Alaska. It rose above the national average in 1974 and remained above through 1986. Since then, growth in relatively low-wage jobs has continued to erode the real per-capita income so that now it is about 14 percent below the U.S. average, about where it was in 1968 (Goldsmith, 2000b). During the years of high incomes, the cumulative per-capita personal income above the U.S. average amounted to $17,500 in nominal dollars per resident.

When Alaska became a state, there was concern whether the tax base would be sufficient to raise the necessary funds to provide the basic services required under the constitution (ALC, 1962). Petroleum revenues allowed state and local governments to fund preexisting programs more adequately and to put new programs in place to build a public infrastructure, promote economic development, counteract the high cost of living, and deliver a full range of public services (Goldsmith, 1990). State expenditures per capita, net of federal transfers, increased from being equal to the U.S. average in 1965, after adjusting for the cost of living, to a peak of more than three times the U.S. average in the early 1980s (Goldsmith, 2000a). Only a negligible part of this increase can be identified as additional costs to state government of regulation and oversight of the petroleum industry itself (Goldsmith, 1995). Per-capita public expenditures, in excess of twice the U.S. average between 1979 and 1992, amounted to $23,000 in nominal dollars per resident.

In response to growing job opportunities, high incomes, and the benefits of public expenditures, Alaska population

growth was fueled by net in-migration every year from 1965 through the early 1990s, except during the lull after TAPS construction and during the recession in the late 1980s. Between 1970 and 1990, the population increased by 245,000 — 93,000 of which were from in-migration. The urban areas were the biggest gainers. This growth in population put pressure on fixed resources.

Pipeline operation and North Slope oil development have affected the economies of every region of the state through many channels. The development and operation of the oil fields have cost billions of dollars, much of which has been spent in Alaska for engineering, construction, oil field, catering, environmental, transportation, wholesaling, security, and other services. Workers from every part of the state as well as other states travel to the North Slope oil fields to work (ADOL, 1983a). State expenditures funded by oil revenues have paid for public services and the construction of an infrastructure in every community. Oil revenues have funded other public programs to foster economic development throughout the state and to counter the high cost of living and doing business. They have eased the burden on individuals and other natural resource industries of supporting the costs of government.

The PFD directly added 5.3 percent to per-capita income in 1998 (Goldsmith, 2000b). The total per-resident distribution since the inception of the dividend in 1982 through 1999 has been $16,500 in nominal dollars. Each Alaskan gets an equal share, independent of circumstances, and as a result, the impact in low-income households and communities is greater as a percentage than in higher-income households and communities. In the Wade Hampton Census Area, which is the region of Alaska with the lowest per-capita income, the PFD was 11 percent of total income in 1997 (ADOL, 1999e).

The North Slope Borough and the City of Valdez have experienced the most direct economic impacts of pipeline operation and North Slope oil production. A comparison of economic indicators from 1997 with those of 1970, before development got underway, shows the magnitude of the change, most of which can be traced directly to petroleum.

In the North Slope Borough, employment by place of work increased 359 percent, from 1,876 to 8,609. It peaked at 11,038 in 1983. Total real personal income increased 302 percent, from $43.5 million to $174.9 million (1998 dollars). It peaked at $183 million in 1995. Real per-capita personal income increased 92 percent, from $12,589 to $24,209. It peaked at $36,742 in 1976. Population increased from 3,456 to 7,224.

In the Valdez-Cordova Census Area, employment by place of work increased 220 percent, from 2,213 to 7,076. It peaked at 10,613 in 1976. Total real personal income increased 238 percent, from $84.2 million to $284.6 million (1998 dollars). It peaked at $376.2 million in 1976. Real per-capita personal income declined 18 percent, from $33,121 to $27,289. It peaked at $67,165 in 1976. Population increased from 5,018 to 10,430. Pipeline and terminal employment have created a stable employment base in a community formerly dependent on the highly seasonal seafood industry, regional transportation, and government (ADOL, 1982a).

Growth in most industries in the state can be attributed to petroleum activity, either as a direct result of doing business with oil companies, from the spending of income generated by the industry, or from public-infrastructure investments and operating program expenditures reducing the cost of doing business in the state or directly stimulating economic activity. The growth of the air cargo industry in Anchorage is partly due to the availability of jet fuel refined in the state from North Slope crude oil.

Fish harvesters and processors have experienced some business losses due to oil spills associated with the transportation of oil, although they have received monetary compensation. There is no evidence that diversion of capital and labor from the fishing industry has occurred as a result of petroleum activity. Like other industries, the seafood industry has been impacted by the general environment of greater economic diversity, lower costs of doing business, higher level of public services, and greater investment in a public infrastructure associated with the economic growth from petroleum activities.

Many economic effects of TAPS operation and North Slope oil production are irreversible. These include the physical infrastructure built with oil revenues, the human capital acquired by Alaska residents working to produce and transport the oil, and the Permanent Fund (Goldsmith, 1985).

As anticipated, Alaska Natives have shared in the positive and negative economic impacts of the operation of TAPS and production of North Slope oil through the direct and indirect employment opportunities created, the public expenditure of oil revenues by the state and local governments, the increased accessibility of Native communities adjacent to the pipeline, and the increase in the non-Native population (Schlickeisen et al., 1971).

Alaska Natives are under-represented as a percentage of the pipeline (JPO, 1997) and the North Slope oil production workforce (McDiarmed et al., 1998; Colt, 1991) based on either population or labor force, just as they are for most industries in Alaska. Nonetheless, this is an important source of income for those who participate in these high-

wage jobs.

Overall, the number of employed Alaska Natives increased 75 percent during the 1970s and 49 percent during the 1980s, but these growth rates trailed the increase in those for non-Natives. Over this period, the Alaska Native unemployment rate has remained virtually unchanged. Even though the economic growth since 1970 provided employment opportunities for many Alaska Natives, many other Alaska Native job-seekers were unable to find jobs at the same time that many immigrants were more fortunate (McDiarmed et al., 1998).

Median family income of Alaska Natives has risen more rapidly than all Alaskan families between 1970 and 1990. It stood at 47 percent of the state average in 1970 and had reached 58 percent by 1990, but most of the relative growth came in the 1970s. The percent of Alaska Native households below the poverty limit has been cut in half from 44 percent in 1970 to 21 percent in 1990, but it remains much greater than the non-Alaska-Native rate of 5 percent (DOC, 1972, 1982, 1993).

A number of other indicators point to a narrowing of the standard-of-living gaps between Alaska Natives and the overall Alaska population. For example, the share of the rural housing stock less than 10 years old and occupied by Alaska Natives increased from 20 to 50 percent between 1970 and 1980, accompanied by a substantial reduction in the share of units with overcrowding and without plumbing. At the same time, the average household size dropped from 5.2 to 3.8 persons (Kruse, 1984). Most rural communities are now electrified, and most have both a primary and secondary school. The percentage of the Alaska Native population with a high school education or currently enrolled increased from 37 to 73 percent between 1970 and 1980 (AFN, 1989). Transportation access and communications facilities in rural Alaska have been improved. The Alaska Native infant mortality rate has decreased from 22 per thousand in 1977 to 14 in 1987 (Alaska Natives Commission, 1994).

At the same time, these indicators show that Alaska Natives as a group still lag behind the general population in standard of living and that further improvements are becoming more difficult to achieve in the face of declining oil revenues and other factors (AFN, 1989). Social and health problems related to the increase in the population of young Alaska Natives — such as alcoholism, drug abuse, sexually transmitted diseases, child abuse, and suicide — are on the rise (Alaska Natives Commission, 1994), but there is no clear link between these phenomena and the oil industry.

It is impossible to determine how much of the change in indicators of standard of living of Alaska Natives is attributable to activities associated with TAPS operation and North Slope oil production; to federal expenditures in support of Native and rural Alaska; to the Alaska Native Claims Settlement Act, which helped clear the way for TAPS construction; and to other forces of change. No comprehensive study has yet documented the impacts that state expenditures made possible from oil revenues have had on rural and Native Alaska. However, a 1989 Alaska Federation of Natives report noted, in discussing the role that the public sector has had on Alaskan villages, “Fortuitously blessed with massive oil revenues, in the mid-1970s the Alaska Legislature began spending large amounts of public money in rural Alaska. State spending purchased capital improvements and community services and raised the level of per-capita income in Native villages closer to that of urban residents” (AFN, 1989).

There are numerous examples of programs which have been implemented or expanded since North Slope oil development, which have targeted rural Alaska, and which have been funded from general revenues. These include power cost equalization, rural development grants, housing assistance, rural school vocational education, community health and emergency medical services grants, and village public safety officers (State of Alaska OMB, 1986). Other statewide programs have also been expanded and impacted the rural areas. These include municipal assistance and revenue sharing, school construction, and the satellite campuses of the University of Alaska. Per-capita state expenditures for capital projects, payments to communities, and payments to individuals were larger in rural Alaska in the mid-1980s (Snow and Depue, 1990), although the total economic impact of state spending was greater in urban areas (ADOL, 1985).

***Exxon Valdez* Oil Spill.** The spill occurred in 1989, spilling approximately 257,000 barrels of crude oil (see Appendix B) and causing economic impacts. Exxon spent approximately $2.2 billion on cleanup activities during 1989, 1990, and 1991 (Exxon Corp., 1999; Etkin, 1998). No complete accounting of these expenditures has been published, but from descriptions of the activities, the direct impact on the Alaska economy can be characterized. Expenditures to hire cleanup workers, to charter boats to assist in the cleanup efforts, and to rent equipment and purchase supplies all affected the economy. A small portion of the response expenditure reimbursed federal, state, and local governments for their cleanup costs during this period, and these activities also impacted the economy. Exxon also paid over $300 million in compensation claims to commercial fishermen during this period (Exxon Corp., 1999). (This payment partially covered the subsequent court award in

the class action lawsuit requiring Exxon to pay $287 million in compensatory damages to commercial fishermen.) An indeterminate share of total expenditures was made outside Alaska or went to nonresident workers and vessel owners.

In 1991, a settlement was reached between Exxon and the State of Alaska and the federal government on various criminal charges against Exxon and civil claims for recovery of natural resource damages resulting from the spill. The criminal fine of $150 million was reduced to $25 million. In addition, Exxon agreed to pay $100 million, divided between the state and federal government, as restitution for injuries caused to fish, wildlife, and lands in the spill region. The federal share of the criminal settlement has been used primarily to fund habitat protection. The state share has been spent on fisheries and recreation-related capital improvements and research.

In the civil settlement with the federal and state governments, Exxon agreed to pay $900 million over ten years, with the proviso that an additional $100 million could be claimed to restore resource losses not known or anticipated at the time of the settlement. The proceeds of this settlement are administered by the *Exxon Valdez* Oil Spill Trustee Council. The largest share, $392 million, has been budgeted for habitat protection through the purchase of critical parcels of land. Habitat acquisitions to date total 635,770 acres at a cost to the Council of $343 million. The rest of the budget has been allocated as follows: $180 million for research and restoration, $173 million to reimburse state and federal governments for damage assessment and cleanup, $40 million to Exxon for cleanup requested by federal and state authorities in 1991 and 1992, and the balance for future activities and administration (*Exxon Valdez* Oil Spill Trustee Council, 2000).

Alyeska paid a civil settlement of $98 million to commercial fishermen, Natives, and other affected parties.

Commercial fishermen, Alaska Natives, and others brought suits against Exxon for compensatory and punitive damages. Of the various plaintiffs, only commercial fishermen, Alaska Natives, Native corporations and local governments were allowed to proceed. Other plaintiffs such as fish processors and tourist businesses that suffered only indirect harm from the spill had their claims dismissed. This suit resulted in awards and settlements of over $300 million in compensatory damages, mostly to commercial fishermen and subsistence users; most of this amount was offset by prior claims payments.

In addition to the compensatory damages, Exxon was directed to pay $5 billion in punitive damages. Exxon has appealed the punitive damage award, which if paid will go to the more than 30,000 original plaintiffs in the case according to a plan created by the plaintiffs' attorneys and approved by the court (Etkin, 1998).

The 1989 payroll of an estimated 11,000 workers associated with cleanup activities, together with procurement and chartering of 628 vessels, pumped enough income into the economy in a short time to create a boom in Valdez and hasten the recovery of the state economy from the recession which began in 1986 (ADOL, 1989a, d; 1990; 1991). By comparison, the loss of employment in the fishing and tourist industries was small, with many workers taking cleanup-related jobs (IAI, 1990d), and compensatory payments largely offset income losses to the fish harvesters.

Total earnings reported in the Valdez-Cordova Census Area doubled from $173 million to $360 million between 1988 and 1989. Employment increased by 31 percent, most directly related to the cleanup. Although other sectors were strained by the temporary flood of workers, the obviously seasonal, rural, and transient nature of the spill activity did not generate a large local multiplier effect. A similar but smaller boom impacted the Kenai Peninsula, where earnings increased 20 percent and employment increased 10 percent. The state unemployment rate, which was unusually high due to the recession, dropped in 1989 to its lowest level since at least 1978 as the easy availability of spill-related jobs drew Alaskans from other part of the state to work on the cleanup. When these Alaskans returned home, they took their earnings with them, generating a multiplier effect throughout the economy (ADOL, 1989c). A part of these earnings also left the state with nonresident workers.

The cleanup effort during the next two years involved fewer workers than in 1989, and the economies of the region began to return to normal. The impacts of the approximately $1 billion paid by Exxon to the state and federal governments for restoration efforts began to be felt shortly

ExxonMobil

Photo 3.3-4. *Shoreline cleanup work during* Exxon Valdez *spill.*

thereafter. This money continues to support capital and operating expenditures related to restoration of the resources of Prince William Sound, and for the purchase of critical habitats. These expenditures had greatest effects on the regional economies in the Prince William Sound area.

Additional oil spill prevention and response expenditures by Alyeska are another continuing economic effect of the oil spill. Since the spill, the TAPS owners have increased expenditures on oil spill prevention and response. Annual expenditures are about $60 million, and about 300 people are employed in SERVS. These expenditures had greatest effects on the Valdez economy, which is consequently larger than it was before the spill (ADOL, 1992).

Opinions differ on whether the economic costs and losses different groups suffered have been adequately compensated by Exxon, and also whether economic activity in the commercial fishing and tourism industries is as high as it would have been without the oil spill. However, the overall economic activity in the state and region, as measured by employment and income, continues to be positively impacted by continued spending associated with the spill.

3.3.2 Sociocultural Systems

By M. Galginaitis, C. Gerlach, P. Bowers, and C. Wooley

3.3.2.1 Introduction and Definition

A sociocultural system encompasses the social organization, behavior, and values of the society. The analytical construct of "social organization" is the combination of regularities in those behaviors and values. The description and analysis of sociocultural systems can occur on any of several levels from the global to any small, definable, and bounded group. The sociocultural systems described in this document are regional and community systems that might be affected by the proposed or no-action alternatives. These are divided into three study areas: *North Slope, Central TAPS,* and *Valdez/Prince William Sound (PWS).* Selected communities that have the highest potential to be directly affected by ROW renewal are examined here.

Sociocultural systems are dynamic and influenced by many interacting causes and effects. Attributing effects or changes to specific actions or factors is difficult. For example, TAPS was only one element inducing and influencing sociocultural change in Alaska. Alaska Native and Euroamerican contact, statehood, and many other factors combined to shape events. The federal legislative conjunction of these processes — the Alaska Native Claim Settlement Act (ANCSA) and the Alaska National Interest Lands Conservation Act (ANILCA) — also contributed to major changes in social organization and cultural value systems (Hopson, 1976; Arnold, 1978; Klausner and Foulks, 1982; Berger, 1985; Downs, 1985; Chance, 1990; IAI, 1990c).

Broadly defined, economic activity is one basic determinant of sociocultural change. Economic factors are thus the starting points in assessing change.

3.3.2.2 Description of Sociocultural Systems Past and Present

The TAPS ROW traverses three distinct geographic and sociocultural areas:

- Organized communities within the North Slope Borough (North Slope study area);
- Communities within approximately 20 miles of the centerline of the ROW (Central TAPS ROW study area). This study area is further partitioned into northern, central, and southern segments; and
- Communities in PWS along the shipping channel from Valdez to Hinchinbrook Entrance (Valdez/PWS study area).

Regional and community sociocultural systems are described for the three major groups of communities for history and social structure (including language and resource harvest), economics, and institutional organization.

The overall study area is quite large and includes many different communities (Figure 3.3-12). Moreover, recent EAs and EISs have focused on the Alaska North Slope, necessitating the inclusion herein of additional up-to-date material on communities in the Central TAPS and Valdez/PWS study areas. The following overview may be useful:

- With the notable exception of communities in the Fairbanks North Star Borough (FNSB), most contain fewer than 1,000 persons and many are much smaller (<100 persons). The "community" of Livengood has no permanent residents.
- Ethnicity, measured as the percentage of Alaska Natives, varies significantly among the study communities. The North Slope communities have a substantial majority of Alaska Natives. Communities in the Central TAPS study area are mixed, some predominantly Alaska Native (e.g., Stevens Village and Rampart), and others substantially Caucasian (e.g., Delta Junction, Glennallen, Paxson, Gakona), and some mixed (e.g., Chistochina, Chitina, Copper Center). The four Valdez/PWS communities include Valdez and Cordova, which are predominantly Caucasian, and Tatitlek and Chenega Bay, which have a majority of Alaska Natives. Population-ethnicity diagrams pro-

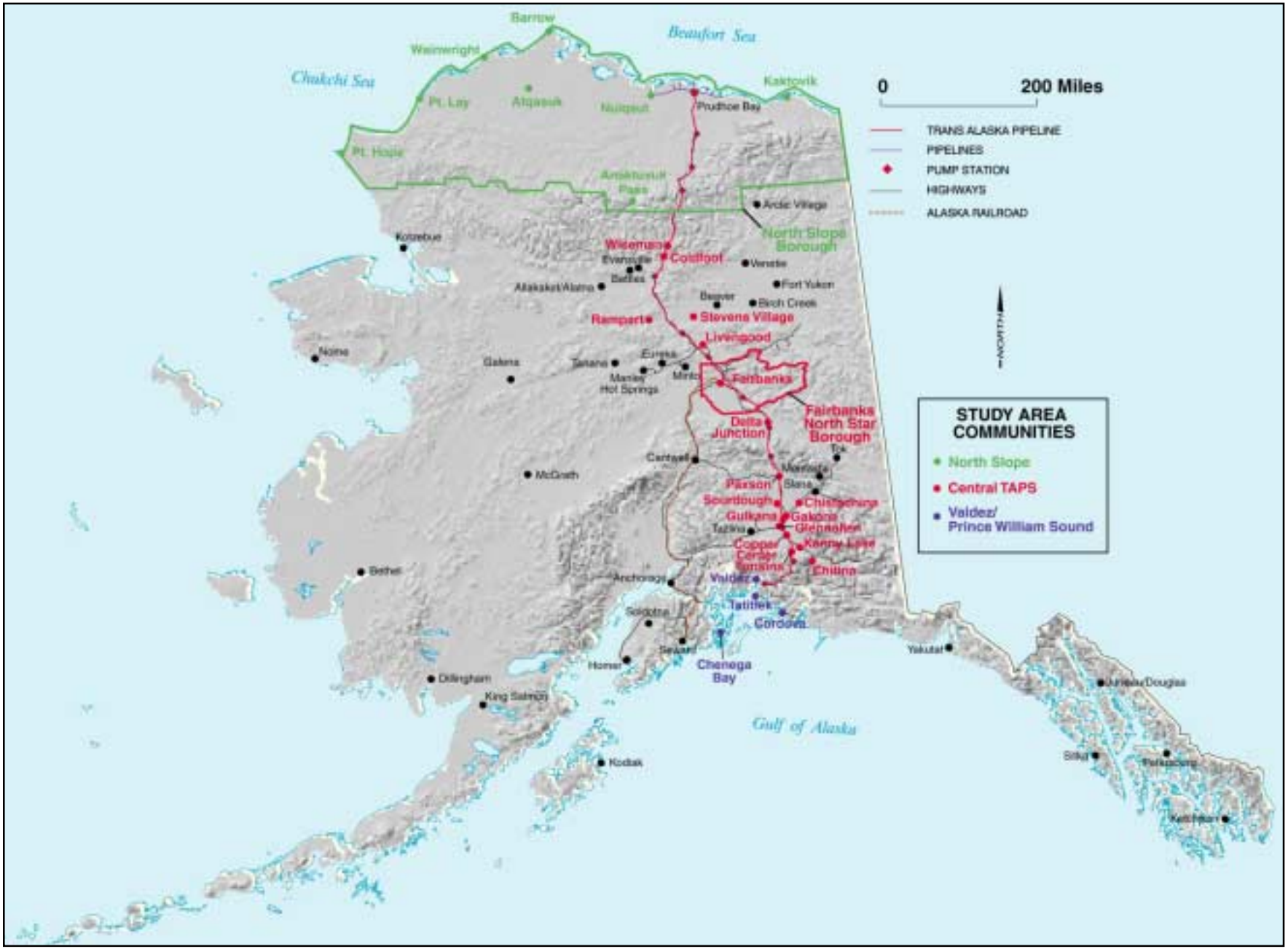


Figure 3.3-12. *Communities in North Slope, Central TAPS, and Valdez/Prince William Sound study areas.*

vided later summarize available statistics.

- Median household incomes vary considerably among these communities. In general terms, all North Slope communities have median household incomes larger than those for the U.S.; most have median household incomes greater than that for Alaska. All communities in the Central TAPS study area have median household incomes less than that for Alaska, and most have median household incomes less than that for the U.S. In the Valdez/PWS study area, Valdez and Cordova have median household incomes greater than either the U.S. or Alaska, and Tatitlek and Chenega Bay have incomes less than either of these benchmarks. Horizontal bar charts presented later summarize median household income data for these communities relative to Alaska and the U.S. overall.
- Employment patterns vary with the community. Workers in the FNSB and Valdez are employed in the oil and gas industry, either directly or through allied service industries. Most other communities are significantly less industrialized. In these communities, state and local government, schools, or Native corporations are often major employers. Subsistence figures more importantly in their economies and social structures. Unemployment and underemployment are concerns of many communities.
- The oil and gas industry, including the pipeline and marine transportation links, affects all Alaskans' lives in terms of the Alaska PFD, revenues to state and local governments (and, therefore, services provided by these institutions), and other indirect economic effects. All thus have an important stake in the decision whether or not to renew the TAPS ROW. North Slope communities derive substantial income from this industry, and many FNSB and Valdez residents are employed directly or indirectly by this industry. Most other communities are not directly affected by this industry, but indirect and cumulative economic effects on these communities are important.

Each community is unique to a degree, with its own history, social organization, and employment patterns. Details are provided below.

North Slope Communities

History and Social Structure. Aboriginal North Slope social organization is not well-known in terms of local detail (Oswalt, 1967; Damas, 1984; IAI, 1989, 1990c). Ethnographic observation dates only from the beginning of Euroamerican contact (Ray, 1885; Murdoch, 1892; Nelson, 1899) and is not systematic. Traditional oral history and archaeological evidence speak to the pre-contact period, but tend to be either very general or particular in scope.

The broad model of pre-contact North Slope social organization based on this evidence consists of a dynamic system composed of small kinship-based, territorially defined local groups of subsistence hunters (Chance, 1966; Burch, 1975, 1998; Damas, 1984). Each local group depended on a seasonal pattern of resource harvest in its territory, and this pattern then formed the essential order of their group lives. The order shifted with annual differences in abundance and distribution of animals, with weather, and with other natural environmental conditions. Some of the coastal Iñupiat communities whose subsistence patterns were heavily tied to the harvest of marine mammals — Point Hope, Point Barrow, Cape Lisburne — were occupied by relatively large numbers of people for long periods. Most other settlements across the North Slope were seasonal hunting and fishing camps. Some of these settlements were situated in areas of multiple subsistence resources. Others were located to take advantage of dense concentrations of a single resource such as fish or caribou, or to facilitate trading opportunities.

Although Euroamerican contact greatly affected traditional Iñupiat social organization, the fundamental organizational feature is that kin-related groups express their cultural identity and values through the idiom of subsistence and the pattern of subsistence activities. Euroamerican contact introduced new resources such as food items and technology that enhanced both subsistence hunting and wage-earning opportunities. The introduction of new disease pathologies, commercial whaling, missionaries and their churches, government-established schools, health services, military recruitment, and Distant Early Warning (DEW) Line site construction produced impacts on Iñupiat sociocultural systems and social organization (Salisbury, 1992; IAI, 1990c; Klausner and Foulks, 1982; Chance, 1966; Bockstoce, 1986; Worl, 1978). Intermarriage between Euroamerican whalers and traders and Iñupiat women created a major new population dynamic. Its principal feature was the incorporation of the newcomers and their offspring in the existing kin-based social units. Development of the North Slope oil industry — dating from the first exploratory programs in what is now NPR-A through the discovery and development of Prudhoe Bay, Kuparuk, satellites, and other discoveries — transformed the economic basis of the North Slope region as a whole.

Historically, perhaps the most significant changes include the Iñupiat adoption of Euroamerican technology and the shift in Iñupiat settlement patterns from a system of many small, territorially confined local groups to that of a

more limited number of large, permanent communities located in a shared regional territory. The relatively recent establishment of permanent settlements at Anaktuvuk Pass, Kaktovik, Nuiqsut, Point Lay, and Atqasuk are evidence of this, especially in the context of the formation of the NSB. The formation and actions of the borough and its communities are the most concrete expressions of these cultural continuities — a successful result of the adoption, integration, and manipulation of "modern" resources in an Iñupiat sociocultural system (Hopson, 1976; Harcharek, 1995; Morehouse and Leask, 1978; McBeath and Morehouse, 1980; McBeath, 1981; Morehouse et al., 1984; Shepro and Maas, 1999).

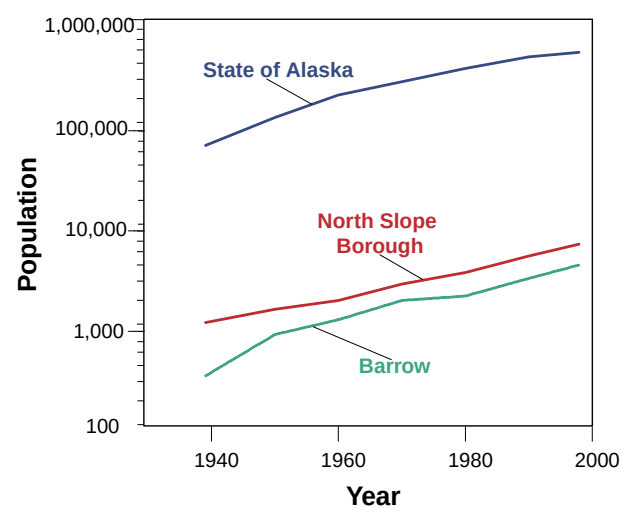
Before the discovery and development of oil and gas on the North Slope and formation of the NSB, the population of the five villages of Barrow, Kaktovik, Anaktuvuk Pass, Point Hope, and Wainwright totaled about 2,500 people. Each village had limited political power, social services, and infrastructure. Housing was privately built, sometimes out of salvaged or donated materials, and was often cramped and marginal. Attending high school required leaving the North Slope, and wage employment opportunities were relatively few and generally involved support positions at the school or DEW Line sites. Per-capita and household incomes were low, both in absolute and relative terms, and North Slope residents relied heavily on local subsistence resources for food, clothing, and heat (Foote, 1959, 1960a, b, 1961; Gubser, 1965; Spencer, 1959; Sonnenfeld, 1956; Ingstad, 1954; Rodahl, 1963; Nelson, 1969; Van Valin, 1945; VanStone, 1962; Brosted, 1975).

This characterization of North Slope communities remained fundamentally unchanged in the early 1970s, even after the Prudhoe Bay discovery, and serves as a pre-TAPS set of conditions. The NSB was not organized until 1972. The Federal Field Committee for development planning in Alaska documented the limited facilities in the existing North Slope communities of that time (Abrahamson, 1968; FFC, 1967, 1968, 1969, 1971a, b). The NSB sponsored its own more elaborate socioeconomic community facility inventory in 1973 (Dupere & Associates, 1973). One important difference was that beginning in 1963, Barrow residents were finally able to heat their homes with natural gas from the South Barrow Gas Field, which had been developed and used only to supply federal government facilities near Barrow. This decreased home heating costs dramatically, a direct and concrete benefit to Barrow residents from oil and gas development.

Trends in salient population statistics for Barrow (the largest community) and the NSB are presented in Figure 3.3-13, along with population figures for the state. Both the state and the North Slope communities have grown significantly since 1939. The state grew at a rate that was approximately 1.5 times that of the North Slope communities between 1939 and 1970. After 1970 as Alaska North Slope oil was developed, the reverse was true. The majority of NSB growth since 1970 has been in the three communities established after the incorporation of the borough (Nuiqsut, Point Lay, and Atqasuk). Further, large investments have been made in the local, state, and federal infrastructures of all NSB communities. NSB villages outside Barrow receive multimillion-dollar allocations for infrastructure projects through the NSB Capital Improvements Program.

Figure 3.3-14 shows data on the population and ethnicity of the North Slope communities for 1999 according to data from the Alaska Department of Community and Economic Development (ADCED) Alaska community database. The same format is used to present population and ethnicity data from each of the other study areas. Population is shown on a logarithmic scale on the y-axis. Ethnicity data are shown on a linear scale on the x-axis. Although there is more to ethnicity than merely a tabulation of the percentage of Alaska Natives as opposed to Caucasian or other, this simple measure captures the first-order differences among the communities. Shown also on the x-axis as the dashed vertical line is the percentage of Alaska Natives in Alaska as a whole (17 percent).

The overall population of the NSB was 9,632 in 1999. All North Slope communities have a greater percentage of Alaska Natives than the state as a whole. Barrow is the larg-



Source: ADCED (1999)

Figure 3.3-13. *Population trends for the State of Alaska, North Slope Borough, and Barrow.*

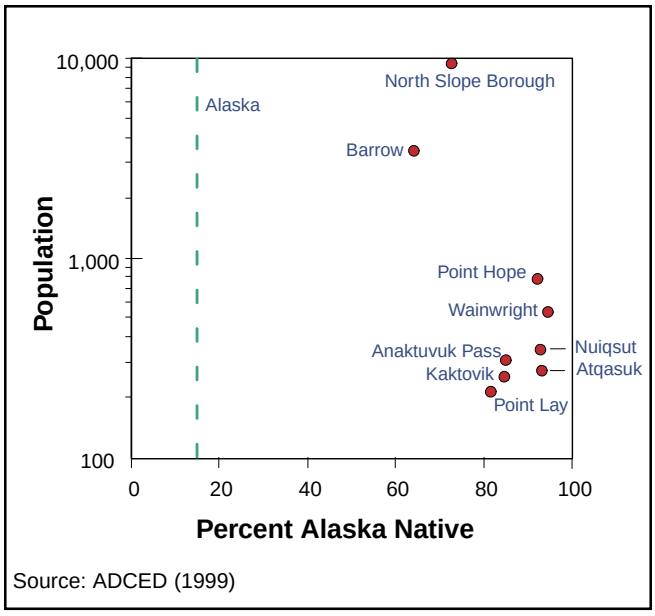


Figure 3.3-14. *Population and ethnicity data, North Slope study area communities, 1999.*

est North Slope community (population 4,438) and has the lowest percentage (63.9 percent) of Alaska Natives. Although there are small differences in the ethnicity of the other North Slope communities, all have a population consisting of at least 80 percent Alaska Natives.

Language retention and use are one measure of cultural identity. The NSB is conducting a census of knowledge of the Iñupiaq language in all NSB communities (Iñupiaq is the native language of the Iñupiat). This census will enumerate and assess the fluency of those who can speak and read Iñupiaq. For the NSB as a whole (Shepro and Mass, 1999), Iñupiaq is the primary language for 9 percent of the households, English for 49 percent, both equally for 34 percent, English and a language other than Iñupiaq for 7 percent, and another language for 1 percent. About 28 percent of NSB residents speak Iñupiaq fluently, and 26 percent can read Iñupiaq. For individual communities the primary household language varies, in a range of 4 to 23 percent for Iñupiaq, 28 to 67 percent for English, and 29 to 60 percent for both. Nuiqsut has the greatest percentage of households using primarily Iñupiaq and the fewest using only English, and is equal to Anaktuvuk Pass when "Iñupiaq" households were added to "Iñupiaq and English" households (about 71 percent of households). Individual fluency in Iñupiaq is highest in Atqasuk, Wainwright, and Nuiqsut, and lowest in Barrow, Point Lay, Point Hope, and Anaktuvuk Pass. The percentage of individuals fluent in Iñupiaq declined slightly between 1993 and 1998.

NSB community social organization is strongly kinship oriented. Kinship provides "...the axis on which the whole social world turned" (Burch, 1975). Traditionally, households were composed of large extended families, and communities were primarily kinship units. The present trend is away from extended family households, in the direction of "nuclear family" units, because of a number of factors — among them regional demographic changes, increased mobility, an increase in the housing supply, and changing economic relationships among people (Harcharek, 1995; Shepro and Mass, 1999; Chance, 1990; Jorgensen, 1990). Inter-household coordination and sharing both within and between communities continues to demonstrate the central importance of kinship for contemporary Iñupiat social organization (ADF&G, 1999f; Shepro and Maas, 1999).

The social organization of the North Slope Iñupiat also extends far beyond the boundaries of households and kinship. While subsistence activities, sharing, and the ceremonial cycle serve as the ideological focus for the expression of these concepts, the full range of institutions is encompassed in this conceptual organizational system. This topic is developed further in the discussion of subsistence below.

North Slope Communities Economics. The history and current dynamics of the socio-economics of the North Slope are well-documented. A regional overview and a discussion of each community are provided in IAI (1990c) and McNabb and Galginaitis (1992). All past Beaufort Sea and North Slope oil and gas lease sales EISs and associated agency documents incorporated by reference provide summary descriptive information and analyses. The State of Alaska (ADNR, 1997, 1998, 1999) similarly provides relevant summary information.

The schedule of subsistence activities particular to each community fundamentally affects the organization (especially in terms of time utilization) of economic activity in each community. All NSB communities demonstrate similar dynamics in this regard, differing because of the distri-

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Photo 3.3-5. *Barrow is the largest North Slope Borough community (July 2000).*

bution and abundance of subsistence resources, as well as employment opportunities. The latter is influenced primarily by NSB-sponsored maintenance and construction projects in each village and the proximity of oil and gas development. Although only small numbers of NSB residents are directly employed by oil and gas operating companies, NSB residents are more commonly employed through support contractors. It should be noted that local monitoring of the oil and gas industry occurs through the NSB Planning Department, which issues development permits with environmental and other stipulations. NSB representatives and local residents also participate in the EA/EIS process for each individual development project. The involvement of ASRC in oil and gas industry includes the provision of support and subcontracted tasks, as well as direct involvement in the development of land for which it owns subsurface rights. Service Area 10 has been developed by the NSB to provide services for Prudhoe Bay industrial development.

Figure 3.3-15 shows the distribution of employment in 1998 among residents of the North Slope communities. The NSB is the largest single employer. Other employment categories are the school district, Native American corporations, government (federal, state, and city), and other (Shepro and Maas, 1999). This distribution varies slightly from community to community, but the NSB pattern is broadly representative. Oil and gas employment is included in the "other" category.

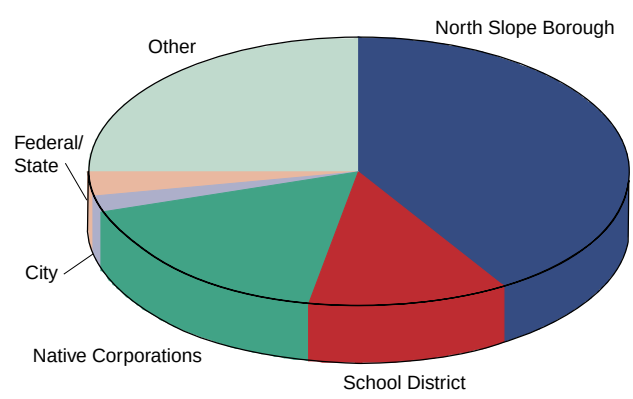
NSB Revenues and Expenditures. The NSB relies primarily on property-tax receipts to fund its operations and pay interest and principal on its bonds. This tax base consists overwhelmingly (95 percent) of petroleum-industry-related property. While the establishment of a NSB "permanent fund" has diminished the reliance on the property tax in recent years, the NSB still collected 71 percent of its revenue from the property tax in fiscal year 1995. The NSB is still, and will continue to be, dependent on the oil and gas industry for most of its budget. In turn, the NSB is the largest employer and the principal capital investor in the region. The NSB's ability to sell bonds for funding capital investments, maintaining facilities, and providing services has been the main driver of local economies on the North Slope since incorporation of the NSB.

NSB revenues peaked in 1987 at $249 million and declined in 1991 to $221 million (BLM and MMS, 1998). Revenues for 1992 through 1995 ranged from $224 to $235 million. These figures are projected to decline somewhat, barring substantial investment by the oil and gas industry, due to depreciation of the existing tax base (Associated Press, 1998a, b; BLM and MMS, 1998). The NSB is seeking to reduce its operating budget, and has become more conservative in the amount of bonds sold to finance capital improvements.

The oil and gas industry (including TAPS) directly affects few North Slope communities (Anaktuvuk Pass, Nuiqsut, Kaktovik, and Barrow). However, petroleum exploration, development, and production activities have substantial indirect/cumulative effects on these communities as a result of the revenue provided.

The NSB in 1998 had 4,191 residents aged 16 to 64. The NSB labor force consisted of 3,823 people, of whom 2,114 (55 percent) were permanently employed full-time. Part-time and seasonal employment accounted for 745 (19 percent) of the labor force, and unemployment for up to an additional 19 percent. Information for 7 percent of the labor force is lacking. Underemployment, defined as working fewer than 40 weeks in the previous year, in the NSB as a whole was estimated to be as high as 40 percent of the total labor force, although only 13 percent of the work force self-reported themselves as underemployed. Unemployment has increased since the 1993 NSB census, and there are indications that underemployment has increased as well. The NSB directly employs 41 percent of those working for wages. An additional 12 percent work for the school district, 17 percent for the Native American corporations, 2 percent for city governments, 3 percent for the federal government, and 25 percent for other employers.

The labor force in all NSB communities except Barrow is at least 84 percent Iñupiat. Barrow's labor force is about 50 percent Iñupiat, and the NSB's as a whole about 58 percent, reflecting the large size of Barrow relative to the other villages. The NSB's unemployed and underemployed are disproportionately Iñupiat. Iñupiat comprise 70 percent of



Source: Shepro and Maas (1999)

Figure 3.3-15. *Major employers of residents of the North Slope Borough in 1998.*

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Photo 3.3-6. *The North Slope community of Nuiqsut.*

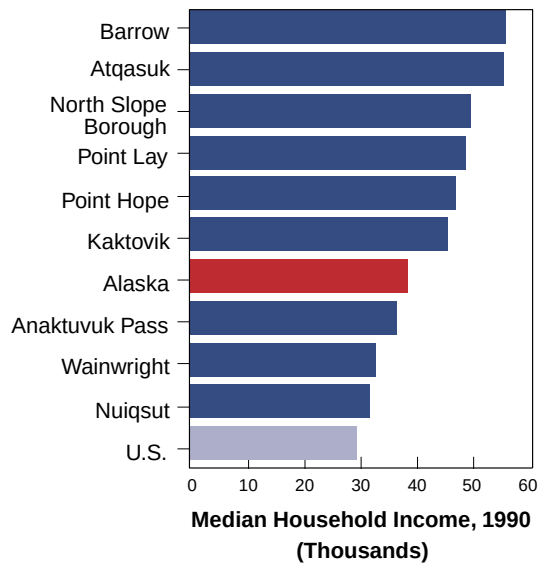
the NSB's population, 58 percent of its labor force, and 88 percent of its unemployed.

Figure 3.3-16 shows the median household income (dollars MOD) for the North Slope study area communities, the State of Alaska, and the U.S. as a whole in 1990, the latest year for which these data are available pending completion of the year 2000 census. The communities shown in Figure 3.3-16 are ranked in descending order. Median household incomes today would be 20 to 30 percent larger because of inflation and real income growth. Although there are several possible measures of community income, this is preferred because it is less distorted by extremes and is more representative of the household. This measure is used to describe all other communities considered in this analysis. As can be seen, the median household income for all North Slope communities in 1990 was greater than that for the U.S. as a whole ($29,943 in 1990). The median household income of five of the eight communities, as well as the NSB as a whole, exceeded that for Alaska ($39,298) in 1990.

Income statistics are useful, but need to be interpreted with care. For example, Iñupiat households typically contain a larger number of members than non-Iñupiat households — a fact which affects per-capita incomes. In addition, because most market goods are more expensive in Alaska (and within Alaska, on the North Slope) than in the U.S. as a whole, incomes themselves do not indicate purchasing power. Finally, incomes do not reflect the contribution of subsistence activities, which reduce the need for food purchases or the level of services provided by state or local government. These limitations acknowledged, median household income statistics are available for most communities in Alaska and are useful for comparison.

NSB Institutional Organization. The NSB derives most of its funding and bonding capacity from taxation on petroleum industry facilities (Section 3.3.1). The NSB was formed as an institution to capture significant benefits from oil and gas development in this region and as a means to address social and political issues. One important issue is the protection of subsistence and the Iñupiat relationship to the land. Resettlement of the communities of Nuiqsut, Point Lay, and Atqasuk soon after the establishment of the NSB increased the number of permanently settled North Slope Iñupiat communities from five to eight. Those who resettled these communities cited a return to their ancestral lands and the pursuit of a subsistence lifestyle as their primary motivations (Hopson, 1976; Brown, 1979; Neakok et al., 1985).

As described above, the NSB provides most government services for the communities of the North Slope potentially affected by the petroleum industry. The NPR-A EIS (BLM and MMS, 1998) predicted that future fiscal and institutional growth would slow because of economic constraints on direct Iñupiat participation in oil-industry employment and growing constraints on the statewide and NSB budgets, although NSB revenues have remained healthy and the borough's own permanent fund continues to grow. The NSB has maintained its role as the primary employer in the region, through the provision of services and maintenance of facilities built through the Capital Improvements Program, as well as continued (though perhaps reduced) construction of infrastructure (Harcharek, 1995; Kruse et al., 1983; IAI, 1990c; Shepro and Mass, 1999). ASRC, the for-profit Native regional corporation formed under ANCSA, accounts for substantial regional and statewide economic activity and employment through its many subsidiaries and



Source: ADCED (1999); Bureau of the Census (DOC, 1992)

Figure 3.3-16. *Median household income of North Slope communities, Alaska, and the United States in 1990.*

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Photo 3.3-7. *Kaktovik on the coast near the Canadian border (July 2000).*

has become one of the largest employers in Alaska (ADOL, 1999h).

All North Slope communities also have for-profit Native village corporations. Of these, Barrow, Nuiqsut, and Kaktovik are particularly active. All North Slope communities also have city councils (although Point Lay is not formally incorporated under State of Alaska law) and some form of traditional council (Indian Reorganization Act or Traditional). In addition, there are two regional nonprofit organizations of importance: the Iñupiat Community of the Arctic Slope (ICAS) and the Arctic Slope Native Association (ASNA). The North Slope Subsistence Regional Advisory Council, organized under ANILCA and consulting with the Federal Subsistence Board, advises on North Slope subsistence-use regulations. In each village there is some form of village subsistence advisory group. For whaling villages, the village Whaling Captains Association often fulfills this function. Nuiqsut also has a formal Subsistence Oversight Panel, formed in conjunction with the Alpine Development Project. All communities have a formal Village Coordinator funded by the NSB, whose responsibility is to facilitate interactions and reduce overlap and inefficiency among this complicated system of organizations and agencies. This system creates significant local employment opportunities.

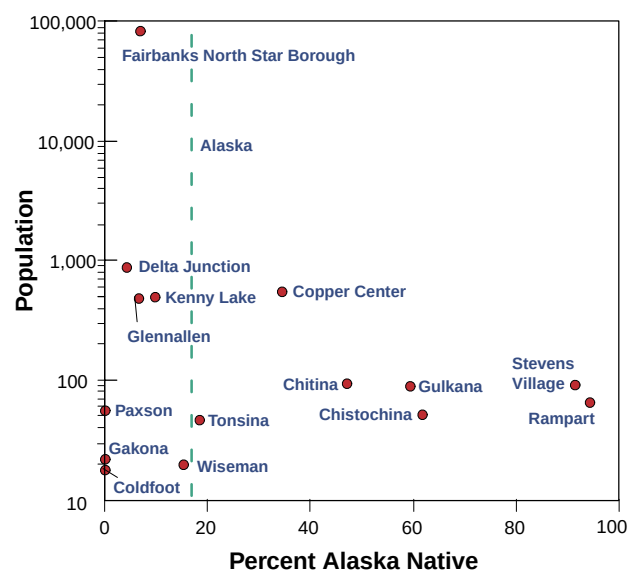
Numerous research efforts are underway in the North Slope communities. These efforts are associated with NSB, federal, petroleum company, or private initiatives and require time and effort from the local populations. Such activities — and especially public hearings and the National Environmental Policy Act process — have become a component of NSB institutional life (Brosted, 1975).

Barrow, as the administrative hub of the NSB, is a special case. Institutional development and concentration are more heavily developed there than in the outlying villages.

Central TAPS Study Area

Communities in the Central TAPS study area are scattered in the vicinity of the pipeline ROW, beginning south of the Brooks Range in the north to Thompson Pass in the south. The communities of the study area (Figure 3.3-12) are segregated into three geographic sections for discussion in this report. The northern segment consists of Coldfoot and Wiseman; the central segment consists of Delta Junction, FNSB, Stevens Village, Livengood and Rampart; and the southern segment includes the Copper River Basin communities of Tonsina, Gakona, Glennallen, Gulkana, Kenny Lake, Copper Center, Chistochina, Chitina, and Paxson-Sourdough.

Figure 3.3-17 provides population and ethnicity data for Central TAPS study area communities (Livengood is not included because it has no year-round population). In terms of aggregate population, this study area is dominated by FNSB with a 1999 population of nearly 84,000. With this exception, populations of the various communities range from very small (e.g., Coldfoot, Gakona, and Wiseman with populations of 18, 22, and 20 persons, respectively) to the small community of Delta Junction with a population of 889. These communities differ substantially with respect to ethnicity. Several, including FNSB, Delta Junction, Kenny



Source: ADCED (1999)

Figure 3.3-17. *Population and ethnicity data, Central TAPS study area communities, 1999 (Livengood has no year-round population).*

Lake, Glennallen, Paxson-Sourdough, Gakona, and Coldfoot, have percentages of Alaska Natives that are less than that for Alaska as a whole (17 percent). The other communities range from slightly more than 18 percent in Tonsina to 94.1 percent in Rampart. With the exception of FNSB, all these communities are quite small. With respect to ethnicity, these communities are quite heterogeneous. Individual community profiles are presented below.

Northern Segment: History and Social Structure. Located at Milepost 175 on the Dalton Highway, **Coldfoot** began as a boom town during the second gold rush to the upper Koyukuk in 1899 (Mills, 1998). The first townsite plat was recorded with the Koyukuk District Recorder in 1901, and a Northern Commercial Company store was established in 1902. Coldfoot peaked between 1902 and 1904, with a post office, two stores, a gambling house, two roadhouses, seven saloons, a number of brothels, two lawyers, and one doctor. Shortly thereafter, gold strikes farther up the Koyukuk, especially around Nolan/Wiseman in 1907, led to the gradual abandonment of Coldfoot and the relocation of many residents to Wiseman by 1912 (Mills, 1998).

Wiseman is located roughly 10 miles north of Coldfoot on the Dalton Highway. The town originated as Wright's Roadhouse at the confluence of Wiseman Creek and the Middle Fork of the Koyukuk River, where it gradually formed between 1907 and 1912 by miners from Coldfoot who were seeking better claims on the nearby gold-producing creeks. Although originally known as Wright's City, the town became Nolan with the establishment of a post office in 1909 (Orth, 1967). The post office name was changed to Wiseman in 1923, where it functioned until its discontinuation in 1956. The population of Wiseman gradually declined through the 1930s and more rapidly after the federal mandate that nonessential mining cease in 1942 with the outbreak of World War II.

Central Segment: History and Social Structure. This segment consists of the culturally, ethnically, and economically heterogeneous communities of Delta Junction, the FNSB, Stevens Village, Livengood, and Rampart. With the exception of Stevens Village and Rampart, the other communities in the vicinity of this segment are predominately non-Alaska Native and participate in the cash economy to varying degrees.

Livengood is primarily a mining community located 70 miles northwest of Fairbanks on the Elliott Highway (Orth, 1971). Although the area has had permanent residents in the past, it is now occupied on a seasonal basis only.

Alaska Native groups apparently occupied the area around Livengood for 9,000 years, and the aboriginal occupation was primarily seasonal and intermittent. Gold was discovered in the Livengood area shortly before 1914, first on Olive Creek and then on Livengood Creek, with the success of these prospects prompting a stampede in the area. By 1918, the Livengood population was over 1,500, with an estimated 5,000 living in the area. By 1919, the short-lived boom was over, and most Livengood residents had moved to better prospects in the Fairbanks mining district.

Stevens Village is a Koyukon Athabascan community on the north bank of the Yukon River, approximately 22 miles upriver from the Dalton Highway. In historic times, the Stevens Village area was occupied by the Gwich'in for an unspecified period of time before arrival of the Koyukon in the 1800s (Slobodin, 1981; Andrews, 1977). Multiple Koyukon place names reflect intensive Koyukon use and habitation (Stevens Village Council, 1999). Prior to direct contact with Russian and Euroamerican traders in their territory, both the Gwich'in and Koyukon traded for foreign goods through a complicated network of intermediaries (McClellan, 1981; Hosley, 1981). The primary effect of the arrival of European traders in the area was to shift the economic cycle to trapping in winter and trading in spring.

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Photo 3.3-8. *Wiseman (August 2000).*

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Photo 3.3-9. *Coldfoot (August 2000).*

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Photo 3.3-10. *Stevens Village (June 2000).*

Trapping stimulated the need for more effective forms of transportation, specifically large dog teams, and this in turn made fishing more important in the annual cycle to provide food for the dog teams. The pre-contact pattern of high seasonal mobility, and the communal and cooperative form of social organization that existed, gave way to a more sedentary lifestyle with a two-season migration. During winter, people lived in residential villages near their traplines, with a summer move to fish camps on major salmon streams and rivers (Hosley, 1981).

As with the Ahtna and other Alaska Native groups, disease was a factor in the alteration of both Gwich'in and Koyukon territorial boundaries in the Stevens Village area. Dall (1870) notes that a scarlet fever epidemic depopulated the Yukon River upstream from the Ramparts, near the contemporary community of Rampart (Raymond, 1871). Although the Alaska Native population was probably not annihilated (Schneider, 1976), the general depopulation of the area provided opportunity for the Koyukon from down river and the Koyukuk Valley to enter the region for trade (VanStone and Goddard, 1981). Apart from epidemic diseases, other forces of cultural change began with a series of gold strikes in the 1880s. The strikes brought a significant number of Euroamericans to the region, and many stayed to trap and trade after the gold fever faded. Trapping, and to a lesser extent mining, freight hauling, and wood cutting for the Yukon River steamers, in combination with subsistence hunting, continued to be important economic activities into the twentieth century.

The prospect of inundation of the Yukon Flats by the proposed Rampart Dam in the 1960s stimulated concern from local residents about development at the expense of natural resources. The Rampart Dam project was not economically feasible and was never undertaken. During the latter half of the 1960s, the proposed construction of TAPS brought considerable opposition from Stevens Village residents. Stevens Village continues to strenuously oppose TAPS in particular, and oil and gas development in general.

In 1969, Stevens Village was one of a number of plaintiffs in a lawsuit seeking to prevent the Secretary of the Interior from issuing a ROW permit for TAPS and the attendant Haul Road (now the Dalton Highway). This lawsuit was an issue as Congress debated ANCSA.

Rampart is situated in the Rampart Canyon area on the Yukon River, just beyond the west end of the Yukon Flats. The community is near the former territorial border of the Koyukon and Gwich'in Athabascans. Rampart was first described by Raymond (1900) as a Gwich'in fishing camp, but during the 1800s the Koyukon incursion displaced the Gwich'in, with the latter becoming more numerous and politically and culturally dominant (John, 1959; VanStone and Goddard, 1981). Disease was a factor in the alteration of Gwich'in and Koyukon territorial boundaries in the Rampart and Steven Village areas. Dall (1870) describes the scarlet fever epidemic that depopulated the section of the Yukon River upstream from the Ramparts, near the present-day village of Rampart. The general depopulation of the region allowed the Koyukon from down river and from the upper-Koyukuk Valley to enter the area for trade, contributing eventually to the establishment of both Rampart and Stevens Village (VanStone and Goddard, 1981).

Russian and Euroamerican explorers apparently moved through this area for the first time in the 1860s. Soon after, there came a series of traders and missionaries who established trade and contact along the length of the Yukon River, including the Rampart area. Euroamerican incursion altered the indigenous seasonal land-use pattern to include winter trapping, spring trading, and more intense fishing in summer and fall to harvest enough to feed the large dog

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Photo 3.3-11. *Rampart (July 2000).*

teams required to efficiently run and maintain an economically profitable trapline. The communal, cooperative, and highly mobile precontact lifestyle gave way to a more sedentary pattern, with a distinctive two-season migration similar to the one in Stevens Village. During winter, people lived in villages with nearby traplines, while summer found them in more or less seasonally permanent fish camps scattered up and down the Yukon River (Hosley, 1981).

Gold was discovered in a series of strikes beginning in the 1880s, culminating with the major Klondike strike of 1897. In 1894, John Minook found gold on what is now called Minook Creek (Schneider, 1976). Minook filed a claim in 1896, and the next year Rampart City was established to supply the mining camps that had sprung up in the hills south of the Yukon River. The cosmopolitan nature of the town is evidenced by the fact that Wyatt Earp and his wife Josie spent at least one winter here enroute to Nome, and that the population swelled to between 1,500 and 2,200 mostly Euroamericans between 1898 and 1899. A few stayed to trap and trade after gold mining declined (Schneider, 1976; Hosley, 1981). During the gold mining peak, Rampart boasted a newspaper, hotels, saloons, a library, a fire department, a hospital, a number of stores, and other businesses. With the coming and going of the gold rush, the traditional Athabascan pursuit of subsistence resources — in combination with trapping, wood cutting to supply the Yukon River steamers, freight hauling, and even some mining — formed a new economic pattern on the Yukon that persisted into the twentieth century. With subsequent gold strikes, most of the Euroamerican population moved to other areas.

In 1900, an important and successful agricultural experiment station was established across the Yukon River from Rampart. From the perspective of both the University of Alaska and the U.S. Department of Agriculture, this was an important setting for experiments in high-latitude farming and gardening. Considerable emphasis was placed on forage crops such as brome hay and barley, and subsistence produce such as potatoes and various greens. This successful station was closed permanently in the early 1920s (ADCED, 1999). An airstrip was constructed in 1939 (ADCED, 1999), and regular air service began after 1948 (Betts, 1997). Today, Rampart residents combine subsistence harvesting, fishing, wood cutting, and trapping, with some work in the mines to form the contemporary economic pattern. The Baan O Yeel Kon Village Corporation was established under provisions of ANCSA (Betts, 1997).

The **Fairbanks North Star Borough** (FNSB) is a predominately non-Native district centered 358 miles north of Anchorage at the junction of the Richardson, Steese, and

D. Lehman (courtesy Alyeska Pipeline Service Company

Photo 3.3-12. *Fairbanks.*

Parks Highway, in the Tanana River valley (Orth, 1971). The FNSB, incorporated in 1964, encompasses an area of 7,361 square miles (19,065 square kilometers) and includes the incorporated cities of Fairbanks and North Pole. The FNSB also includes the unincorporated communities of College, Ester, Fox, Harding, Lake, Moose Creek, Pleasant Valley, Salcha, and Two Rivers. Major facilities/institutions in the FNSB include the land-grant University of Alaska and the military installations of Eielson Air Force Base and Fort Wainwright. About 22 percent of the FNSB population consists of military personnel and their families.

Alaska Natives, who presently comprise 7 percent of the FNSB population, have used the Tanana River valley for nearly 12,000 years (Holmes et al., 1996). However, aboriginal occupation was largely seasonal and intermittent. One Athabascan community, Saachaege (known by early explorers as Salchaket), thrived along the Salcha River. The Salcha band contained about 30 individuals around 1900, but dispersed after the discovery of gold in 1902 (Andrews, 1975).

Fur traders Al Harper and Jack McQuesten were the first non-Natives known to have entered the Tanana River valley, arriving sometime in the early 1870s. By 1875, a trading post was in operation 75 miles upriver from the mouth of the Tanana, and Euroamerican and Athabascan contact and interaction were probably well-established by this time (Andrews, 1975).

In 1901, E.T. Barnette established his trading post on the Chena River, near the current location of downtown Fairbanks (Cole, T., 1981). In 1903, Judge James Wickersham moved the seat of the Third Judicial District from Eagle on the upper Yukon River to Fairbanks. The City of Fairbanks was incorporated in the same year. After the first gold strike in the Fairbanks area by Felix Pedro, the community economy was driven by gold mining.

The community underwent an economic boom from

1904 to 1909, with rapid population increase, urbanization, and a bonanza in gold mining. From about 1910 to 1923, Fairbanks was in decline; population decreased as did gold production. From about 1924 until the onset of World War II, Fairbanks was revitalized, largely due to completion of the government-owned railroad, which fostered development of the Healy coal fields. Readily available coal facilitated the industrialization of mining operations, primarily by the Fairbanks Exploration Company. The company, noted for its large gold dredges and engineering features such as the Davidson Ditch, was a mainstay of the Fairbanks economy during the Great Depression (Bowers and Gannon, 1998; Cole, D., 1999).

In 1942, with the drastic reduction in gold mining as "nonessential" to the war effort, Fairbanks began a shift to a military town (Cole, D., 1999). Fairbanks and adjacent Ladd Field were important locations during World War II. With construction of TAPS in 1974-77, Fairbanks further shifted toward a service center for pipeline maintenance activities and for support of North Slope oil development (Dixon, 1978). Fairbanks is currently the center of supply, transportation, and administrative oil-development activities in this region (ADCED, 1999; Huskey, 1995).

Between 1970 and 1976, the FNSB population increased by an estimated 37 percent, from 30,618 to 42,000 (Kruse, 1976). The Fairbanks population remained relatively high, even after pipeline construction was completed in 1977. By 1980, the population had risen to 53,983, and by 1999, it had further increased to a high of 83,814. The FNSB population is culturally and ethnically diverse, including approximately 63,751 Caucasians, 3,663 American Indians, 1,547 Eskimo, 120 Aleut, 5,553 African Americans, 1,998 Asian Pacific Islanders, and 1,088 representing other ethnic groups estimated for 1990 (ADCED, 1999). The city of Fairbanks accounts for approximately 37.5 percent of the population of the FNSB.

Delta Junction is a predominately non-Alaska-Native community approximately 79 miles southeast of Fairbanks, near the junction of the Alaska and Richardson Highways. (Orth, 1971). Although Alaska Native groups occupied the eastern Interior for nearly 12,000 years (Holmes et. al, 1996), populations in the immediate vicinity of Delta Junction appear to have been sparse. Lieutenant Henry Allen, the first non-Alaska-Native to traverse the area, reported encountering no Alaska Native inhabitants from just south of the Robertson River to the mouth of the Goodpaster River (Allen, 1900). However, during an 1898 expedition into the same country, Lieutenant J.C. Castner encountered Alaska Natives from the upper Copper River who were hunting caribou (Castner, 1900). Castner also encountered prospectors in search of gold, although no gold was ever discovered in commercial quantity. Soon after gold was discovered around Fairbanks in 1902, a trail was established from Valdez to Big Delta, a place situated north of the present location of Delta Junction.

Traffic passing through the Delta Junction area resulted in a resident population of predominately Euroamericans. Roadhouses began to appear around the turn of the twentieth century. The Sullivan Roadhouse and Bates Landing (the latter now known as Rika's Roadhouse) were constructed in 1906 (Delta Junction Chamber of Commerce, 1999; Alaska Historical Society, 1999). Travelers followed a wilderness road along the east bank of the Tanana River to the Fairbanks mining district. In 1911, Lieutenant Billy Mitchell of the U.S. Army Signal Corps established a military reservation at Big Delta, as part of the Washington/Alaska Military Cable and Telegraph System (ADCED, 1999). In 1919, the trail from Valdez to Fairbanks was upgraded to become what is now the Richardson Highway.

The military significance of Alaska and the development of Delta Junction were established during World War II. The U.S. Army constructed the 1,500-mile-long Alaska Highway from Dawson Creek, British Columbia, to the present location of Delta Junction from 1942 to 1943 (Campbell, 1995). Allen Army Base was created along the Alaska Highway roughly 5 miles south of Delta Junction as a transfer station for Lend-Lease aircraft en route to the Soviet Union. This station became permanent in 1948 and was renamed Fort Greely in 1955. With increasing traffic on the Alaska Highway and development of the military installation, the Big Delta population slowly migrated to the present location of Delta Junction (Delta Junction Chamber of Commerce, 1980).

With the discovery of oil at Prudhoe Bay in 1968 and

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Photo 3.3-13. *The community of Delta Junction (June 2000).*

construction of TAPS from 1974 to 1977, Delta Junction entered a new phase of its boom-and-bust development economy. In 1975, a pipeline construction camp located about 8 miles north of Delta Junction reached a population of 1,536, roughly twice that of Delta Junction itself (Northwest Alaskan Pipeline Company, 1980). At the time, the community was unprepared for the population influx resulting from pipeline construction. City services were limited, with no ambulance service and no water or sewer system during construction (Rural Impact Program, 1977). In 1978, primarily with oil revenues, the Hammond Administration stimulated development of commercial agriculture in the Delta area (Snodgrass et al., 1982).

Currently, Delta Junction is facing economic decline with the scheduled phase-out of Fort Greely. Plans for a National Missile Defense System (NMDS) site there may partially offset the impact of the fort closure.

Southern Segment: History and Social Structure. Copper River Athabascans probably had early contacts, either direct or indirect, with Europeans as early as the 1790s, when the Russians established trading posts in PWS (Reckord, 1983). They did not successfully penetrate the Copper River Basin until 1819, when Kilimovsky established a trading post at Taral (VanStone, 1955). Subsequent Russian explorations of the area met with disaster when Serebrennikov and company were massacred near an upper Ahtna village in 1845 (Ketz and Arndt, 1987). Regional famine led to the abandonment of the Taral Post during the winter of 1849 and 1850 (Ketz and Arndt, 1987). The most significant exploration of the area by a non-Alaska-Native was by Lieutenant Henry Allen in 1885, when he followed the Copper River to the Tanana and beyond (Allen, 1900). Allen was accompanied by Ahtna Athabascan people for various parts of the journey (Allen, 1900; Sheppard, 1999).

The Alaska Native residents of the area, the Ahtna, speak an Athabascan language that shows some similarities to Tanaina, but is generally distinct from neighboring groups (Kari, 1977; de Laguna and McClellan, 1981). In historic times, Ahtna settlements consisted of winter residential settlements and short-term hunting and fishing camps (Ketz, 1983). Winter villages were controlled by a "chief," either a wealthy man who was a leading chief of the region or a head of an extended household (de Laguna and McClellan, 1981). Major communities or settlement groups had their own areas for hunting, fishing, and berry picking. The Ahtna were involved in a widespread trading network that involved the Eskimo, other Athabascans, the coastal Eyak and Tlingit, probably the coastal Chukchi of Siberia, and the Russians (de Laguna and McClellan, 1981). This pattern of widespread trade and interaction lasted until well after initial contacts with Euroamericans.

Between 1900 and 1940, Ahtna sociocultural systems were affected by mining activities and the development of inter-regional transportation systems. Gold strikes at Eagle, Valdez Creek, and other locations brought an influx of miners into the region (Reckord, 1983). The miners introduced new diseases, including the 1919 Spanish influenza that decimated many Alaska Native communities and fundamentally altered the demographic structure (Ahtna, Inc. 1973). Between 1910 and 1939, the Kennicott Copper Mine near McCarthy was the largest industry in the region. This development stimulated construction of the Copper River and Northwestern Railroad, which was built between 1908 and 1911 and connected the Kennicott mines with PWS (Reckord, 1983). The transportation system expanded when construction of the Richardson Highway connected Valdez and Fairbanks between 1905 and 1914. Construction of the Glenn Highway as a result of World War II connected Anchorage with the Alaska Highway at Tok (Reckord, 1983).

Over the last 30 years, the population has been transformed from predominately Alaska Native to the present mixture. Only Chistochina and Gulkana still have Alaska Native majorities. This is not to say that Alaska Native culture ceased to be a significant force in the social and cultural fabric of the area. However, the increasing presence of Euroamericans reflects accelerated social and economic changes for Ahtna residents of the area.

The economic and service center of the region is **Glennallen**, a predominately non-Alaska-Native community located near the junction of the Glenn and Richardson Highways (Orth, 1967). Copper Center, located between Mileposts 100 and 105 on the Richardson Highway, has shifted from Alaska Native to predominately non-Alaska Native over the past 30 years. **Copper Center** has a slightly larger population than Glennallen, but far fewer businesses

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Photo 3.3-14 *Glennallen (August 1997).*

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Photo 3.3-15. *Copper Center (June 1995).*

(Copper Valley Economic Development Council, Inc. 1992). Glennallen is one of the few communities in the Copper River region that is not located near the site of a pre-existing Alaska Native settlement (ADCED, 1999). Jobs in the service sector involve the most households in eight of the ten communities, with construction a leading employer in two. Federal and state government employment involves the next highest percentage of households for four communities.

Central TAPS Study Area Community Economics

Figure 3.3-18 shows these Central TAPS study area communities ranked in descending order of median household income in 1990, along with comparable data for the State of Alaska and the U.S. as a whole. Median household incomes for this group of communities in 1990 ranged from $4,999 for Wiseman to $38,750 for Gulkana.

In contrast to the North Slope communities, all these communities had median household incomes in 1990 less than that for Alaska ($39,298). Several, including Chistochina, Kenny Lake, Tonsina, Rampart, Chitina, Stevens Village, and Wiseman, had median family incomes less than that for the U.S. overall ($29,943).

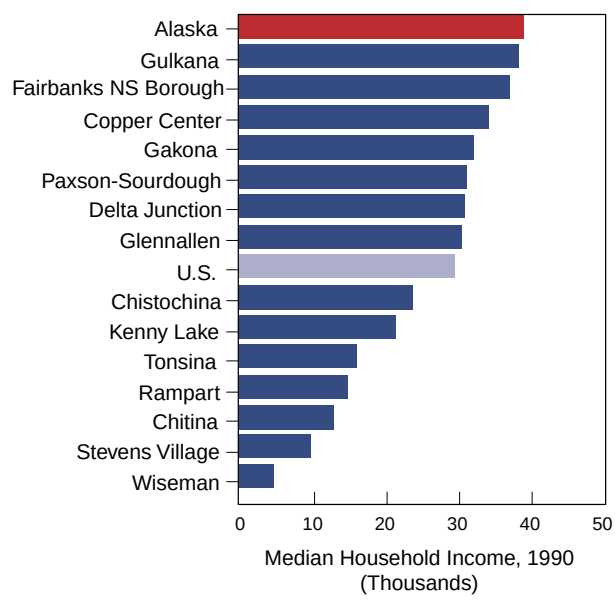
Northern Segment Economics. During construction of TAPS in the 1970s, a construction camp and airstrip were established near the old Coldfoot settlement. With the 1979 BLM establishment of public service areas along the Dalton Highway, Coldfoot was one of two locations chosen. In 1981, Coldfoot Services, a truck stop that eventually included a hotel, a restaurant, and a recreational vehicle (RV) park, was established. There is no current information available on subsistence and economic activities, apart from the fact that most Coldfoot residents are employed by Coldfoot Services, the BLM, or a state agency.

Wiseman residents participate in a mixed subsistence and cash economy. Community members hunt, fish, gather berries and greens, and run traplines as a cash-producing activity. Caribou, moose, and Dall sheep comprise the primary game resources used by Wiseman residents, and meat and other resources are actively shared within and outside the community. Because fish populations are low, fishing is not an important subsistence activity.

All ten Wiseman households fall below the poverty line, with a median household income of $4,999 (ADCED, 1999). Of the 16 potential workers in Wiseman, eight have jobs, all in mining. Trapping, tourism, cabin and campground rental, and work in Coldfoot provide limited sources of local income. Nonlocal sources of cash include commercial fishing, trucking, and construction (Scott, 1993).

Central Segment Economics. Road construction and maintenance during World War II provided some economic support for Livengood, but the most significant burst of economic activity occurred when Livengood became a primary center for storage and transfer of pipe during construction of TAPS (APSC, 1975). TAPS resulted in short-term growth, but this diminished significantly as soon as construction ended. The ADCED database contains no information on economic conditions in Livengood. Seasonal employment is still vested primarily in mining.

In 1999, the resident Stevens Village population was 92 individuals scattered among 37 households (ADCED, 1999). Residents, who are primarily Alaska Natives, rely



NOTE: Coldfoot mean income in 1990 was zero.
Source: ADCED (1999)

Figure 3.3-18. *Median household income of TAPS study area communities, 1990.*

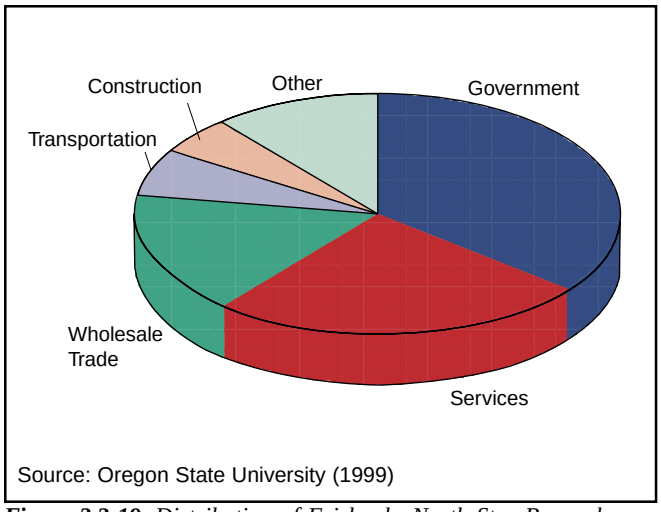


Figure 3.3-19. *Distribution of Fairbanks North Star Borough employment by sector, 1997.*

heavily on subsistence activities for their livelihood today, since full- or part-time wage-earning opportunities are few. Employment is sometimes available with the local school, the clinic, Village Council, and store. Seasonal employment is available fighting fires in the summer or doing construction work. Four individuals in the community hold commercial fishing permits (ADCED, 1999).

The FNSB economy is relatively diverse by Alaskan norms, with much of the impetus for local employment related directly to North Slope oil and gas development. Total employment in FNSB was 49,979 in 1997 (Oregon State University, 1999). Figure 3.3-19 shows the distribution of FNSB employment among various sectors and industries in 1997. The government (federal, state, local, and military) was the single largest employer, followed by services (which includes oil-field services and related); wholesale trade; transportation and public utilities; construction; finance, insurance, and real estate; mining; and other. Although the FNSB economy is relatively diversified, it has a much higher dependence on government than a typical city in the contiguous 48 states.

Although the Tanana River Basin has been used historically for subsistence by a variety of Native and non-Alaska Natives (Andrews, 1975), the FNSB is not considered rural as defined in ANILCA, and borough residents are not considered subsistence users. The Division of Subsistence, ADF&G, does not maintain community profiles for Fairbanks. Although ADF&G collected limited data on the Tanana River salmon fishery in 1981, this information was collected before implementation of ANILCA and before eligibility criteria were established for the subsistence fishery. For the two-year study period, at least half of those surveyed would not meet the "customary and traditional" criteria established in federal law (Caulfield, 1981). The Department of Wildlife Conservation, ADF&G, has harvest data from 1982 to the present. These data are recorded with residency, permit type, game management unit in which animals were harvested, and mode of transportation to and from hunting areas.

Delta Junction had a population of 889 in 1999 (ADCED, 1999). As of 1994, there were about 75 operating farms in the area. Other employment opportunities are provided by Alyeska Pipeline Service Company and by a small number of local businesses that cater primarily to the tourist trade and traffic during summer. Alyeska employed 74 Delta residents in 1994. During the same period, most jobs were provided by the federal government, with transportation, communications, utilities, and self-employment accounting for the rest. With the scheduled closure of Fort Greely in 1999-2001, employment statistics will change significantly. Since none of the communities in the Delta area is a federally recognized ANCSA entity, the residents are not considered rural subsistence users.

The 1999 population of Rampart was 66. The population has fluctuated greatly through time, reflecting mostly the rise and decline of gold mining. Today, there are numerous unoccupied structures in Rampart — a legacy of occupation and abandonment by Euroamericans and of the gold rush in the early 1900s.

Rampart residents rely heavily on subsistence for their livelihood, since full- and part-time wage-earning opportunities in the community are few. Limited employment opportunities may be offered at the local school, village store, health clinic, or Village Council. Some seasonal employment is available through the BLM fire protection program. Five people hold commercial fishing permits. Of the 56 Rampart residents age 16 and older in 1990, 87.5 percent were not active in the wage labor force. Only seven were actually employed in the community. The Alaska Community Database shows 43 percent employed in health services, 28.5 percent in mining, and 28.5 percent in public administration, but these frequency assessments clearly mask the small number of people actually employed.

Copper River Economics/Resource Harvest. Like many rural Alaska Native villages, the Copper River Basin communities have undergone an historical and economic transformation from a primary emphasis on subsistence to a mixed cash-and-subsistence economy. Since the mid-1970s, this shift is reflected in part by an increased emphasis on the cash economy as indicated by lower per-capita harvest levels in all communities throughout the region (Stratton and Georgette, 1984; McMillan and Cuccarese, 1988).

Historically, much of the cash economy centered on trapping, commercial mining, and the delivery of services for travelers and miners. The region now has a more diversified economic base and a greater number of employment options in state and federal government, although Alaska Natives living away from the major service centers probably do not have equal access to such employment opportunities. From the 1970s to the present, the trend has been toward greater involvement in the wage-labor and cash economy throughout the region. The schedule and intensity of subsistence activities in each community are partly related to the availability of wage labor. All of the Copper River Basin communities are similar in this respect, although wage-labor opportunities and a non-Alaska-Native majority in Glennallen and Copper Center result in a more stable economic base and less dependence on subsistence resources here than in the smaller outlying villages and towns. Specific subsistence activities and harvest activities are discussed in Section 3.3.3.4.

Valdez/Prince William Sound

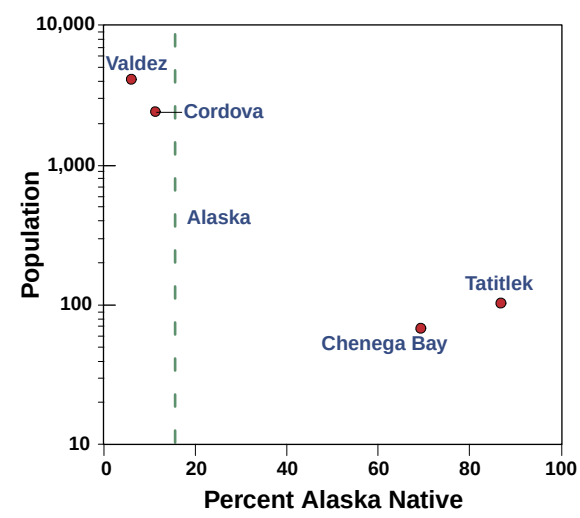
The Valdez/PWS communities considered in this analysis include Chenega Bay, Cordova, Tatitlek, and Valdez (Figure 3.3-12).

Population and Ethnicity. Figure 3.3-20 presents 1999 data on population and ethnicity (percentage Alaska Natives) for these four communities. These appear to form two clusters: the small, predominantly Alaska Native communities of Chenega Bay and Tatitlek, and the larger, predominantly non-Alaska-Native communities of Cordova and Valdez. In terms of 1999 population, the communities vary in size from Chenega Bay with 69 villagers to Valdez with 4,164 residents. Cordova with 11.1 percent and Valdez with 5.9 percent have populations with a smaller percentage of Alaska Natives than the average for the State of Alaska (17 percent). Chenega Bay with 69.1 percent and Tatitlek with 86.6 percent have a larger percentage of Alaska Natives than the State of Alaska.

History and Social Structure. The cultural history of PWS before Euroamerican contact is known primarily through oral traditions and archaeological data that indicate the region was the homeland of aboriginal people for thousands of years. The Alutiiq-speaking people who lived in PWS before contact were residents of various geographically based local groups (de Laguna, 1956), and Eyak-speaking people lived in various locations near the Copper River delta (Birket-Smith and de Laguna, 1938; Oswalt, 1967). During the contact period (post-1741), the cultural boundaries in the Copper River/Controller Bay area fluctuated among various Eyak, Chugach, and Tlingit groups who inhabited the region (de Laguna, 1972, 1956; de Laguna et al., 1964; Johnson, J.C.F., 1984). Many current Alaska Native residents of the four modern PWS communities are descendants of these groups, although in-migration and intermarriage with Alaska Natives from other regions and with non-Alaska Natives has occurred.

The broad social patterns before Euroamerican contact point to local group control and use of maritime and some terrestrial resources, supplemented by trade. Local groups appear to have been hierarchically structured, including higher- and lower-ranking families, commoners, and a portion of the population who were slaves taken in battle. The economy was based on adaptations to the changing yet productive coastal environment. They used watercraft to hunt marine mammals; they trapped, netted, and caught fish; and they preserved and stored numerous littoral and terrestrial resources for shared consumption (de Laguna, 1956; Fitzhugh and Crowell, 1988).

The post-contact period can be divided into these broad categories: the Russian fur trade (1785-1869), the American fur trade (1869-1910), whaling (1840-1930), fox farming (1918-1935), commercial fishing (1890-present), and mining (1900-present). Initial contact, after the brief 1741 Vitus Bering "discovery" of Alaska Native presence on Wingham and Kayak islands, occurred in the 1780s and 1790s (Steller, 1988). Russian and Spanish explorers, as well as English and American traders seeking sea-otter pelts, caused major cultural disruptions by bringing trade goods as well as exotic diseases into the region, resulting in



Source: ADCED (1999)

Figure 3.3-20. *Population and ethnicity data for Valdez/Prince William Sound communities, 1999.*

a reordering of the size and distribution of the local social units, as well as their subsistence cycles (Hassen, 1978). Commercial whaling and sea-otter hunting reduced the population of those important species nearly to extinction. The villages known to have persisted into the 1800s include the Eyak village of Alaganik and the Chugach villages of Tatitlek, Chenega, Nuchek, and Kiniklik.

Throughout the mid- to late 1800s, as diseases decimated human populations and as seasonal fur-hunting expeditions to former local-group territories were undertaken, seasonal habitations and travel camps were used. More extensive Russian contact in the 1800s also involved sea-otter and terrestrial-mammal hunting, the introduction of Russian Orthodox Church teachings, and the development of an educated Alaska Native and Russian/Native Creole population (Pullar, 1997). The syncretism of Russian Orthodoxy and Alaska Native culture persists in area villages.

The Alutiiq populations continued to decline because of epidemic diseases, especially in the 1890s and 1920s. Depopulation caused changes in settlement and subsistence patterns, although hunting furbearers in exchange for trade goods continued. Gold mining in the Klondike resulted in the settling of Valdez in 1898 as the stampeders' jumping-off point into the Klondike gold fields. The U.S. Army built Fort Liscum in 1900 at the present site of the Valdez Marine Terminal, to assist miners who either ran out of supplies or otherwise were not successful in the gold rush. Valdez continued to prosper in the early 1900s, when gold and copper discoveries in PWS were developed.

Copper mining at the Ellamar mine adjacent to Tatitlek began in 1902. Tatitlek's population increased between 1900 and 1910 when work related to the Ellamar mine drew villagers from Nuchek (Stratton, 1990). The Cordova area also figures prominently in the history of PWS, as well as the cultural, political, and industrial history of Alaska. Cordova's townsite was formed in about 1906 as a port associated with the Kennicott copper discovery and the Copper River and Northwestern Railroad. Other early twentieth century activities affecting the Cordova area included commercial fishing, the attempted development of the Bering River coal field, and the Katalla oil refinery.

Industrial developments have affected the size and nature of the region's population. The non-Alaska-Native population in the more accessible and economically diversified communities of Valdez and Cordova grew during the twentieth century. During the same period, the predominately Alaska Native villages of Chenega and Tatitlek maintained relatively small and homogeneous populations. Chenega and Tatitlek also relied on the larger Valdez and Cordova for some supplies, which used to be shipped by boat (Bilderback, 1956) or purchased directly in town by village residents.

The commercial fishing industry has shaped the history, culture and social organization of the PWS communities, and it continues to be the dominant force in the local economy. Commercial fishing is an increasingly expensive and competitive business (MMS, 1993b). However, fishing also provides a lifestyle and an avenue for the gathering of fish from commercial nets for subsistence use. Fishing also provides access to areas of PWS for subsistence hunting and other resource-gathering activities.

Extensive commercial fishing in PWS began in the early 1900s, as Valdez's first cannery opened in 1917. Many "outsiders" including Scandinavians and Chinese laborers came to the region during this time. Commercial fishing initially focused on salmon and herring, and later expanded to include halibut, shrimp, rockfish, clams, and crab. In the mid-1900s, Chenega villagers adjusted to the economic opportunities presented by the commercial fishing industry by taking up seasonal residence at the "Shipyard" site near the Port Nellie Juan cannery (Stratton and Chisum, 1986). By the 1940s, Cordova also had become dependent on commercial fishing, and many Tatitlek residents fished for the Cordova canneries. During the 1950s and 1960s, fur trapping and seal bounties also provided area residents a source of cash to supplement commercial fishing. In the 1950s and 1960s, Chenega and Tatitlek village residents fished commercially and worked at canneries in the summer or as winter caretakers of the canneries.

Valdez's connection to the Southcentral Alaska road system is unique among PWS communities. Valdez was the original gateway to Interior Alaska before the Alaska Railroad was constructed between Seward and Fairbanks in 1923. The road that became the present-day Richardson Highway made Valdez a transportation hub into the Interior. Although commercial fishing has been a prominent socio-economic feature of Valdez, state government employment with the Harborview Hospital (a state facility for the handicapped), the Alaska State Troopers, and a state regional highway maintenance facility fostered a dependence on state employment during the 1950s and 1960s.

In 1964, destructive tsunamis associated with the Great Alaska Earthquake killed 26 of 76 Chenega residents, devastating the community on Chenega Island. The survivors were evacuated to Cordova, and many later moved to Tatitlek when houses were completed for them (Davis, 1984). After passage of ANCSA in 1971, survivors formally applied for village status. Eligibility hearings were held in 1974, and in 1984, approximately 60 people resettled at the new Chenega Bay village on Evans Island.

PWS villagers have experienced minimal direct impacts from TAPS construction and pipeline operations, although some village residents have taken advantage of TAPS-related employment opportunities, and some are employed by Alyeska or its contractors in Valdez. In 1989, the *Exxon Valdez* oil spill (EVOS) and the associated cleanup activities created significant impacts on the PWS communities. Thousands of workers and others came to Valdez for the cleanup. This influx resulted in social and subsistence disruptions, but also provided an economic windfall for the regional economy (see MMS, 1993b for socioeconomic impacts to each community; see also Wooley, 1995 and Jorgensen, 1996 for cultural and socioeconomic impacts of the spill and subsequent litigation). PWS community residents participated in the cleanup to varying degrees. Residents who did not participate directly were also affected by the local population influx, fishing closures, and various other social impacts (MMS, 1993b).

Many area residents have participated in industry oversight committees enacted as a result of EVOS and OPA 90, including the PWS Regional Citizens Advisory Council (RCAC). Residents have also been involved in restoration work, including the Chugach Regional Resources Committee that provides input for subsistence restoration projects. Other restoration programs have been initiated including elders-youth conferences, harbor-seal harvest assistance, and shellfish restoration projects. Many residents, especially area fishermen, have been actively involved in oil spill preparedness and response in the communities and have worked for the Ship Escort/Response Vessels System (SERVS).

Chenega Bay and Tatitlek. The PWS communities of Chenega Bay and Tatitlek are unincorporated communities. Because of their small size, the nature of their Alutiiq culture and history, and the economic history of PWS, these communities have very different socioeconomic structures than the predominately non-Alaska-Native towns of Valdez and Cordova.

Traditional Alutiiq local groups were comprised of extended family units sharing multi-room houses. Communities were based on related kin united by residence and ties to certain territory. Some matrilineal tendencies (kinship considered through mother's side) have been noted for the Alutiiq; however, kinship was probably bilateral (both mother's and father's), based on language terminology. Russian (Eastern) Orthodoxy replaced traditional shamanic beliefs after breakdown of traditional society in the late 1700s. Russian Orthodoxy remains central to the religious identity of many local residents. Chenega Bay, Tatitlek, and Cordova have Russian Orthodox churches, and Valdez also has a small Orthodox community, but no church (St. Vladimir's Orthodox Theological Seminary, 1999). The Orthodox Church has also influenced local language, economics, social activities, and kinship (Davis, 1984). While the Alutiiq and Russian languages are no longer spoken daily, some traditional knowledge of both languages still exits and is used and transmitted across generations.

Compared to the traditional Alutiiq social organization, the contemporary villages of Chenega Bay and Tatitlek exhibit a more Western type of social organization (separate nuclear family units within a wage-earning economic system) as a result of historic-era acculturation, the influence of ANCSA corporation economics, and government-sponsored construction and social programs. In Chenega Bay, additional changes in village social organization occurred in the 20 years after the earthquake and tidal wave as the survivors adapted their lives to new surroundings in Cordova, Tatitlek, and elsewhere before building the new village of Chenega Bay. However, beneath the external changes, the harvesting and communal sharing of wild resources remain widespread in Tatitlek and Chenega Bay (Fall and Utermohle, 1999) — evidence of the Alutiiq cultural background of these communities. The continuing practice of communal wild-food sharing reflects underlying cultural values distinct from Western social mores in which the individual nuclear family generally procures and consumes food in relative isolation from neighbors.

Both Chenega Bay and Tatitlek have for-profit Alaska Native village corporations and IRA (Indian Reorganization Act) councils recognized by the Bureau of Indian Affairs. The Chugachmiut regional nonprofit organization (formerly North Pacific Rim) operates the Tatitlek and Chenega Bay health clinics. The Chugach Regional Resources Committee provides input on local subsistence issues, including EVOS restoration projects. Subsistence hunters from PWS

Frank Flavin (for Alyeska Pipeline Service Company)

Photo 3.3-16. *The Prince William Sound community of Chenega Bay.*

communities are also actively involved in the Alaska Native Harbor Seal Commission, a tribal consortium concerned with management of harbor seals. The Chenega Village Council operates the local facilities serving roughly 25 village homes with water, sewer, electricity, fuel delivery, and the landfill. The Tatitlek Village Council operates similar local facilities serving roughly 35 village homes. Both Tatitlek and Chenega Bay are actively involved in the Prince William Sound Economic Development Council (PWSEDC), a recently established forum fostering economic growth and development in Chenega Bay, Cordova, Tatitlek, Valdez, and Whittier (PWSEDC, 1999). Tatitlek and Chenega Bay are also directly affected by, and have input into, the Prince William Sound Aquaculture Corporation (PWSAC) regarding the corporation's influence on local commercial and subsistence fisheries.

Valdez and Cordova. These communities are organized like other communities of their size and nature in Alaska. Valdez, with its close association to the oil and gas industry, has been compared to the town of Kenai, whereas Cordova more closely resembles Southeast Alaska fishing communities such as Petersburg. Valdez is organized as a municipality and has an extensive array of public services. Housing is comprised of mobile homes, apartments, and single family homes.

Valdez has a large tax base and employment related to Alyeska, as well as a cargo-and-container shipping facility that continues the community's tradition as a transportation hub. The U.S. Coast Guard (USCG), the Valdez Fisheries Development Association, and the Valdez Native Association are active local employers. (Recent summaries of Valdez social and economic life are available in MMS, 1993b, and Tomrdle and Miraglia, 1993. Earlier sources include Morsell et al., 1979, and City of Valdez, 1992).

The March 27, 1964, earthquake destroyed old town Valdez. The relocation and rebuilding of Valdez were followed by the construction and operation of TAPS and the VMT beginning in 1973. The construction phase, in particular, introduced further permanent economic and population growth in Valdez, and brought direct and indirect socioeconomic impacts to area communities. Robbins (MMS, 1993b) describes the impact of these events. Tourism played an increasingly important role in the growth of PWS communities in the 1990s because of the area's spectacular scenery and outdoor recreation opportunities.

Changes in the classification and reporting of ethnic categories have obscured the diverse Alaska Native ethnic backgrounds present in the Cordova area. However, as a percentage of the overall population in Cordova, the Alaska Native population is decreasing. An updated discussion of the Alaska Natives in Cordova, including Eyak Corporation and Chugach Alaska Corporation, is found in MMS (1993b).

Housing in Cordova is a combination of single-family homes, trailers, and apartments. Most households are nuclear family groups or single persons; 76.3 percent had two or more people. Cordova is accessible by air and boat, but is not involved in large cargo shipping. Other organizations central to life in Cordova and Valdez are PWSAC, the Cordova District Fishermen's Union, and the Prince William Sound RCAC.

Prince William Sound Community Economics. Figure 3.3-21 shows the median household incomes of the Valdez/PWS communities in 1990 (the latest year available) ranked in descending order, together with that for the State of

Danny Daniels for Alyeska Pipeline Service Company

Photo 3.3-17. *The Valdez boat harbor is home to numerous fishing vessels.*

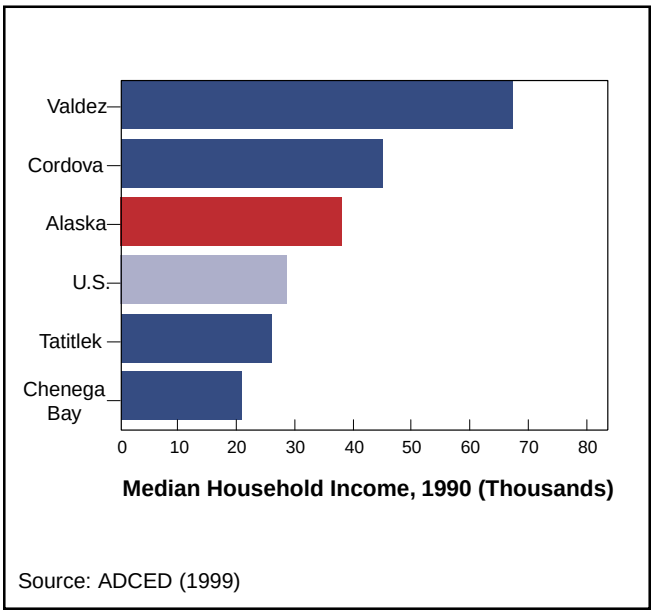


Figure 3.3-21. *Median household income of Valdez/Prince William Sound communities, 1990.*

Alaska and the U.S. as a whole in the same year. Valdez ($68,570) and Cordova ($46,304) had median household incomes greater than that for either Alaska or the U.S. as a whole. Tatitlek ($27,188) and Chenega Bay ($22,083) had median household incomes lower than Alaska or the U.S.

Chenega Bay and Tatitlek residents continue to depend on seasonal commercial fishing for cash income, augmented by seasonal labor on local construction projects, village corporation employment, and activities related to EVOS restoration and SERVS. Dividends resulting from the EVOS trustee land sale have been distributed and may have triggered a recent migration of residents from Chenega Bay. Although all of the communities have access by air, the Chenega Bay and Tatitlek airstrips have only recently been expanded, and local transportation is still primarily by boat.

Current employment includes fish processing and oyster farming, some residents still hold commercial fishing permits, and subsistence harvests continue to account for a large percentage of the local food supply (ADCED, 1999). Oyster farming has been initiated at Tatitlek and Chenega Bay. Increased sport hunting and sport fishing in PWS have presented subsistence harvesters with competition for wild resources. A coho salmon hatchery at Boulder Bay near Tatitlek is being built to enhance salmon returns for local subsistence use, and a fish and game processing facility is also under construction. In the 1990s, logging of village and regional corporation lands on Montague Island and near Tatitlek employed PWS residents and produced some corporate income (MMS, 1993b). The recent sale of village corporation lands to the state and federal trustees as part of the EVOS restoration has resulted in additional corporate income and shareholder dividends.

The oil and gas industry — particularly TAPS oil transportation — drives the economy of Valdez. This contrasts with the community of Cordova, whose people are generally opposed to non-fishing-related industrial growth (Morsell et al., 1979). The Petro-Star refinery, which opened in 1993, produces jet, marine, and heating fuel, and also provides a significant tax base for Valdez (Tomrdle and Miraglia, 1993). Alyeska and the other companies related to the oil and gas industry provide the majority of the tax base for the infrastructure and administrative amenities that Valdez provides its citizens (MMS, 1993b). The declining tax base that typically follows decreased or discontinued oil and gas production, transportation, and shrinking property valuations presents a major fiscal problem for the City of Valdez.

Cordova's primary industry in the TAPS era has been fishing and fish processing. Commercial fishing dominates Cordova's economy. Cordova's fishing industry changed significantly during the 1970s due to the limited-entry system and the construction of modern multi-species (as opposed to exclusively salmon) fish processors located in the Cordova industrial park (Alaska Consultants, 1979). In the 1970s, government employment was second in importance to fishing and fish processing. Local and state government had a small presence at the time, as was particularly true of communities with economies heavily dependent on fishing and fish processing.

A summary of Cordova's growth and economic development through the 1980s (MMS, 1993b) describes the many ways Cordovans have worked to protect and stabilize the fishing industry, rather than diversify the local economy. Projects such as a deepwater port, the Copper River Highway, and the Bering River coal development have brought out conflicting goals for development among the various Cordova constituencies.

Cordova presently supports a large fishing fleet and several fish-processing plants, although government jobs pro-

David Predeger for Alyeska Pipeline Service Company

Photo 3.3-18. *The community of Tatitlek.*

David Predeger for Alyeska Pipeline Service Company

Photo 3.3-19. *Valdez.*

State of Alaska

Photo 3.3-20. *The boat harbor at Cordova.*

vide important employment income. Nearly 400 residents hold commercial fishing permits, and nearly half of the households have a member whose work is associated with fish harvesting or processing. Cordova has seen an increase in tourism, as it has become a destination for cruise-ship companies. The large employers are North Pacific Processors, Cordova School District, the hospital, the city, and the State Department of Transportation. The U.S. Forest Service and USCG also have personnel in Cordova, and the Prince William Sound Science Center is based in Cordova to study and monitor the ecosystem of PWS.

3.3.3 Subsistence

By M. Galginaitis, C. Gerlach, P. Bowers, and C. Wooley

3.3.3.1 Definition of Subsistence

The term *subsistence* has different definitions and meanings emerging from a complicated legislative and social history (Davidson, 1974; Arnold, 1978; Lewis, 1978; Lonner, 1980; Kelso, 1981, 1982; Worl, 1982; Schwarber, 1983; Case, 1984, 1989; Berger, 1985; Caulfield and Brelsford, 1991; Kancewick and Smith, 1991; Naiman, 1996; Loescher, 1999). ANILCA provides the operational basis for definition of the term in this document. Other legislative acts and regulatory actions relevant for the understanding of subsistence management issues on federal lands include the Federal Subsistence Management Regulations (36 CFR 242 or 50 CFR 100), the Federal Advisory Committee Act (FACA), and the Federal Advisory Committee Management Regulations (41 CFR 101-6).

ANILCA explicitly recognizes that for rural Alaskans (Native and non-Native) *subsistence* includes a complex set of behaviors and values that extend far beyond the harvest and consumption of wild resources. The current regulations define *subsistence use* as "the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools of transportation; for the making and selling of handicraft articles out of inedible by-products of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade" (FSB, 1999). For some resources in certain areas, the Federal Subsistence Board (FSB) has determined that all rural Alaskan residents are qualified subsistence users. For other resources, the FSB has made more restrictive "customary and traditional" determinations of eligibility. To show customary and traditional use, a community or area is evaluated in terms of:

- The time, depth, and consistency of its use;
- Seasonal repetition over many years;
- Efficiency in terms of effort and cost;
- Consistency of harvest or use of fish and wildlife in proximity to the community or area;
- Historic or traditional means of handling, preparing, preserving, and storing fish and wildlife that have been used by past generations;
- The inter-generational transmission of hunting and fishing skills, values, and knowledge;
- Sharing and distribution of the harvest;
- Dependency on a wide variety of fish and wildlife resources available in an area; and
- The provision of substantial cultural, economic, social, and nutritional elements to the community or area.

Subsistence is historically rooted in Native and Alaskan culture, economy, and tradition. The nine factors listed above attempt to integrate salient aspects of subsistence into criteria for a regulatory definition of "customary and traditional use." These criteria do not fully capture the sociocultural significance of subsistence. This topic addressed below, followed by a detailed description of actual subsistence harvest patterns for each of the regions.

3.3.3.2 Sociocultural Significance of Subsistence

Harvest and consumption are the most visible aspects of such a system and the most logical entry point for examining a social system with a subsistence ideology. The fundamental values of such societies are expressed in the *idiom* of subsistence, so that kinship, sharing, and subsistence resource-use behaviors (preparation, harvest, processing, consumption, celebration) become inseparable (Langdon and Worl, 1981; Elanna and Sherrod, 1984). Worl (1979)

and Nelson (1979) describe subsistence as a central focus of North Slope personal and group cultural identity in addition to its economic role. Hopson (1976, 1978) establishes the political and ideological power of subsistence as an organizing concept for the North Slope Borough. Simeone (1998) documents the central place subsistence has in village life and identity in Athabascan communities. McNeary (1978) and North Pacific Rim (1981) describe the socioeconomic aspects of subsistence in the changing cultural landscape of the PWS region. In each region, communities express their unique identities based on their enduring connections between current residents, those who used the areas in the past, and the wild resources of the land. Elders' conferences, spirit camps, and other information exchange and gathering events serve to solidify these cultural connections between generations and between the people and the land and its resources. While all local subsistence economies are similar, the general values and central organizing concepts have many common threads.

Many studies have examined the relationship between the subsistence and wage economies and how both subsistence and wage activities are integrated into rural Alaskan socioeconomic systems. (General theoretical or conceptual treatments are available in Wolfe, 1983; Wolfe et al., 1984; and IAI, 1988.) Although not always made explicit, it is recognized that all rural communities and rural socioeconomic systems are not the same. One salient variable is the ethnic composition of the community. Others include the diversification of the local economy and the availability of wage employment.

An extensive series of community studies focusing on local patterns of wild-resource use as a component of the overall economy was conducted during the 1980s in a wide range of communities throughout Alaska (e.g., Sobelman, 1985; Reed, 1985; Stratton, 1989, 1990, 1992; Galginaitis et al., 1984; and IAI, 1989). Some of these communities are predominately Alaska Native, others are predominately non-Alaska Native, and others are more ethnically mixed. Some have developed wage or self-employment economies, while others have few such opportunities. In the NSB, both subsistence activities and wage economic opportunities are highly developed and highly dependent on each other (Kruse et al., 1981; Kruse, 1982, 1991; Harcharek, 1995; Shepro and Maas, 1999). Those most active in subsistence activities tend to be those who are also very involved in the wage economy. Monetary resources are needed to most effectively harvest subsistence resources, both as an individual (e.g., to purchase a boat, snowmachine, all-terrain vehicle, fuel, guns and ammunition) or as the head of a collective crew (e.g., for whaling).

Rural Alaskans harvest over 40 million pounds of wild foodstuffs annually (Wolfe, 1996) — food produced through hunting, fishing, and gathering averages just over one pound of wild food per person per day. Nobmann (1997) compares harvest data to a type of "food balance sheet." Harvest data describe the amount of wild food available to a certain group of people and are a rough estimate of what is eaten. Actual consumption varies from what is harvested or brought into the kitchen. However, few wild-food consumption studies have been undertaken in Alaska.

Subsistence foods consist of a wide range of fish and game products that are generally rich in nutrients, often low in fats, and contain less harmful fats than many non-Alaska-Native foods (Nobmann, 1997). Social, emotional, spiritual and cultural benefits are other important aspects of subsistence food harvesting and sharing that contribute to personal and community health.

According to 1990 estimates (Wolfe, 1996), the annual wild food harvest in rural Alaska was 375 pounds per person, compared to 22 pounds per person in urban Alaska. Assuming that on average, 0.2 pounds of wild food contains 0.44 grams of protein, and 2.94 pounds of wild foods contains 2,400 kilocalories, the amount of wild food harvested in 1990 represented 243 percent of the rural population's protein requirements and 35 percent of the population's calorie requirement. In contrast, the food reportedly harvested by urban residents represented 15 percent of their protein requirements and 2 percent of their calorie requirements. Clearly, wild foods represent a major source of healthy foodstuff in rural Alaska.

Socioeconomic and state and federal subsistence studies often use fixed income figures to describe how many Alaska Natives live below the poverty level in a given village. Regardless of how economists define the poverty level, villagers feel that they live well and are functioning members of an active cultural tradition if they are able to obtain most, if not all, of their food from the land and to share these foods with neighbors and kin.

3.3.3.3 Activities That Make up Subsistence

Subsistence encompasses a wide range of activities, the most visible and easily documented of which is the actual harvest of subsistence resources. This and later sections describe selected aspects of subsistence-resource harvest activities for potentially affected communities in each of the three study areas. Summary descriptive information for several regions and communities in those regions is available (Schroeder et al., 1987).

North Slope Communities

North Slope subsistence-resource harvest activities have been relatively well-documented, and the following discussions incorporate by reference the most pertinent agency information syntheses for recent federal and state oil and gas lease sales and early planning efforts (USACE, 1997; ADNR, 1997, 1998, 1999; USACE, 1999; BLM, 1978, 1979, 1983a, b; MMS, 1979, 1982, 1984, 1990; BLM and MMS, 1998). These sources for the most part contain a regional overview as well as a discussion of relevant communities, with a presentation of more detailed information as required. Each is also supported by an extensive record of public hearing testimony as well as written comment, which is also incorporated by reference.

Each North Slope community exhibits a unique pattern of subsistence resource use. This section addresses the types of resources used and the seasonality of harvest for each village. This information is displayed in Figure 3.3-22, which is based on NSB Contract Staff (1979). Figure 3.3-22 is a qualitative presentation, with the height of the curves indicating level of effort. The figure must be interpreted with caution, because of the following:

- For each village, it presents only the suite of resources normally harvested and the period(s) during which those resources would be expected to be available. The level of expected harvesting effort is estimated for each resource for the period of its availability. No assessment of actual harvest or the importance of each resource is implied by this representation.
- Actual subsistence effort and harvest vary from year to year. The mix of resources harvested and the timing will vary due to annual resource variability in abundance and distribution, weather, time constraints, resource-harvester characteristics, and other factors. The subsistence cycle for any specific year could differ materially from that shown in Figure 3.3-22.
- The pattern represented is aggregated, so that some individuals may actively participate in only a subset of the activities included in overall annual cycle.

Thus, only a long time-series (based on informant experience, other local or traditional knowledge, and/or systematic recorded observations) can truly represent a community subsistence pattern. Specific short-term information might misrepresent the long-term pattern but is important to indicate the range of behavioral adaptability of subsistence-resource harvesters.

The relative importance of different subsistence resources and the variation that can be expected from year to year are addressed in the next section. Key general points introduced by Figure 3.3-22 are:

- Each village relies on a unique combination of subsistence resources, but caribou are part of each village's subsistence-use pattern, and are the most important terrestrial subsistence resource in terms of edible weight.
- Fish are also harvested by residents of all villages and is a primary resource for all except Anaktuvuk Pass (an inland community with limited direct access to fish resources). Anaktuvuk Pass residents still consume a significant amount of fish obtained through trade or other sharing.
- Communities which harvest whales depend heavily on that resource but do have some ability to partially compensate for years of low or no harvest of whale (more reliance on other resources), sharing from other communities.
- Nuiqsut, Kaktovik, and Barrow harvest and consume significant amounts of caribou, fish, and whales (and other marine mammals). Anaktuvuk Pass exhibits a narrower subsistence pattern dependent primarily on caribou. Marine resources are obtained through trade, sharing, or participation in the harvest activities of other communities.

Central TAPS

Annual harvest patterns specific to the Central TAPS study-area communities are described elsewhere in this report. Given that there is a gradual but distinctive ecological gradient from south to north across the study area, the patterns of the Copper River Basin communities contrast with those of the villages scattered along the central and northern segments of the TAPS study area.

The Copper River Basin communities procure and use a wide variety of subsistence resources, although salmon is clearly a dominant component of the subsistence system. The major factor affecting patterns of Native use is historic right to the use of specific fishing sites (Simeone and Fall, 1996, p. 62; Sheppard, 1999, p. 4). The presence of roads, proximity to population concentrations, and pre-existing and long-established use are at least partially responsible for the clustering of fish-wheel sites. Land ownership along the Copper River is dominated by Ahtna, Inc., and the National Park Service, and therefore there are relatively few areas where non-Natives can establish fish-wheel sites. Regardless of who owns or controls the land, local Natives feel that they have historical rights to procure the salmon, in all of their seasonal manifestations, and use the river as they have for generations.

Apart from the importance of salmon, Copper River

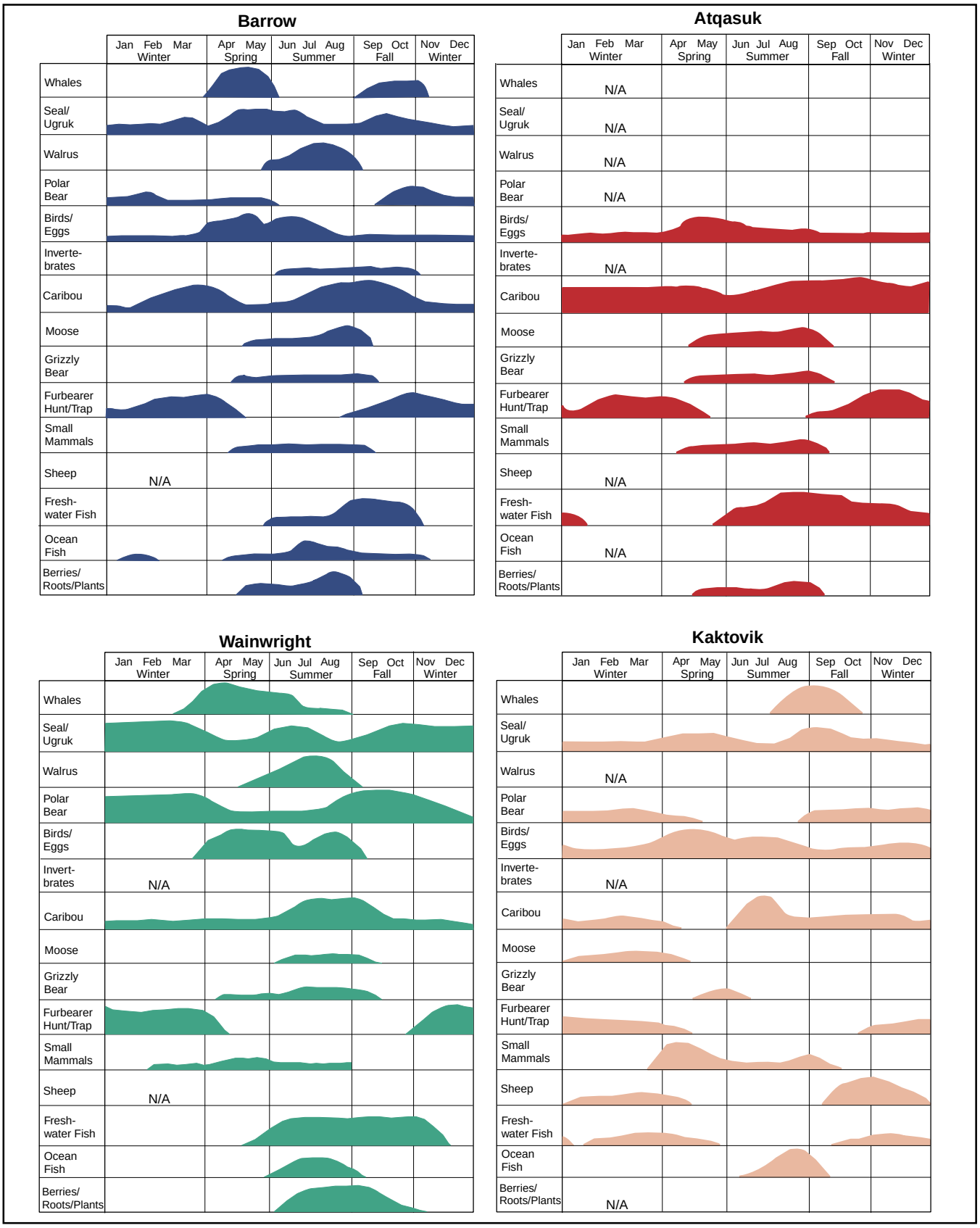


Figure 3.3-22. *Qualitative presentation of annual subsistence cycle for North Slope communities. Patterns indicate desired periods for pursuit of each species based on the relationship of abundance, hunter access, seasonal needs, and desirability. Heights of graphs indicate level of effort (after NSB Contract Staff, 1979).*

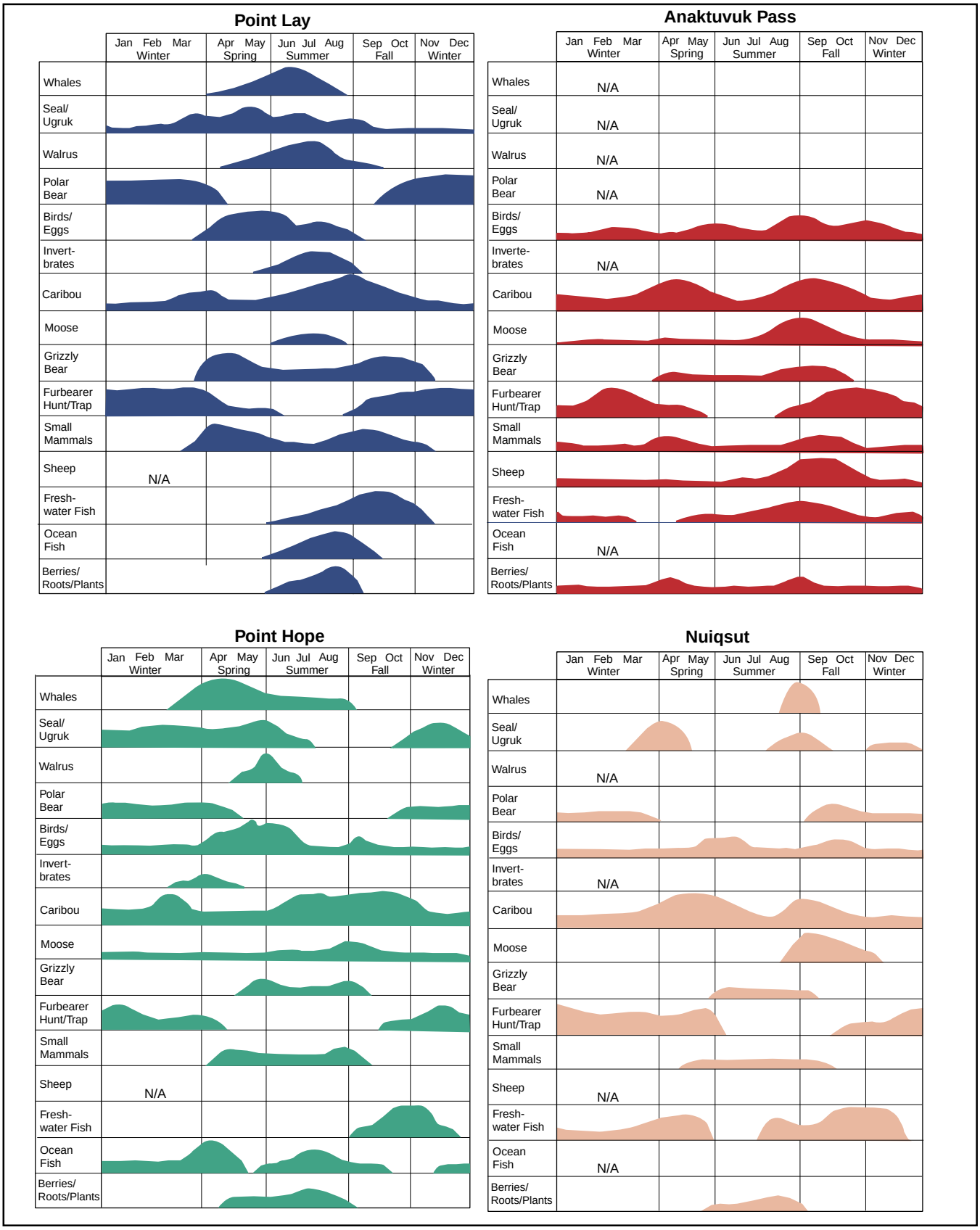


Figure 3.3-22. *Qualitative presentation of annual subsistence cycle for North Slope communities. Patterns indicate desired periods for pursuit of each species based on the relationship of abundance, hunter access, seasonal needs, and desirability. Heights of graphs indicate level of effort (after NSB Contract Staff, 1979).*

households harvest berries, caribou and moose. However, big-game hunting is seemingly restricted to less than half of the households in most of the communities; the implication is that even in those communities with large and diverse harvests, major resources are acquired by a minority of community members (Sheppard, 1999, p. 4). The use of minor resources such as freshwater fish or other large game tends to be idiosyncratic and depends primarily on local availability. Hunting of upland game birds may not be as significant to Alaska Natives as it is to non-Natives, but the use of porcupine and hare is favored by Native Copper River Basin Native inhabitants. Only those resources that are acquired in quantity or in "large packages" are primary sources of resource distribution. Shared resources include salmon, caribou and moose. Moose, in particular, are very important in traditional ceremonial activities.

Wiseman is a predominately white community, but the residents there are still actively involved in the practice of a subsistence lifestyle. For Stevens Village and Rampart, summer and fall salmon harvests are extremely significant subsistence activities (Betts, 1997; Borba and Hammer, 1996). Moose continue to be important, with the best harvest areas being along the Yukon River and associated sloughs and tributaries, and around inland lakes and meadows. The harvest of waterfowl and the procurement of small game are also important parts of the seasonal subsistence round. Berries and other wild plant foods are also collected, although their importance tends to vary along individual lines. Wiseman is best characterized as a mixed subsistence/cash economy lifestyle, although it may be that all Interior villages should be characterized in the same manner. Wiseman community members hunt, fish, gather berries and greens for food, and run traplines for cash — the extent of their involvement with trapping depending on the price of fur. Wiseman residents procure moose, black and grizzly bear, Dall sheep, and a variety of small game and furbearers such as wolf, lynx, marten, fox, beaver, mink, weasel, snowshoe hare, grouse, ptarmigan and marmot. When caribou occasionally venture into the Wiseman area, they are pursued (Scott, 1993, p. 23).

Valdez/Prince William Sound

Throughout the twentieth century, people harvested wild resources for trade and sustenance, adapting their harvests to the changing environmental and cultural conditions. Although the cultural matrix of subsistence has changed, the current residents of the PWS region, particularly the villages of Chenega Bay and Tatitlek, continue to rely heavily on subsistence fishing and hunting for their food. As in many areas of Alaska (Wolfe and Bosworth, 1994), PWS residents participate in a mixed subsistence/cash economy. Subsistence foods provide PWS residents, particularly villagers, with some economic stability and a strong measure of cultural identity.

As in other regions, each community in PWS has a unique resource-harvest cycle that fluctuates with changes in resource availability, weather conditions, seasonal employment opportunities, and in smaller communities, the productivity of certain key harvesters. The annual harvest cycles are described in detail for Chenega Bay (Stratton and Chisum, 1986), Tatitlek (Stratton, 1990), Cordova (Stratton, 1992), and Valdez (Tomrdle and Miraglia, 1993).

Salmon and other fish including halibut and herring remain a vital and generally available subsistence resource, and are taken in large quantities during the spring, summer, and fall by residents of all communities. The spring herring spawn (with roe on kelp and other delicacies) is particularly valued among villagers from Tatitlek and Chenega Bay. Marine mammal harvests have varied as their populations have fluctuated, but sea lions and when available, harbor seals are taken opportunistically by Alaska Native villagers throughout the year. Deer and moose hunting by residents of all PWS area communities occurs in the fall and extends into winter. Waterfowl hunting primarily occurs in the fall, and black bear hunts in spring and fall. Intensive shellfish harvests occur during spring, and berry gathering is a fall activity. During summer, a spirit camp at Nuchek on Hinchinbrook Island has been instrumental as a forum for area youth to learn harvesting, processing, and traditional values from village elders.

3.3.3.4 Subsistence Harvest Patterns

This section provides data on subsistence harvest patterns for communities in the North Slope, Central TAPS, and Valdez/PWS study areas. Following is an overview:

- Subsistence has central importance to the communities in the study areas. A subsistence discussion is found in all ERs and EISs addressing oil and gas developments in Alaska. Selection of the proposed action or no-action alternative could, in principle, affect subsistence (see Section 4).
- Historical impacts of operation of TAPS and ANS fields on subsistence are difficult to assess, because comparable, accurate, and relevant pre-TAPS harvest data are not available for all communities.
- Quantitative harvest data are useful, but measure only one aspect of subsistence.
- Except where otherwise noted, harvest data are presented below in terms of aggregated categories in-

cluding marine mammals such as bowhead whales, walrus, seals, and sea lions; terrestrial mammals such as caribou, moose, and bear; fish (most importantly salmon, but an "other fish" category is also provided); and "other" (a broad category including birds, eggs, and vegetation). These categories facilitate interpretation of the graphs. (References contain more detailed subsistence-harvest data.)

- Because there is substantial variability in annual harvest data, data are presented for several years when available. Data from only one year provide a less precise estimate of typical harvests.
- Data are presented for the latest year(s) available, but data from more recent years may be more representative of actual harvest patterns.
- Year-to-year variation in the per-capita harvest is magnified by the fact that some species have a disproportionate effect on harvest totals. For example, bowhead whales weigh 2,000 pounds at birth and range to a maximum size of about 60 feet with a weight of 120,000 pounds (ADF&G, 1994a). A small difference in the number of bowhead whales harvested by a community translates to a large variation in per-capita harvest.
- Reported harvest data are in various units of measurement, including total pounds (dressed pounds),[5] pounds per household, and pounds per capita. Where possible, harvest data are expressed in common units of pounds (dressed) per capita (lb/capita).
- Harvest data differ from consumption data (available for same areas) on a community-by-community basis. Some communities use part of the harvest for sharing with others. However, harvest data provide a more relevant measure of economic importance and are presented in this section.
- There are statistically significant community-to-community differences in per-capita harvest. Wolfe and Walker (1987) performed a careful statistical analysis of harvest data. They found that the amount harvested varies substantially among communities. (There are also significant differences between rural and urban communities [ADF&G, 1994]). These differences are reflected in the data presented below.
- Significant community-to-community differences exist in the composition and size of the harvest. Bowhead whale harvesting, for example, is confined to some of the North Slope communities. Fishing is important in many areas, but typically accounts for a majority of the harvest in the Central TAPS and Valdez/PWS study areas.
- The monetary value of subsistence harvests is substantial when compared with cash incomes of families in many rural areas (ADF&G, 1994). The "replacement value" of subsistence harvests in comparison to cash income varies with the region of Alaska.[6]
- Harvest success is a complex function of effort, technology, population dynamics, migratory routes, weather conditions, ice and sea conditions (for marine mammals), availability of food, population of predators, competition from nonlocal hunters, regulatory-agency management policies, and industrial activity. These variables are intercorrelated and their effects are difficult to distinguish.

North Slope Communities

This section uses quantitative subsistence-harvest information from a number of additional sources (ADF&G, 1999f; Harcharek, 1995; Shepro and Maas, 1999; Hall et al., 1985; Brower and Opie, 1996, 1997; S. R. Braund & Associates, 1988, 1989, 1993; and IAI, 1990a, b). This represents most if not all of the quantitative data available. Other information for selected resources and communities may exist but is not readily available. Bowhead whale harvests are the exception, as nearly complete information for this resource is available.

Anaktuvuk Pass. Only one year of subsistence harvest data is available from Anaktuvuk Pass (Brower and Opie,

[5]Harvest figures are converted from *round* to *dressed* weight. As noted in Wolfe and Walker (1987): "Although it varies by community and species, in general "dressed weight" is about 70 to 75 percent of round weight for fish, 60 to 65 percent of round weight for game, and 20 to 60 percent of round weight for marine mammals [whales, seals, walrus]. Dressed weight is the portion of the kill brought into the kitchen for use, including bones for particular species. It represents an estimate of the pounds of usable wild resources harvested by the sampled households during the study year."

[6]Determination of the appropriate "price" of various subsistence harvests in "replacement value" studies is not straightforward, because subsistence harvesting has a social as well as economic component, many species have no established market price (some are not permitted to be sold by law), and other challenges exist to a comprehensive methodology. To illustrate, National Oceanographic and Atmospheric Administration (NOAA) rules (50 CFR 230.4) contain a number of prohibitions relating to aboriginal subsistence whaling. For example, only licensed whaling captains or crew under the control of those captains may engage in subsistence whaling. They must follow the provisions of the relevant cooperative agreement between NOAA and a Native American whaling organization (e.g., Alaska Eskimo Whaling Commission), the aboriginal hunters must have adequate crew, supplies, equipment, and they may not receive money for participating in the hunt. No person may sell or offer for sale whale products from whales taken in the hunt, except for authentic articles of Native handicrafts. Because these rules specifically prohibit sale of whale meat, a "market price" is difficult to establish. (For details, see www.polarpub.com.)

1996). For the 1994-95 season, caribou constituted 83 percent of the community's total subsistence harvest. This is consistent with Binford's estimate that 85 to 88 percent of the Anaktuvuk Pass "subsistence diet" consisted of caribou (Binford, 1978). Moose and sheep accounted for 13 percent and fish about 4 percent of the harvest. The number of caribou taken was estimated at 311 animals, yielding 444 pounds of edible meat per household (148 lb/capita). This was reported to be a "low caribou" year, which is supported by the number of caribou estimated to be taken in prior years: 592 in 1990, 545 in 1991, 600 in 1992, and 574 in 1993 (ADF&G, 1999f). Pounds of edible meat per household varied from 846 to 985 (282 to 328 lb/capita) for these years.

Caribou is the most important subsistence resource harvested by Anaktuvuk Pass residents. However, they consume a much wider range of resources obtained through sharing or other exchanges with residents of other communities (Harcharek, 1995; Shepro and Maas, 1999). When caribou are less available, secondary resources such as moose, sheep, and fish become more important, but cannot fully compensate for the "missing" caribou (NSB Contract Staff, 1979).

Anaktuvuk Pass residents have expressed concern that ANS oil and gas development and associated activities (particularly at Alpine and NPR-A) may adversely affect the number of caribou that pass through this area. This number is a complex function of population size, possible shifts in habitat use, the number and location of natural predators (wolves in this case), hunting pressure and human presence (possible avoidance behavior), as well as industrial development. Caribou harvested by Anaktuvuk Pass villagers come principally from the Teshekpuk Lake Herd and the Western Arctic Herd — as opposed to the Central Arctic Herd. Available data indicate that the size of both of these herds have increased in recent years and are currently stable (see Section 3.2).

Barrow. Three years of quantitative data are available for Barrow: 1987 to 1989 (Figure 3.3-23). Marine mammals and caribou are both extremely important for Barrow residents, and especially for Barrow Iñupiat residents (Harcharek, 1995; Shepro and Maas, 1999). Because of its size and the relatively wide distribution of the resources upon which its population depends, Barrow's community subsistence harvest varies less from year to year than for the smaller NSB villages. (Whaling is discussed in a separate section below.)

Kaktovik. A complete subsistence-harvest survey was conducted in Kaktovik in 1985, 1986, and 1992 (Figure 3.3-24). In addition, a survey of caribou harvest was com-

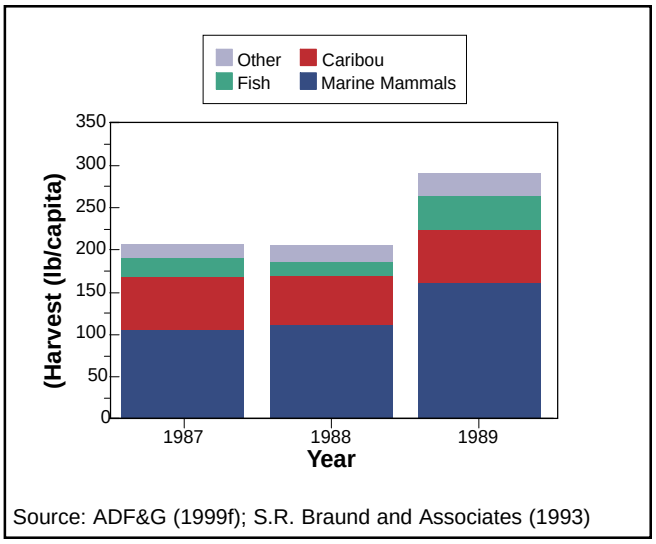


Figure 3.3-23. *Selected summary quantitative subsistence-harvest data, Barrow.*

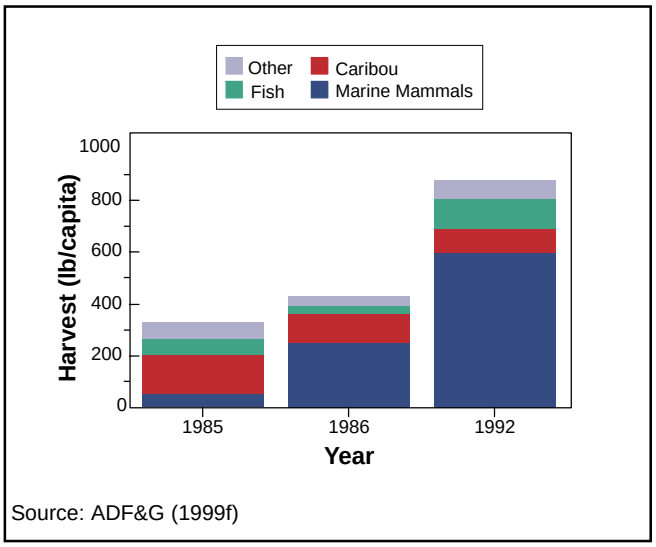


Figure 3.3-24. *Selected summary quantitative subsistence-harvest data, Kaktovik.*

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Photo 3.3-21. *Butchering a whale at Barrow.*

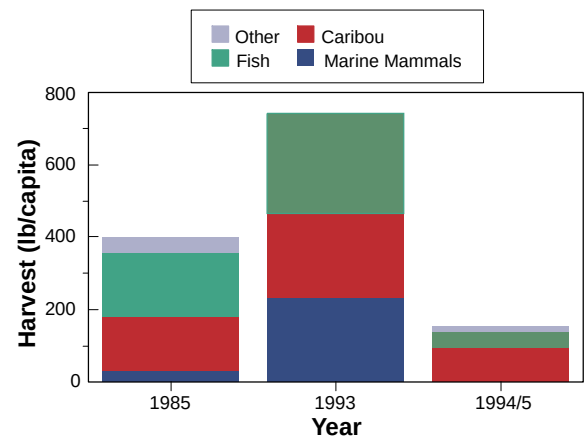
pleted in 1987, 1990, and 1991. The total caribou harvest was reasonably consistent, averaging approximately 21,000 lb/yr, with the exceptions of a somewhat low figure in 1990 and a peak in 1985, which was a year in which no bowhead whale was landed in Kaktovik. (Some Kaktovik residents were members of successful crews which whaled in other villages.) Thus, increased caribou hunting could have been a response to the lack of a bowhead harvest. It should also be noted that while three bowheads were taken in both 1986 and 1992, those taken in 1992 were much larger. The per-capita harvest of marine mammals in 1992 was twice as high as that in 1986. In 1986, significantly more caribou were harvested in terms of edible pounds per capita than in 1992. Fish are also a significant subsistence resource.

Nuiqsut. A complete subsistence-harvest survey was conducted in Nuiqsut in 1985, 1993, and 1994-95 (Figure 3.3-25). Of note is that Nuiqsut harvested a bowhead in only one of these years. However, their success rate has been such that 1993 was actually the more typical year. Conceptually, the Nuiqsut subsistence harvest can be divided into thirds — a third each for fish, caribou (and moose), and marine mammals. Years when whales are not harvested require more use of fish and caribou, as reflected especially in 1985. The overall harvest in 1994 and 1995 was significantly less than in the other two years.

Bowhead Whales. The harvest of bowhead whales is one of the most important subsistence activities for several communities on the North Slope and merits more discussion. The EIS for NPR-A (BLM and MMS, 1998) notes that the "bowhead whale is the preferred meat and the subsistence resource of primary importance [to several communities on the North Slope], because it provides a unique and powerful cultural basis for sharing and community cooperation... In fact, the bowhead could be said to be the foundation of the sociocultural system."

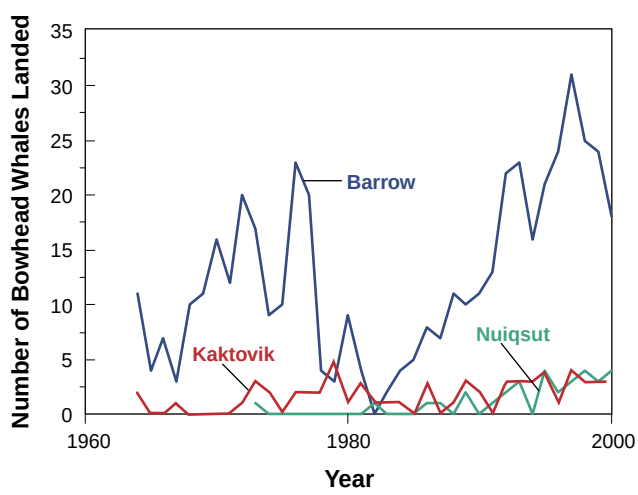
The communities of Little Diomede, Savoonga, Gambell, Wales, Kivalina, Point Hope, Wainwright, Barrow, Nuiqsut, and Kaktovik participate in whaling activity to various degrees. Barrow is the most important in terms of total harvest. Figure 3.3-26 shows a time series of the number of whales harvested for Barrow, Kaktovik, and Nuiqsut from 1964 to 1997. The harvest has been quite variable. Factors contributing to this variability include quotas, level of effort, weather, ice conditions, and whale migration routes.

The Iñupiat people used traditional methods of whaling until the mid-1800s. Beginning in 1848 (USACE, 1999), commercial whalers began to use new weapons and techniques that made hunting more effective — ultimately decimating whaling stocks. Subsistence whaling returned to low levels at the end of the commercial whaling era in the 1920s. More recently, the harvest increased to the point that there was concern over possible over-harvesting (USACE, 1999). Based on erroneous estimates of the bowhead whale population, the International Whaling Commission (IWC) voted to ban aboriginal hunting rights to the bowhead whale in 1977. Alaska Natives formed the Alaska Eskimo Whaling Commission (AEWC) to organize the whaling communities, fight this ban, and argue for revised quotas. New studies revised upwards the estimated bowhead whale



Source: ADF&G (1999f); Brower and Opie (1997a)

Figure 3.3-25. *Selected summary quantitative subsistence-harvest data, Nuiqsut.*



Sources: S.R. Braund and Associates (1993) cited in USACE (1999); Richardson (2000. pers. comm.)

Figure 3.3-26. *Documented annual bowhead-whale harvest for Barrow, Kaktovik, and Nuiqsut, 1964-1997.*

population to 8,200 in 1993.

The subsistence harvest of bowhead whales in Alaska is now managed by a cooperative agreement between the AEWC and the National Marine Fisheries Service, with oversight by the IWC. The cooperative agreement was enacted to meet IWC requirements, and provides local management. Harvest quotas are determined from estimates of the size and growth rate of the bowhead whale population and from the number of whales landed per capita and the population size of each Alaska Eskimo community. Enforcement of the bowhead harvest quota is based on the honor system where each community is given a number of strikes. A percentage of the unused strikes can be carried over to the next year, and within a year unused strikes can be transferred between communities.

The AEWC is now charged with allocation and enforcement of quotas.[7] Quotas apply to the number of whales struck (e.g., by harpoons) and/or landed and have increased from 20 struck/14 landed in 1978 (USACE, 1999) to 75 strikes in 1999 (including some carryovers from previous years). The AEWC allocates this quota among the ten whaling communities. Thus, the observed harvest data shown in Figure 3.3-26 reflects changing quotas as well as hunt success.

Weather, ice and sea conditions, and availability of food affect the bowhead whale migration (USACE, 1999). Changing weather affects where whales are encountered and harvested in any year. When whalers must travel farther to find whales, costs are higher, as are the chances of being caught in bad weather and of meat spoiling.

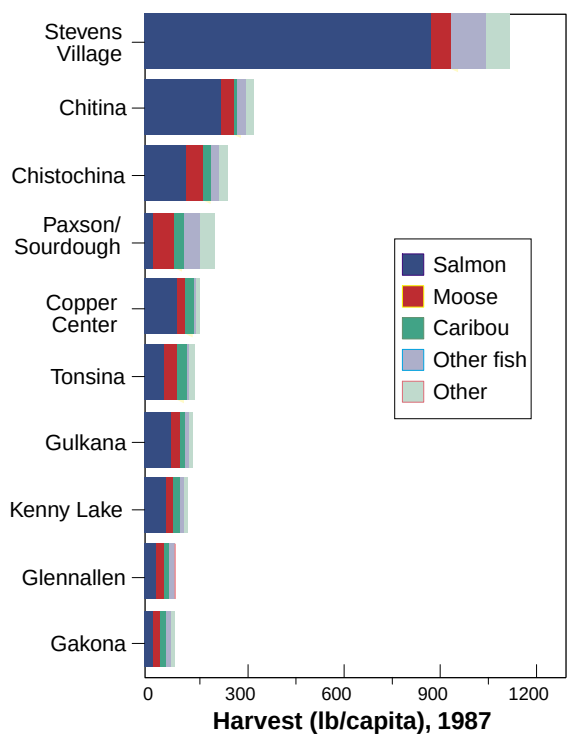
Alaska Natives are concerned that oil and gas development activity on the ANS will adversely impact the harvest because, among other reasons, whales sometimes avoid loud noises. Seismic exploration activity is of particular concern. This impact is not associated with operation of TAPS, but rather with exploration and production activities on the ANS and is discussed further in the section on cumulative impacts.

Central TAPS Study Area

Subsistence harvest patterns for the communities in the Central TAPS study area are not as well-researched and described as subsistence activities in PWS and on the North Slope. Subsistence harvest information for the Copper River Basin communities is more complete than elsewhere in this study area. Even there, the quantitative data are limited to one or two years of observation and are often reliable only for selected game species and fish stocks. Most ADF&G subsistence studies are community-based, although parts of Interior Alaska are summarized only at the regional level. Only those communities and areas that meet the "rural" and the "customary and traditional" criteria for subsistence-resource users as defined in ANILCA are described below. Only the Copper River Basin communities of Chistochina, Gakona, Gulkana, Kenny Lake, Chitina and Tonsina, and the central and northern communities of Stevens Village and Wiseman satisfy these criteria.

Figure 3.3-27 provides harvest data for Central TAPS communities for 1987 (Gerlach et al., 2000; Sheppard and Gerlach, 2000) ranked in descending order of the total harvest per capita. These communities differed significantly in total harvest in that year. Although there is substantial year-to-year variability, it is likely that these communities differ significantly in average subsistence harvest.

The overall importance of the various species harvested, in terms of the percentage contribution to the total, was quite similar. Salmon, for example, was the largest con-



Source: Gerlach et al. (2000); Sheppard and Gerlach (2000)

Figure 3.3-27. *Harvest data for rural communities in the Central TAPS study area, 1987.*

[7]The IWC quota for 1998 through 2002 is a total of 280 bowheads landed (average 56 per year). The number of bowheads struck in each of these years cannot exceed 67, with some exceptions for carryovers from previous years. Current village annual quotas set by the AEWC include 3 for Kaktovik, 4 for Nuiqsut, and 22 for Barrow (Richardson, 2000, pers. comm.).

tributor to the total in nearly all communities, typically accounting for about half of the total. Other fish were also important. Terrestrial mammals, including moose and caribou, accounted for a substantial fraction of subsistence harvests. Note the difference between the subsistence mix of these communities compared to those on the North Slope — among other things, these Central TAPS communities do not engage in whaling. Marine mammals are not harvested.

Copper River Basin Communities. Between 1982 and 1987, the total harvest for six Copper Basin communities increased from approximately 240,000 to 360,000 pounds. The total harvest went down for Gakona and Gulkana, with most of the decline accounted for by smaller harvests of moose and salmon. However, the harvest in other Copper River communities increased significantly during this period. Instead, these communities are best characterized in terms of tiers of resource use. At the lowest tier, only berries are commonly harvested. At the next level, households harvest salmon and berries. The most intensive usage is characterized by the harvest of salmon, caribou, moose, and berries. It should be noted that the hunting of big game is generally restricted to less than 50 percent of the households in all of the Copper Basin communities. Even in communities with large and diverse harvests, a minority of community members harvest the major subsistence resources.

Shared resources include salmon, caribou, and moose. A factor affecting the latter, in particular, is the central role of moose in potlatching and ceremonies which involve significant sharing of food among Alaska Native residents.

Alaska Native natural-resource use is based on historic rights to the use of specific fishing sites (Simeone and Fall, 1996). The presence of roads, proximity to population concentrations, and long-established use are responsible, in part, for the clustering of fish-wheel sites. Since ownership along the Copper River is dominated by Ahtna, Inc., and the National Park Service, there are relatively few areas where non-Alaska Natives establish fish-wheel sites (Simeone and Fall, 1996). Regulations restrict dipnetting to the Chitina area. For the last 20 years, trapping has not been a significant subsistence or economic activity.

Stevens Village. Harvest information for Stevens Village was collected by the Division of Subsistence, ADF&G, and by Doyon, Inc. (Sumida, 1988; Patterson, 1974). The ADF&G data were gathered in 1984-85 from 30 households representing 100 percent of the village. Salmon were harvested primarily by means of fish wheels and gill nets, with much of the harvest used to feed dogs. Other types of fish were harvested by setting traps or nets throughout the year (Sumida, 1988). Moose were usually harvested during the fall along rivers and sloughs, or from Yukon River islands accessible by boat. Bears were harvested incidentally to the pursuit of other subsistence activities. Waterfowl were harvested from lakes, ponds and sloughs in the spring, especially before breakup on the Yukon River. Both small and large game were hunted during the winter along with trapping. Berry picking occurred in the summer and fall in areas adjacent to the village and downstream in the Yukon River Canyon. Wood harvesting took place year-round, with particularly favored locations upstream along the Yukon River. Moose hunting was an especially important subsistence activity in the fall.

Salmon accounted for the majority of the 1984 harvest. King salmon were particularly important in the community network of distribution and exchange (Sumida, 1988). The combination of whitefish and other fish species comprised about 10 percent of the total edible harvest. Although moose were an important subsistence resource and were highly sought after, the success rate for moose was lower than for most species. In 1984, the moose harvest contributed only 5 percent to the total harvest. Black bear and birds were also highly valued by community residents.

Rampart. Subsistence fishing is a significant activity in Rampart. Harvest levels for chinook and summer and fall chum salmon for 1995 are reported in Betts (1997). A reported 1,235 chinook, 1,104 summer chum, and 2,803 fall chum were harvested by 27 Rampart households in 1995. Using harvest tickets maintained by the ADF&G from 1990 to 1995, Betts (1997) determined that only 12 moose were taken during this period. With a stated commitment of Rampart residents to the importance of moose in their diet and culture, such a low number may reflect low moose numbers, underreporting or no reporting of game taken by local residents, or some undetermined cause.

In 1966, salmon were harvested primarily by means of fish wheels and gill nets both up and down the Yukon

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Photo 3.3-22. *Fish wheel on the Yukon River.*

River, as well as on side streams and creeks (Betts, 1997). Much of the chum harvest was used for redistribution or barter, since there are currently few dogs in the community. Other fish species were harvested with gill nets or with rod and reel. During the winter, nets were sometimes set under the ice, and hook-and-line gear was used for jigging through the ice. Salmon were widely shared in the community and are important for covered-dish suppers and potlatch ceremonies (Betts, 1997). Moose were said to be an important subsistence resource, with harvest typically occurring on or near the Yukon or near inland lakes and meadows. Moose meat was and is widely shared and is sometimes reserved for potlaches (Betts, 1997). Bears were usually harvested incidentally to the pursuit of other subsistence resources (Betts, 1997). Waterfowl were primarily harvested on waterways from boats, or on foot near inland lakes and sloughs in the spring (Betts, 1997). Hunting of both large and small game was typically done with rifles in relatively close proximity to the village, or incidentally to other subsistence activities. Berry picking was, and continues to be, important in the summer and fall, especially along the banks of the Yukon. Wood harvesting was accomplished by floating cut logs downriver in the fall, or by hauling them behind snowmachines or trucks in the winter (Betts, 1997).

The most complete subsistence-harvest information for the community as a whole is available in Patterson (1974) on the basis of information collected in 1973 and extrapolated from an incomplete database created by Doyon, Inc. The Patterson report is limited in many ways, such as the fact that it does not include information about the number of households participating in the survey or the village population size at the time of the survey. Total pounds harvested are reported to be approximately 46,000 pounds, but reliable harvest quantities by species are not available.

Wiseman. Wiseman residents practice a subsistence lifestyle. The best available subsistence information is an ADF&G study by Carol Scott for the 1990-91 harvest year, and the harvest summaries maintained by the Division of Wildlife Conservation, ADF&G, for Game Management Unit 24 from 1988 to 1995 (Scott, 1993). Wiseman residents hunt, fish, gather berries and greens for food, and run traplines as a source of cash. Moose, black bear, grizzly bear, Dall sheep, wolf, lynx, marten, fox, beaver, mink, weasel, snowshoe hare, red squirrel, grouse, ptarmigan, and marmot are harvested regularly. Caribou occasionally venture into the Wiseman area and are harvested when they do. The moose harvest is extremely important to Wiseman residents because this species provides such a large quantity of meat per animal (Scott, 1993). The amount of meat necessary to last through the winter varies with the number of children in a household. In years when hunting success is low for highly desired species such as moose, every effort is made to compensate by harvesting another species.

The practice of passing harvested resources around the community is an acknowledged and accepted part of the local lifestyle (Scott, 1993). Most residents consider the sharing of meat to be traditional, and a few also believe that sharing resources provides them with greater hunting success. How much is shared and who participates in the sharing vary from year to year. In part, the nature and extent of sharing depend on how much is harvested each year per household.

From 1990 to 1991, 87 percent of the Wiseman community was directly associated with trapping, so that at least one member of a household maintained a trapline. During this period, approximately 1,140 miles of established trapline were claimed and used, suggesting a large-scale pattern of land and resource use. Wiseman residents also actively garden and collect wild plants to produce a source of fresh vegetables and greens not otherwise available.

Valdez/Prince William Sound

This section incorporates quantitative subsistence harvest data for PWS from the ADF&G Subsistence Division reports (Fall, 1995; Fall et al., 1996; Fall and Utermohle, 1999; Stratton and Chisum, 1986; Stratton, 1989, 1990, 1992; Tomrdle and Miraglia, 1993), as well as data from the ADF&G Subsistence Division community profiles database (ADF&G, 1999f). The majority of the data were collected for studies undertaken by the ADF&G since EVOS to assess spill impacts and to collect data on subsistence-harvest restoration. Two studies (Fall, 1995; Fall et al., 1996) were conducted in association with the U.S. Minerals Management Service (MMS), and one (Fall and Utermohle, 1999) was undertaken jointly by ADF&G and the Chugach Regional Resources Commission. Maps of community-based harvest areas are published in most ADF&G studies and are also available at the ADF&G Subsistence Division. Before 1989, the available data (McNeary, 1978; Stratton and Chisum, 1986) did not rely on systematic household surveys.

Valdez. In 1993, the Joint Boards of Fish and Game ruled that Valdez was an urban area; i.e., subsistence was not a principal characteristic of the economy, culture, and way of life. A Valdez "Nonsubsistence Use Area" including the Valdez city limits was created in GMU 6D (ADF&G, 1999f). This meant that Valdez residents no longer qualified for priority use of fish and game on federal lands. Valdez residents now must apply for available Tier II permits to

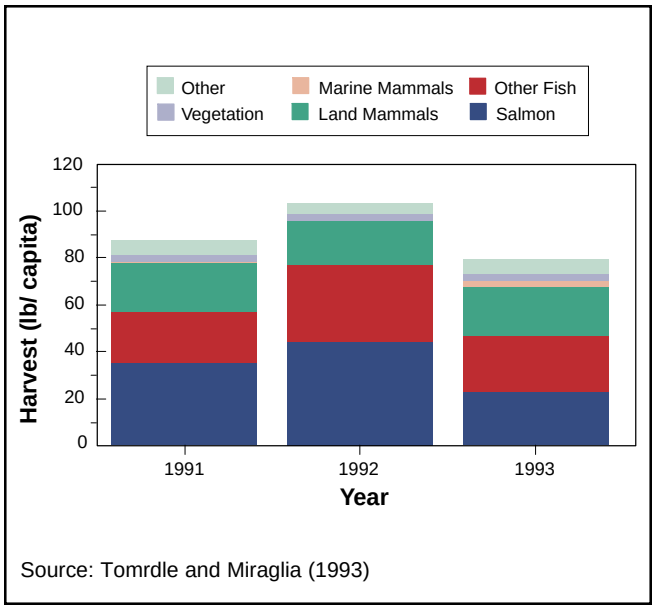


Figure 3.3-28. *Per-capita harvests of wild resources by resource category, Valdez.*

participate in the Nelchina caribou hunt. Under the 1999 state regulations, all residents qualified for subsistence use of fish and game on state lands.

The ADF&G Subsistence Division, under contract to the U.S. Forest Service, conducted the only systematic survey of Valdez harvest patterns in 1991 and 1993 (Figure 3.3-28). Measured in pounds of usable weight, the wild resource harvests in Valdez in 1991 and 1992 were similar to the other road-accessible and mostly non-Alaska-Native communities of Kenai and Homer (Tomrdle and Miraglia, 1993). Compared to the Alaska Native villages of Chenega Bay and Tatitlek, harvests at Valdez were much lower. Use of fish and wildlife is widespread in Valdez. For some households, it is very important economically and socially. Nevertheless, for most households, wild-resource harvesting is peripheral to cash employment and regarded mainly as an opportunity for recreation and enjoying the natural environment.

Tatitlek. As Stratton noted (Stratton and Chisum, 1986), household participation in subsistence during the 1980s was "virtually universal" in Tatitlek. The average household used roughly 20 different kinds of wild resources. Marine mammals (sea lions and harbor seals) and fish (including salmon, halibut, rockfish and herring spawn) made up a significant portion of the harvest. Salmon generally are harvested from commercial catches using gill nets or purse seines, from subsistence nets, and from rod and reel. The primary harvest areas are the waters near the village, including Tatitlek Narrows, Port Fidalgo, and Valdez Arm, as well as the Copper River flats (Stratton, 1990). Herring and herring-roe availability and locations fluctuate annually. Other fish, including halibut, black cod and others, are taken commercially, and some are used for subsistence purposes. Marine invertebrates are also harvested locally and during commercial fishing. Marine mammals have traditionally been taken in PWS, but recent population fluctuations have been evident in the variability of the harvest. Deer, with some moose, goat, and black bear, are the primary terrestrial mammals harvested in the region. The northern part of PWS and Montague Island were the primary deer-hunting locations.

Subsistence is an essential aspect of life in Tatitlek, with most residents involved in harvesting, using, and sharing wild resources. Figure 3.3-29 shows trends in per-capita harvests of wild resources (Fall and Utermohle, 1999). Since the decline right after EVOS, resource harvests have rebounded; however, local concerns remain about continued restoration of some resources and cultural values.

Cordova. The first published study of Cordova-area subsistence (McNeary, 1978) summarized harvest activities by drawing a distinction between local hunters and nonresident hunters. This study found few families practicing a total subsistence lifestyle; however, it noted that the majority of residents hunt and fish to supplement their income. The study found that 10 to 20 percent of the population lived a combined subsistence and cash economy.

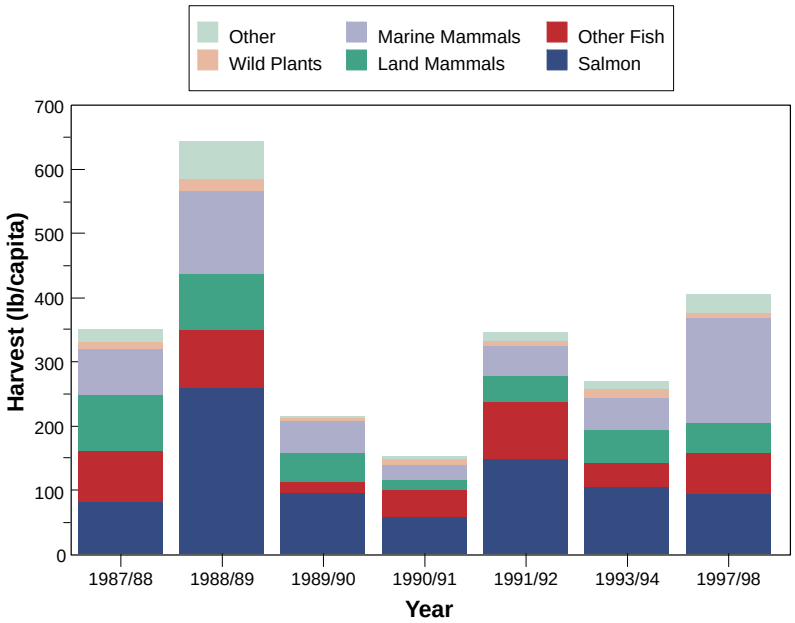
Equal consideration of subsistence use of coastal resources was noted as one of the objectives in the Cordova Coastal Management Plan (Alaska Coastal Management Program, 1986), indicating the value people place on this aspect of resource use.

In 1999, according to ADF&G household subsistence surveys in Cordova, harvests of wild foods are at "substantial levels" and the range of wild foods is also notable (Stratton, 1992). Marine resources predominate the harvest, with salmon and other fish the largest categories by weight. Terrestrial mammals and shellfish are also substantial, reflecting Cordova's location adjacent to both marine and terrestrial ecosystems. The range of resources used has stayed relatively constant since the late 1980s (Fall and Utermohle, 1999), as shown in Figure 3.3-30.

Chenega Bay. Subsistence harvests in Chenega Bay have been diverse, including roughly 18 to 23 different wild resources per household. The data ADF&G has systematically collected for management purposes and for spill impact studies indicate a trend away from marine mammals toward salmon and other fish. Not including 1989-90 and 1990-91, which were disrupted by EVOS and cleanup, per-capita harvests since resettlement have ranged well above the 222 pounds per person of meat, fish, and poultry that

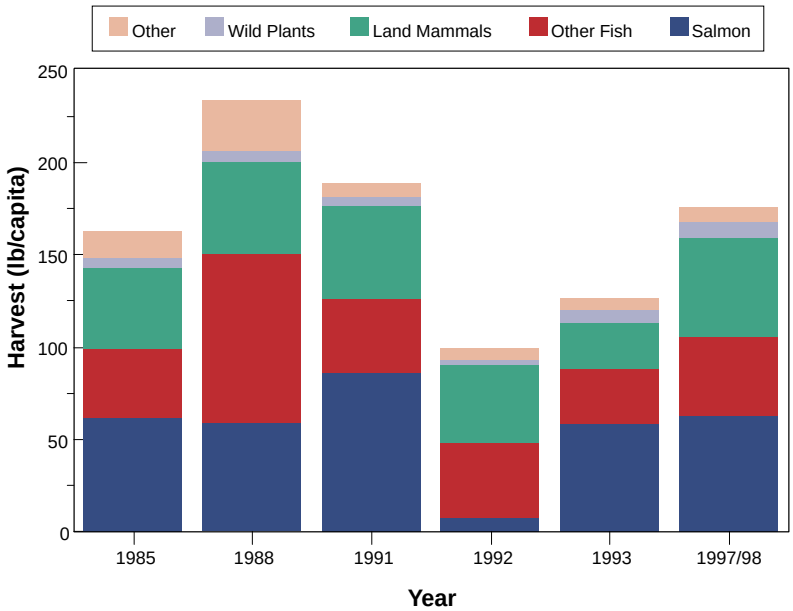
the average American family purchases annually, reaching a high of 577 in the 1997-98 study year.

The modern infrastructure of electricity, telephone, and improved mail service at the new Chenega Bay village has had major effects on hunting and fishing. Electric freezers have enabled villagers to store and preserve wild resources and store-bought groceries. Although the costs for fresh and frozen meat and groceries via mail order are high, telephone and mail-plane service to the new village makes that an option which was not available in the old village (Stratton and Chisum, 1986). The new airstrip has enhanced this process, and the dock (with water, showers, and



Source: Fall and Utermohle (1999)

Figure 3.3-29. *Per-capita harvests of wild resources by resource category, Tatitlek.*



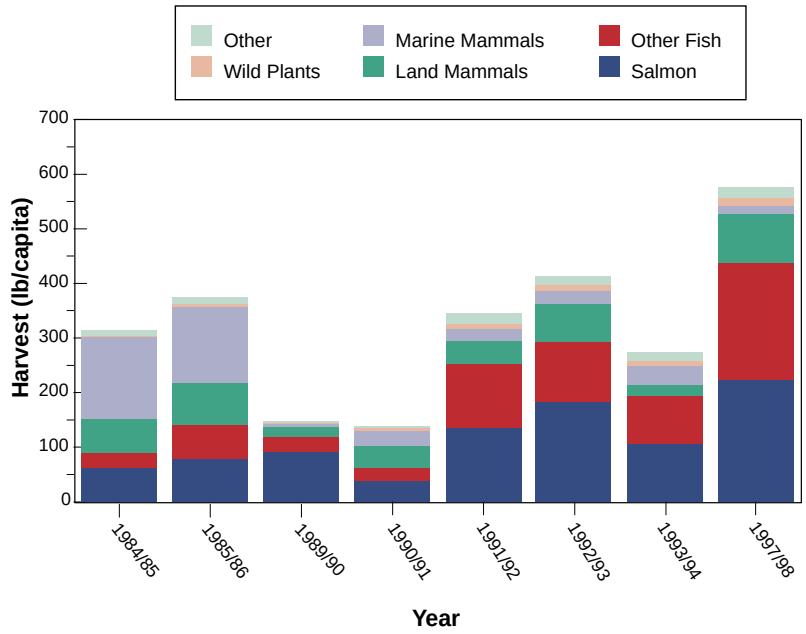
Source: Fall and Utermohle (1999)

Figure 3.3-30. *Per-capita harvests of wild resources by category, Cordova.*

a store) at the new village facilitates fish, shrimp, and crab sales and exchanges with commercial fishermen.

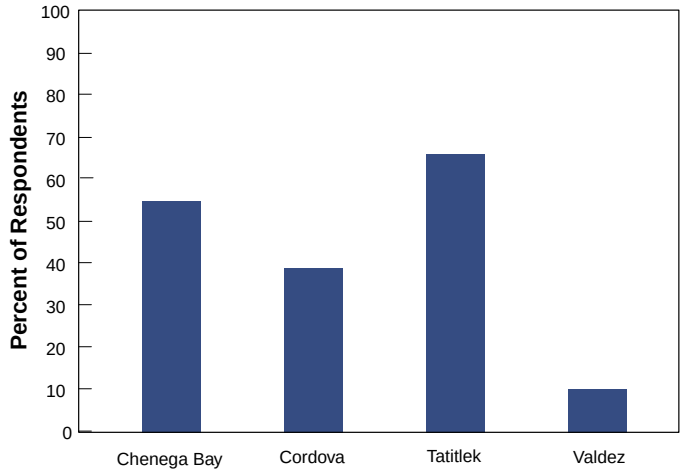
According to Fall and Utermohle (1999), most Chenega Bay households report that natural-resource populations have not recovered from EVOS. Particular concerns remain for populations of marine mammals and herring. Other concerns and issues affecting resource availability that have been raised in Chenega Bay include ocean pollution, climate change, over-fishing, and competition with other user groups. A majority of Chenega Bay households said their use of subsistence resources in 1997-98 was higher than before the spill.

Figure 3.3-31 shows trends in per-capita harvest in Chenega Bay (ADF&G, 1999f), and Figure 3.3-32 summarizes responses to a questionnaire (Tomrdle and Miraglia, 1993) regarding consumption of wild resources in four



Source: ADF&G (1999f)

Figure 3.3-31. *Per-capita harvests of wild resources by category, Chenega Bay.*



Source: Tomrdle and Miraglia (1993)

Figure 3.3-32. *Percent of respondents reporting eating any wild foods the day before, PWS communities, 1992.*

PWS communities. There are substantial differences in the fraction of respondents that consumed wild foods. By this measure, Tatitlek and Chenega Bay are quite similar and report significantly higher use of wild resources than Cordova or Valdez. The same conclusion is reached by comparing the per-capita harvest data presented in Figures 3.3-28 to 3.3-31; Tatitlek and Chenega Bay have a greater average per-capita harvest than Valdez and Cordova.

3.3.3.5 Access to Subsistence Resources

North Slope Communities

Historical subsistence access routes for the mid-Beaufort Sea area have been documented in BLM and MMS (1998). Other sources (IAI, 1990a, b) also discuss such routes for Kaktovik and Nuiqsut. Topographic features such as river valleys, shorelines, large lakes, the coastline, and geological formations such as pingos are crucial to the Iñupiat for navigating routes during trips on the land. For coastal villages, the coastline and navigable rivers are especially significant. Subsistence sites also commonly have a cultural resource or historical component, as part of the settlement pattern of the past (often a very mobile pattern), and are often in turn used as landmarks or navigational aids.

The Iñupiat also incorporate new technologies into their subsistence activities where advantageous. This process was evident at contact and continues through the present. Once snowmachines became reliable and affordable, they quickly replaced dog teams. Shallow-draft boats with engines enabled subsistence users to travel waters that before were barriers. Global positioning system (GPS) units allowed for route-finding without reference to landmarks. During whaling, each village has a standard set of named waypoints for local traditional landmarks that are entered into every crew's GPS unit.

Access to subsistence resources is predominately by boat when there is open water and snowmachine when there is not. Four-wheel all-terrain vehicles can provide access in either season under the proper conditions, but are generally not used for long trips. Travel between communities can be by boat or snowmachine, but is more commonly through commercial air carriers. Occasionally, subsistence hunters will charter a plane for transportation for hunting caribou or sheep, although the expense makes this the exception rather than the rule.

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Photo 3.3-23. *Snowmachine and baleen in Nuiqsut.*

Management and regulatory practices are a relatively new aspect of access to subsistence resources on the North Slope. These practices include restrictions or limited access on certain federal land: ANWR for Kaktovik subsistence users, Gates of the Arctic National Park for Anaktuvuk Pass (NPS, 1992), explicit or perceived exclusion of subsistence users from developed oil fields (Hopson, 1976), and the potential displacement of subsistence resources and/or subsistence users themselves by features of oil-field development such as elevated roads and pipelines (IAI, 1990b; Haynes and Pedersen, 1989).

Central TAPS Study Area

The type of access to subsistence-use and harvest areas is similar for all communities in this study area. Although regional differences exist from south to north in seasonal preferences for certain resources, methods of transportation to and from hunting areas, technologies used in the pursuit of fish and game, and techniques of procurement are similar. There are idiosyncratic and cultural differences in individual and group approaches, and each rural community has its own issues on access to subsistence-harvest areas by resident and nonresident alike. However, all Interior subsistence users are governed by the same federal and state regulations, and all use in one way or another the same means and methods to and from hunting and fishing areas. Moreover, rural Interior Alaskan subsistence users are generally subject to the same pressures from increased road access (e.g., the Dalton Highway) to traditional use areas by nonresident hunters from urban and suburban areas. For example, the state will continue to maintain the Dalton Highway, which will remain open regardless of the status of TAPS. The impact of TAPS on access to traditional subsistence-use areas occurred with construction and with development of the attendant transportation grid. Current impacts, such as a significant increase in nonlocal and nonresident hunters, result from increased use of the road system, rather than directly from pipeline operations.

Subsistence users throughout the Interior continue to incorporate new technologies in their hunting and fishing activities, typically in ways consistent with traditional cus-

toms, practices, and patterns of land use. Access to hunting areas is most often by road vehicle such as trucks and cars, by all-terrain vehicle (ATV), and/or by snowmachine. Snowmachines are now used along trail networks that may have been in existence for hundreds of years. ATVs are used in much the same way, with the exception being a more intensive use during summer and fall when there is little or no snow on the ground. Motorized boats are used in conjunction with nets and fish wheels throughout Interior Alaska, although preferred fishing sites are typically in areas of traditional significance. In a few villages, particularly in the northern part of the TAPS route, dog teams are still maintained and used. Section 811 of Title VIII of ANILCA guarantees access to federal lands through the protection of the right to use motorized vehicles on such lands. Many urban Alaskans are opposed to use of motorized vehicles for a traditional and customary subsistence hunt. Nonetheless, federal statute protects this right of access. As is true for the rest of Alaska, rural communities and areas are linked by commercial and private air carriers.

Valdez/Prince William Sound

The primary means of access for subsistence resources in PWS is by boat, including commercial fishing boats and skiffs. A large portion of the subsistence harvest is taken from commercial nets. Fishing boats and skiffs are used to catch bottomfish and marine mammals, and are used to access deer and goat hunting areas. Some Cordova and Valdez residents use small airplanes to travel to hunting and clamming areas in PWS and along the Gulf of Alaska coast. Some Valdez residents use the highway system to hunt caribou near Glennallen in GMU 13 and moose along the Richardson Highway, and some use snowmachines to hunt ptarmigan. Some area residents harvest intertidal resources and berries on foot within walking distance of the villages of Tatitlek and Chenega Bay, although skiffs and four-wheel-drive vehicles are also used.

3.3.4 Cultural Resources

By P. Bowers, B. Potter, C. Gerlach, and C. Wooley

3.3.4.1 Introduction

This section describes the cultural resources and cultural history along the TAPS ROW. The study area is divided on the basis of shared cultural traditions and similar environments into the North Slope, Interior or Central (Brooks Range divide to Pacific Coastal Mountains divide), and Valdez/Prince William Sound (PWS) study areas. These units of analysis are roughly equivalent to the historic territories of the Iñupiat (Eskimo), Athabascan (Indian), and Alutiiq (Pacific Eskimo) cultural areas.

Cultural resources are sites, districts, structures, buildings and objects that can provide information on prehistory or history. Under the guidelines of the National Historic Preservation Act (36 CFR 800), prehistoric or historic sites ("historic properties") are those that are listed in, or are eligible for inclusion in, the National Register of Historic Places (NRHP). For a site to be considered "historic," it must be more than 50 years old, unless it has exceptional national, state, or local significance. Specific locations may also hold significance for contemporary Alaska Natives as sacred sites (see Executive Order 13007, 1996) and traditional cultural properties.

Alaska's prehistory is still poorly understood, but research during the past three decades along the TAPS route, in North Slope oil and gas exploration and development areas, and in PWS has made significant contributions (e.g., Cook, 1970, 1971, 1977; Hall and Gal, 1988; Haggarty et al., 1991; Lobdell, 1986). In the TAPS study area, cultural resources of widespread ages are found in varied environmental settings and are represented by a remarkable diversity of site types. To provide some idea of the number and density of sites an area within 5 miles of either side of the pipeline or a haul road would include approximately 950 sites of potential historical interest. (The word potential is used because not all sites in this area have been evaluated in terms of criteria for listing in or eligible for inclusion in the NRHP.) Approximately 39 percent of the (950) sites are reportedly located within 0.5 miles of the pipeline centerline, 54 percent within 1 mile, 72 percent within 2 miles, and 94 percent within 4 miles.

Of the sites that are assignable to age, 61 percent are prehistoric or have prehistoric components, and 34 percent are historic; the remaining sites are categorized in various ways (e.g., historic Cold War, prehistoric/historic, protohistoric/historic). Sites are geographically concentrated in a number of areas reflecting both the intensity of research and the distribution of natural resources. Some of these 950 sites are Native historic and cemetery sites on native owned or selected land; there may be other Native sites not listed in state files.

Cultural sites are found in a wide variety of environmental settings. Among sites for which data are available on the environmental setting, approximately 49 percent in upland spruce forest, 23 percent in alpine tundra, 17 percent in moist tundra, and 17 percent in bottomland spruce forest (total adds up to more than 100 percent because a site may be listed in more than one category). Approximately 52 per-

C. Holmes, OHA

Photo 3.3-24. *Broken Mammoth Site, one of the oldest documented sites in Alaska.*

Peter M. Bowers

Photo 3.3-25. *Excavation of the Gallagher Flint Station archaeological site during TAPS construction. This important prehistoric site has multiple occupations spanning the Holocene (Dixon, 1975; Ferguson, 1997). This site is located 0.4 miles from the pipeline centerline on the North Slope.*

cent of sites are located near rivers and 7 percent near lakes.

Prehistoric sites in the TAPS study area include lithic chipping stations, hunting lookouts, campsites, villages, house pits and tent rings, caches, a caribou drive fence, quarry sites, a pictograph, and a rock shelter. Within 1.3 miles of the pipeline lies the Broken Mammoth site (Photo 3.3-24), one of the oldest documented sites in Alaska and, for that matter, in the New World. Multi-component and/or stratified sites are relatively uncommon. Most of the sites are surficial or shallowly buried because environmental factors do not permit burial through the accumulation of sediment over extended periods of time. Historic sites include the Prudhoe Bay discovery well (located north and east of PS-1) recently nominated to the NRHP, Alaska Native traditional land-use sites, roadhouses, cabins, homesteads, telegraph line stations, trading posts, grave sites and cemeteries, a shipwrecked steamboat, military sites, historic trails, gold rush towns, gold mining sites, gold dredges and associated ditches, railroad-related features, aircraft wreckage, and historically significant structures such as bridges.

TAPS cultural resources vary with respect to legal status. One site, the Gallagher Flint Station (Photo 3.3-25), is a National Historic Landmark. Six properties are listed on the NRHP, and another 16 are listed NRHP sites within the bounds of larger districts. There are three archaeological districts and three historic districts eligible for inclusion in the NRHP, and 13 are listed sites within the boundary of a property that has been determined eligible. At least 40 sites have been evaluated and determined not to be eligible for inclusion on the NRHP.

3.3.4.2 Cultural History of the TAPS Route

North Slope

The oldest (8,800 to 11,800 years ago) well-documented sites in northern Alaska are part of what some archaeologists refer to as the Paleoindian tradition (Figure 3.3-33). The oldest site on the North Slope, the Mesa Site, was discovered as a result of oil and gas exploration activities in 1978 (Kunz and Reanier, 1994; Reanier, 1995). Information from this site, along with other discoveries along TAPS, provides evidence of temporal and cultural connections with similar sites in more temperate latitudes. The Putu and Bedwell sites, overlooking the Sagavanirktok River, figure prominently in northern prehistory.

In 1970 and 1973, Alexander (1987) excavated the Putu Site — the first in Alaska said to have produced fluted projectile points (Figure 3.3-34) — and an associated radiocarbon date (11,500 years old). This suggested arctic fluted points were as old as those from the Clovis and Folsom cultures of mid-continental North America, and greatly influenced Alaskan archaeological thinking during the 1970s and 1980s. Although the Putu fluted points likely were not associated with the 11,500-year-old radiocarbon date, the Putu site suggests that lanceolate points similar to those from the Mesa site (Figure 3.3-34) may have persisted until 8,800 years ago in the Brooks Range (Reanier, 1995).

The nearby Bedwell site, which also contained lanceolate projectile points, has been dated to 10,500 years ago (Alexander, 1974; Reanier, 1995). The Hilltop site, located

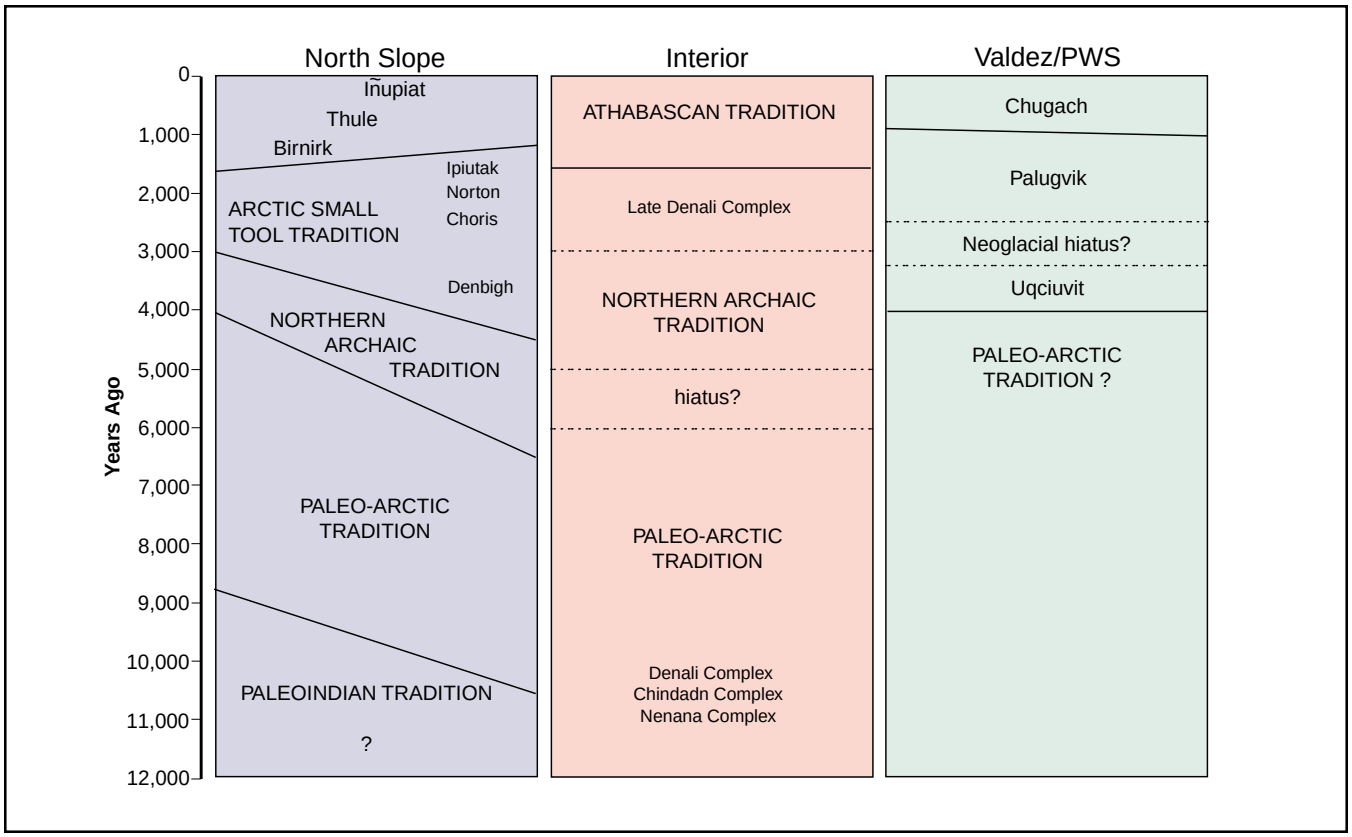
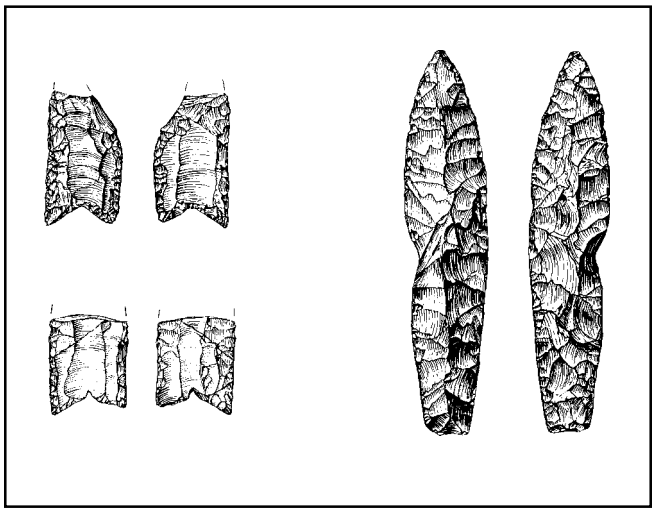


Figure 3.3-33. *Cultural chronology of the TAPS study area. This chart is provisional, because the categories evolve with new discoveries. Here, the term* culture *refers to discrete episodes of technological and environmental change that archaeologists can identify in sites. Archaeological "cultures" are theoretical constructs used to label the changing technologies and environmental adaptations seen in the archaeological record. The wider use of the term* culture *involves complex systems of behavior and beliefs usually not evident in the archaeological record.*



R. Reanier

Figure 3.3-34. *Fluted projectile points (left) and lanceolate points (right).*

on a bedrock knoll above the Atigun River, was also discovered during TAPS construction. The site contained lanceolate points and other Paleoindian tools similar to those from the Mesa Site, and was recently dated to 10,400 years ago (Reanier, 1995). Putu, Bedwell, and Hilltop each afford impressive views of the surrounding landscape and appear to have functioned as hunting lookouts and weapon repair stations. The Mesa Site and these three sites from along the pipeline route have shaped our knowledge of North Slope cultures at the end of the last Ice Age.

The American Paleoarctic Tradition (Anderson, 1970), a possible contemporary of the Paleoindian Tradition, is generally thought to date in the Arctic between 7,000 and 10,500 years ago; although recent evidence suggests it persisted to Mid Holocene times (Bowers, 1999; Ferguson, 1997). Certain stone tool types found in American Paleoarctic sites are remarkably similar to stone technologies from Northeast Eurasia. Paleoarctic sites from the North Slope include the Gallagher Flint Station (Dixon, 1975; Bowers, 1983; Ferguson, 1997) and the Lisburne Site (Bowers, 1982, 1999). The Gallagher Flint Station located between the pipeline and the Dalton Highway, was discovered and partially excavated by E.J. Dixon as part of the TAPS cultural resources mitigation program in 1970, 1971, and 1974 (Cook 1970, 1971; Dixon 1972, 1975). Bowers (1983) and Ferguson (1995, 1997) conducted later investigations. The site occupies more than 4,400 square meters

(m^2) of a large glacial kame, and is composed of 13 spatially-separated areas of past human occupation dated by 20 radiocarbon determinations. Materials recovered were mainly stone, although some wood, pottery, and bone was also recovered.

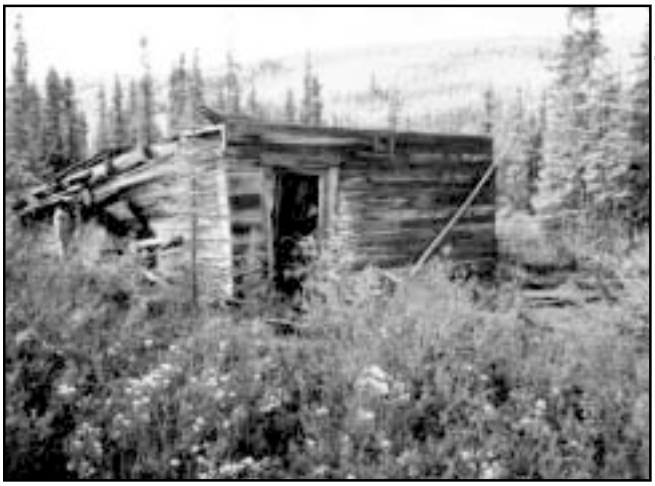
The site attracted international attention due to an old radiocarbon date of 10,500 years ago (Dixon, 1975) and stood for a number of years as the oldest evidence of people in Arctic Alaska. The date was reportedly associated with a core and blade industry thought to relate to Pleistocene Siberian cultures. A re-analysis of the dating and technology from Locality I of the Gallagher Flint Station suggests it dates instead to 7,000 years ago and is more closely related to the Mesolithic Sumnagin industries of Northeast Asia (Ferguson 1997, p. 26). In addition to the question of early human occupations of the North Slope, the site adds important though yet unpublished data on the cultural history of Northern Alaska, particularly on aspects of inland subsistence and settlement patterns, lithic technology, and hunting strategies. The site contains evidence of the American Paleoarctic, Northern Archaic, and Arctic Small Tool Traditions, spanning most of the Holocene Epoch.

More recent sites (appearing 6,500 to 6,000 years ago) include side-notched projectile point forms, a hallmark of the so-called Northern Archaic Tradition (Anderson, 1968). The broad occurrence of this point type throughout Interior and northern Alaska and the Yukon may represent the spread of a new boreal-forest-oriented cultural tradition (Anderson, 1984). The Northern Archaic is represented as well on the North Slope at sites such as Kuparuk Pingo (Lobdell, 1986).

Following the Northern Archaic Tradition, beginning roughly 4,500 years ago is a prehistoric culture referred to as the Arctic Small Tool Tradition (Irving, 1964), known for its tiny, finely flaked stone tools, and the oldest coastal sites. This dramatic change in stone-tool technology may mark the introduction of the bow and arrow and probably represents the origins of Eskimo culture on the North Slope. The original definition of the Arctic Small Tool Tradition has been expanded to include later cultures such as Choris, Norton, and Ipiutak, extending in time until about A.D. 900. Arctic Small Tool sites along the Arctic Coast include the Putuligayuk River Delta Overlook Site (Lobdell, 1981) and the Arctic Foothills Mosquito Lake Site, located next to TAPS (Cook, 1977).

The Mosquito Lake site lies adjacent to, and now partly beneath, the pipeline near the entrance to the Atigun Gorge. The site was discovered in 1966 by Herbert L. Alexander and was excavated in 1971, 1974, and 1975 during TAPS construction by Michael L. Kunz and others (Cook, 1977). Mosquito Lake is a large site with 17 occupation areas spread across a hillside above the Atigun River — 13 of the occupation areas were assigned to the Denbigh Flint Complex. The site provided important new data on the age of the Denbigh Flint Complex because in addition to a radiocarbon date of 3,500 years ago, it also yielded five dates between 2,000 and 2,700 years ago that suggested Denbigh persisted in the Brooks Range much later than previously thought. A recent study of Arctic Small Tool Tradition lithic technology analyzed artifacts from the Mosquito Lake Site (Wenzel, 1998).

Beginning in the first millennium of the Christian era, prehistoric inhabitants of the North Slope increased their reliance on hunting marine resources. The Birnirk culture, identified from the type site near Barrow (Ford, 1959; Stanford, 1976), suggests that marine-mammal hunting from strategic promontories may have become a preferred subsistence strategy. At the same time, however, terrestrial-mammal hunting, especially for caribou, remained important (e.g., Gerlach and Hall, 1988; Cook, 1977). Later, the Birnirk culture developed into the Thule culture, a ubiquitous arctic culture clearly ancestral to the present-day Iñupiat people. Subsistence was broad-based, with exploitation of both Interior and coastal resources. The historic Iñupiat people interacted with non-Native explorers, whalers, traders, and missionaries to form the rich cultural milieu known today on the North Slope. Aniganigaruk, a small historic winter village located near TAPS in the Atigun River valley, is an example of a site that has greatly expanded our knowledge of Nunamiut Iñupiat (inland Eskimo) origins and lifeways. James Corbin investigated the Aniganigaruk site in 1970-71 during TAPS construction



NLUR photo # TN98-3-29

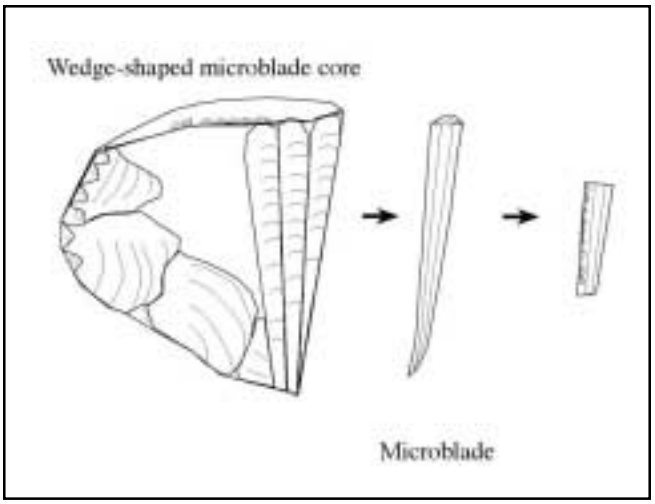
Photo 3.3-26. *Photo of historical site (LIV-299), a building associated with a mine operating from the 1930s to the 1940s in Vault Creek valley (Higgs, 1998). This site is located 0.6 miles from the pipeline centerline.*

(Corbin 1971, 1975). The site, dating to about 1880-90, consisted of at least 11 structures, 5 of which were excavated. This important site was the first arctic excavation which systematically documented the Nunamiut Iñupiat's primary house types, the *icelik* (skin tent) and *ivrulik* (winter moss house) (Corbin, 1975). Data from this early historic period site were also used to characterize the caribou antler industry of the inland Iñupiat.

Central TAPS Study Area

In the Interior, the late Pleistocene-early Holocene American Paleoarctic Tradition is represented at numerous sites, with its regional variant, the Denali Complex (West, 1967). The tradition appears to date slightly older in the Interior than on the North Slope (Holmes, 1998; West, 1996), although neither region is adequately studied. In the Tanana River drainage, "Chindadn" triangular points, which may predate the Paleoarctic microblade industries, have been found at the Healy Lake sites (Cook, 1969, 1975; Holmes and Cook, 1999), Broken Mammoth (Yesner, 1994), Swan Point (Holmes et al., 1996), and Chugwater (Maitland, 1986; Lively, 1988). These bifacially worked points are dated to 10,000 to 11,000 years ago at both the Broken Mammoth and Swan Point sites. The only clearly dated organic tools from this early period come from the lowest artifact levels at the Broken Mammoth Site. Three worked mammoth-ivory pieces suggest that these points were in use from 11,200 to 11,800 years ago (Holmes, 1996). Both the Broken Mammoth and Swan Point sites have addressed important issues relating to human subsistence and technology in the Late Pleistocene and Early Holocene (12,000 to 9,000 years ago) in Interior Alaska (Holmes, 1996; Holmes et al., 1996). Hearth dates associated with unequivocal artifacts from the lowest components at both sites yield estimates of almost 11,800 years ago — among the earliest in the Americas. The substantial preservation and diversity of faunal remains at Broken Mammoth, including bison, elk, caribou, small mammals, waterfowl, and salmonid fish elements, enable archaeologists to reconstruct past subsistence patterns (Yesner, 1996; Yesner et al., 1992). Swan Point contains the oldest microblade technology in Alaska (Figure 3.3-35) and supports the hypothesis that the earliest human migrants to Alaska used microblades (Holmes, 1998), in contrast with earlier interpretations based on data from the Nenana Valley (Hoffecker et al., 1993; Powers and Hoffecker, 1989).

Another site in the Interior that raises questions about the age of Alaskan fluted points is the Girls' Hill site. Girls' Hill was situated on the south side of the Brooks Range along the top of a bedrock knoll overlooking the Jim River



B. Potter, NLUR.

Figure 3.3-35. *Artist's conception of microblade and core.*

near Pump Station 5. The site was excavated before the knoll was used as a material source for TAPS construction (Gal, 1976). Girls' Hill was a rich site, with more than 7,000 microblades and numerous other artifact types, and radiocarbon dates that ranged from 1,900 to 4,500 years ago. Among the artifacts found at Girls' Hill were four fluted points, one of which was found within 50 cm (20 inches) of the sample which produced the 4,500 year-old date (Gal, 1976). The site figures prominently in the controversy over the age of Alaskan fluted points because Girls' Hill is the only site with fluted points associated with radiocarbon dates. The archaeological community remains divided over the age of these points, and Girls' Hill provides evidence for those who argue Alaskan fluted points are much younger than their southern counterparts in the Clovis and Folsom cultures.

The Northern Archaic Tradition is well-represented in Interior Alaska and along TAPS localities where notched points are found, including the mid-Holocene level at the Swan Point Site (Holmes et al., 1996) the Chugwater Site, and several sites found by Alyeska archaeologists in the Tolovana River area near Livengood (Derry, 1976). Use of microblade core and burin technologies appears to continue into or side by side with the Northern Archaic Tradition, as evidenced at Broken Mammoth, Swan Point, Gerstle River, Campus, and Delta River Overlook (Bowers, 1999; Mobley, 1991; Holmes et al., 1996). The so-called "Late Denali Complex" is poorly understood at this stage of research in Interior Alaska (e.g., Dixon, 1985), including sites such as Campus, Broken Mammoth, Swan Point, and Dixthada. The upper component of the Broken Mammoth site falls in a time range of 2,200 to 3,000 years ago (Holmes, 1996).

The Athabascan Tradition is a prehistoric-historic cul-

ture attributed to the northern Athabascan Indians of Alaska and northern Canada. These sites date from about A.D. 500 to A.D. 1880. Protohistoric (or late prehistoric) Athabascan sites include artifact assemblages predominately characterized by Native-made items (with an increased occurrence of organic and copper tools) and a smaller amount of non-Native trade goods such as iron and glass beads obtained through trade with Hudson's Bay Company and the Russian American Company (A.D. 1741-1850). Historic Athabascan sites (post-1850) generally have a mixture of log cabin and house pit dwellings affiliated with a larger percentage of Euroamerican artifacts. Several important Athabascan Tradition sites include Dixthada, and Swan Point (Holmes et al., 1996), Paxson Lake sites (Ketz, 1983), Dakah De'nin's village (Shinkwin, 1979), Taral (VanStone, 1955), and the Ringling Site (Workman, 1976; Arndt, 1977; Hanson, 1999).

The Ringling site is a late prehistoric Athabascan site located adjacent to a gravel quarry near the modern village of Gulkana. The TAPS-related archeological excavations at this site provided new information regarding the prehistory of the ancestors of the modern-day Ahtna people in the Copper River valley (Workman, 1976). Workman's extensive 1975 and 1976 excavations documented human use and occupation of the area during the first half of the second millennium A.D., including intriguing evidence of local copper artifact trade. The Ringling site, with its copper and obsidian artifacts and extensive history of use, provides important data for understanding the human history of the Copper River valley (Hanson, 1999).

At the time of direct Euroamerican contact in the nineteenth century, the study area was primarily used by several bands of Gwich'in, Koyukon, Tanana, and Ahtna Athabascans (McKennan, 1981; Andrews, 1977; Mishler, 1986). The basic historic Athabascan social structure included a group of families whose subsistence activities centered on procurement of both anadromous and freshwater fish and terrestrial game animals (Andrews, 1975; McKennan, 1981).

The Yukon and Copper river drainages have a documented Euroamerican history of less than 220 years, and during that time, the area experienced significant changes. Contact between the Ahtna and the Russians occurred in the eighteenth century, with trading forays into the Copper River Basin from PWS (VanStone, 1955). A trade monopoly was established that existed off and on until the sale of Alaska to the U.S. in 1867. Interior-Alaskan Euroamerican history began with an exploration phase followed by development of trading posts, roadhouses, and missions. Prospecting and small-scale gold mining occurred in the Koyukuk River area from the early 1880s, and small trading posts were established along the Koyukuk in the 1890s.

Coldfoot, an historic mining town adjacent to the pipeline, was founded in 1899 during the second gold stampede to the Middle Fork of the Koyukuk River. During its heyday in 1902-04, it consisted of stores, a post office, a gambling establishment, roadhouses, saloons, brothels, offices of lawyers and doctors, the Koyukuk Mining District Commissioner's office and the U.S. Marshall's office. Robin Mills excavated the site in 1994-95 and analyzed more than 18,700 historic artifacts from structural ruins, trash pits, and a privy. In addition to providing new detailed information relative to the material culture and commodity flows during the gold rush in Alaska, Coldfoot was used by Mills (1998) in the development of abandonment and settlement system dependency models in relation to early Placer gold mining in Alaska. The data gathered from Coldfoot largely corroborated expectations related to these models (Mills, 1998, p. 331-341).

The Klondike gold rush of 1898 to 1899 brought an influx of Euroamericans to the Alaskan Interior. The more successful posts eventually developed into settlements sustained by mineral-resource extraction, building a commercial center for Interior Alaska. Gold mining, especially in the Fairbanks mining district, provided impetus for development and settlement of the Interior. The growth of Fairbanks led to the development of a trail connecting Fairbanks to Alaska's southern coast. The historic Valdez-Fairbanks Trail, established in 1905, served as an overland link between the Pacific port of Valdez and Interior Alaska (U.S. Army, 1969). This route, which TAPS generally parallels, would not have been feasible without roadhouses and other facilities built to assist the freighters, mail contractors, miners, hunters, and other travelers.

The Valdez Trail lost its significance as the main terrestrial route to Fairbanks after completion of the Alaska Railroad in 1923. Sections of the original Valdez Trail were abandoned after construction of the Richardson Highway. With the onset of World War II, the Alaska, or Alcan, Highway provided the first direct overland route between the contiguous 48 states and Interior Alaska. Military bases built during World War II near the TAPS route include Eielson Air Force Base and Fort Greely. The wartime facilities eventually became part of the Cold War military buildup, training ground, and cold regions testing laboratory.

Valdez/Prince William Sound

The pre-European history of the PWS region is not well

understood because of the scarcity of systematic archaeological survey data and limited testing and excavation results. The Palugvik and Uqciuvit sites have been the focus of detailed analysis, although others have been tested recently (Yarborough, 1997). The earliest known occupation, the Uqciuvit phase, is thought to date between 4,400 and 3,300 years ago and includes evidence of marine-mammal hunting (Yarborough and Yarborough, 1996). A possible hiatus in the occupation of portions of PWS corresponding with the Neoglacial period (3200 to 2500 years ago) has been proposed (Yarborough, 1997) based on an occupational gap at Uqciuvit during the Neoglacial. Subsequent occupations between roughly B.C. 400 and A.D. 1100, identified as the Palugvik phase (de Laguna, 1956), and between A.D. 1000 and roughly A.D. 1700, identified as the Chugach phase, characterize the currently known regional prehistory. Splitting adzes (Photo 3.3-27) and stone lamps are associated with both the Palugvik and Chugach phase sites in Prince William Sound. No coastal sites were documented during TAPS construction in the Valdez area.

Detailed archaeological reconstructions of Chugach Alutiiq, Eyak, and Tlingit social life in the PWS/Copper River Delta area just before Euroamerican contact are also incomplete. Walker (1982) noted both semi-subterranean and above-ground plank houses in a village in the Tatitlek area in the 1780s, perhaps indicating both winter and summer structures at one site or possible cultural amalgamation of groups with two different house styles. Intergroup trade was a feature of life in the region during the 1700s, as Native Ahtna and Chugach Alutiiq people used a trail from Valdez over Thompson Pass into the Copper River Basin as a trade route. Intergroup warfare was also common, with the remains of numerous defensive locations present on elevated islets (de Laguna, 1956). The impact of industrial activity in the PWS region is evident in historic ruins near area shorelines including cabins, canneries, fox farms, copper mines, railroads, and oil and coal exploration sites, but only reconnaissance-level cultural-resource inventories have been conducted at these sites (Stern and Gibson, 1982; Buzzell, 1995; Haggarty et al., 1991; Haggarty and Wooley, 1992).

3.3.5 Land Ownership and Land Uses

By ClearWater Environmental, Inc. staff

3.3.5.1 Introduction

TAPS and its associated facilities are located primarily on public lands. Forty-seven percent of the TAPS ROW is on federal lands, and 43 percent of the TAPS ROW is on State of Alaska lands and State of Alaska lands which have been conveyed to municipalities and boroughs, reserving the TAPS ROW in the conveyancing documents.

C. Wooley

Photo 3.3-27. *Splitting adze from the PWS region.*

Private ownership consists of Alaska Native Corporation holdings (under ANCSA), Alaska Native Allotment parcels, and privately owned parcels in the Fairbanks, Delta Junction, Copper River Basin, and Valdez areas. With minor exceptions, valid rights-of-way for construction and operation of TAPS exist on all parcels, public or private. Refer to the land status maps in Appendix C for changes in land ownership trends adjacent to the TAPS ROW from 1972 to 1999.

3.3.5.2 Land Ownership

As of November 1999, the federal government (primarily the BLM) owned 47 percent of the lands within the TAPS ROW and the state government (including trust lands and municipalities) owned 43 percent. The remaining lands (10 percent) affecting the right-of-way are owned by ANCSA Native Corporations, Alaska Native Allotees, and other private landowners including the TAPS Owners, who acquired fee property at Pump Station 1, Pump Station 8, Pump Station 9, the Nordale Yard, the North Pole Metering Station, both sides of the Tanana River crossing, the Valdez Marine Terminal, approximately 2 miles in the Fox area including Engineer Creek, and five other small parcels.

Since acquisition of the TAPS ROW by the TAPS Owners, some parcels have been conveyed to private individuals and to other entities and/or subdivided into smaller plots and homesites. As a result, the number of individual private parcels underlying the ROW has increased from the original 196 in 1972 to 419 parcels in 1999 (the original 196 included 91 unpatented federal mining claims in the Middle Fork of the Koyukuk River area, the Treasure Creek area, and the Delta River-Phelan Creek area). With minor exceptions, all privately owned parcels are subject to perpetual right-of-way agreements acquired from persons in title when the TAPS ROW was acquired.

Table 3.3-12 provides a summary comparison of land

Table 3.3-12. *Summary comparison of land ownership of TAPS ROW from 1972 to 1999.*

	February 2, 1972			November 1, 1999		
	Feet	Miles	Percent	Feet	Miles	Percent
Federal	3,476,485 (a,c)	659	82%	1,984,104 (b)	376	47%
State	598,767	113	14%	1,815,869	344	43%
Municipality/Borough	547	0	0	547	0	0
Private (including Native ownership)	149,582	28	4%	424,861	80	10%
Total	4,225,381	800	100%	4,225,381	800	100%

Source: TAPS construction record drawings (G-100, Rev. 4, 12/95); Land Field Services, Inc. records.
(a) A significant amount of lands underlying the TAPS route transferred from federal to state ownership between 1972 and 1974, when the Federal Grant and State Lease were signed.
(b) This footage is exclusive of the right-of-way (8.7 miles) retained covering the replacement of TAPS pipe at Atigun Pass in 1990-91.
(c) Approximately 8 miles of federal lands underlying the TAPS route were encumbered by federal mining claim locations.

ownership of the TAPS ROW before construction (1972) and on November 1, 1999. Figure 3.3-36 is a sample of the maps contained in Appendix C showing land ownership.

Section 17(c) of ANCSA originally precluded the selection of any federal lands within the utility corridor withdrawal (PLO 5150, as amended) by the ANCSA Native Corporations. However, subsequent actions by the U.S. Congress and the Secretary of the Interior have authorized conveyances of TAPS corridor lands to the following Native regional corporations: Ahtna (38 miles), Chugach Alaska (11 miles), and Cook Inlet Region Incorporated (CIRI, 2 miles). These conveyances were made subject to the TAPS ROW.

In addition to lands obtained by these regional corporations, nine Alaska Native Allotments lying within the TAPS ROW have been conveyed to individual owners under the provisions of the Alaska Native Allotment Act. With one exception presently under negotiation, easements for the TAPS ROW have been acquired across all these parcels.

3.3.5.3 Land Use

The boundaries of the TAPS ROW from Prudhoe Bay to Valdez, as designed and acquired by Alyeska and the Owner Companies and approved by the federal and state regulatory agencies, are sufficient for the construction and operation of the pipeline, attendant facilities, construction and operation of the pump stations, the river training structures, the communication sites, and the fuel gas line. Other state and federal authorizations included airstrips, construction camps, access roads, material sites, pipe storage yards, disposal sites, and other specific-use sites. The TAPS ROW on public lands is a non-exclusive use, but other uses must be compatible. (See Section 11.C of the Federal Grant and Sections 17.c and 17.e. of the State Lease.)

Federal Lands

Major changes in both federal land ownership and land use designations have occurred in lands along the TAPS ROW, including special restrictions on use of lands within 5 miles of the Dalton Highway north of the Yukon River.

The most sweeping changes in land use designation occurred on federal lands adjacent to the federal utility corridor withdrawal (PLO 5150, as amended) as a result of the passage of the Alaska National Interest Lands Conservation Act (Public Law 96-4897) of December 2, 1980, commonly referred to as ANILCA. ANILCA provided for the disposition of lands as required by Section 17(d)(2)(A) of ANCSA. These are commonly referred to as the “d-2 lands.” This Act placed approximately 97 million acres into new and/or expanded parks and refuges and reclassified 25 Alaska rivers as wild and scenic (ANILCA Title VI).

Figure 3.3-37 indicates the location of current refuges, wilderness area, and parks in the TAPS vicinity. With the exception of the wild and scenic rivers (Delta and Gulkana rivers) which are subject to valid existing rights, there are no conflicting land uses on these federal park and refuge lands which affect the TAPS ROW. As a result, there should be no direct impact on these federal lands arising from ROW renewal.

The Delta and Gulkana Rivers Wild and Scenic River Management Plan recognize PLO 5150 (the utility corridor withdrawal) as amended.

State Lands

Concerning State of Alaska lands, there has been significant conveyancing activity from the State of Alaska affecting lands adjacent to TAPS since 1972. This activity falls into four major categories.

First, under Alaska statute AS 29.65, boroughs, unified municipalities, and cities are eligible to select state lands.

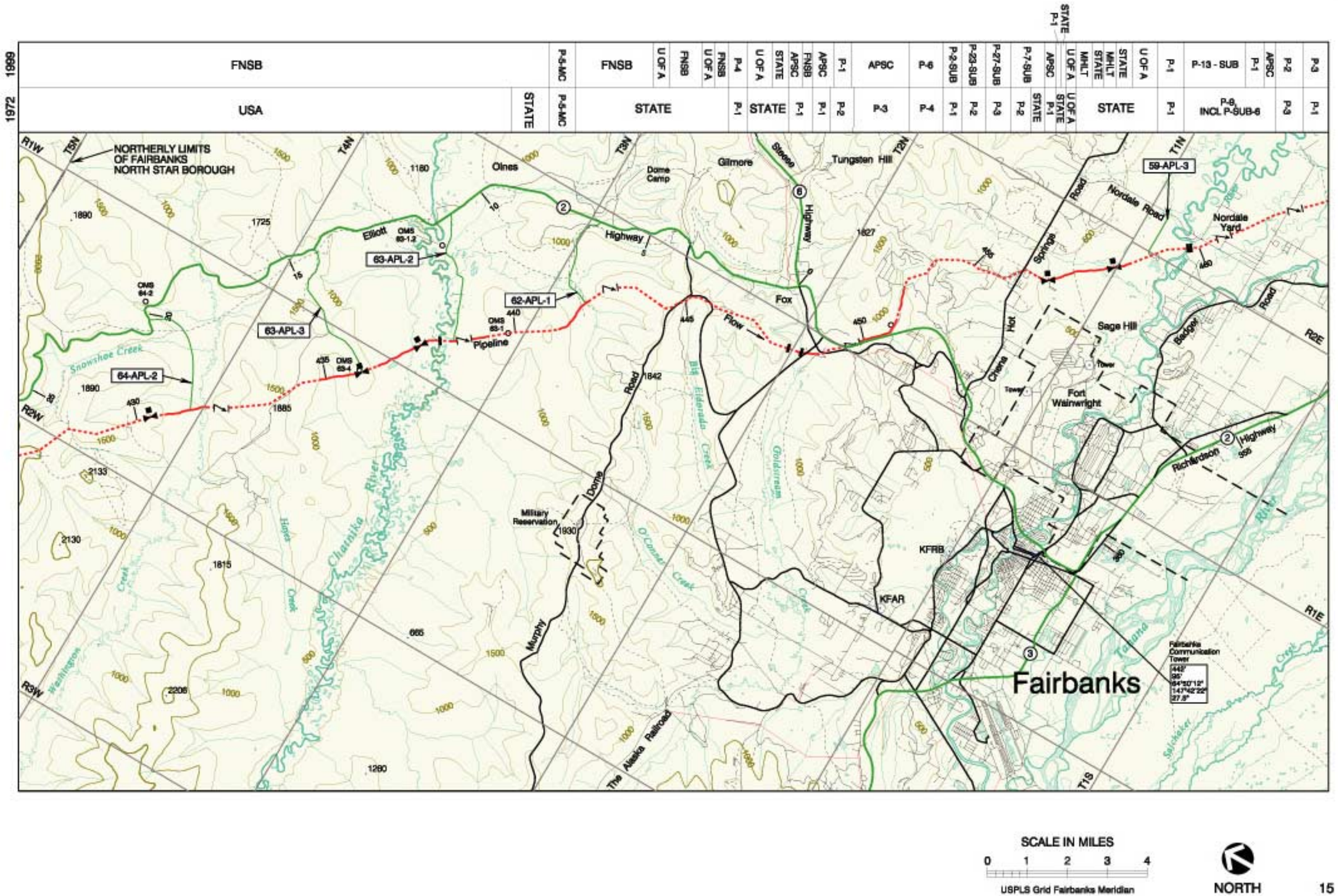


Figure 3.3-36.
Sample land ownership map from Appendix C.

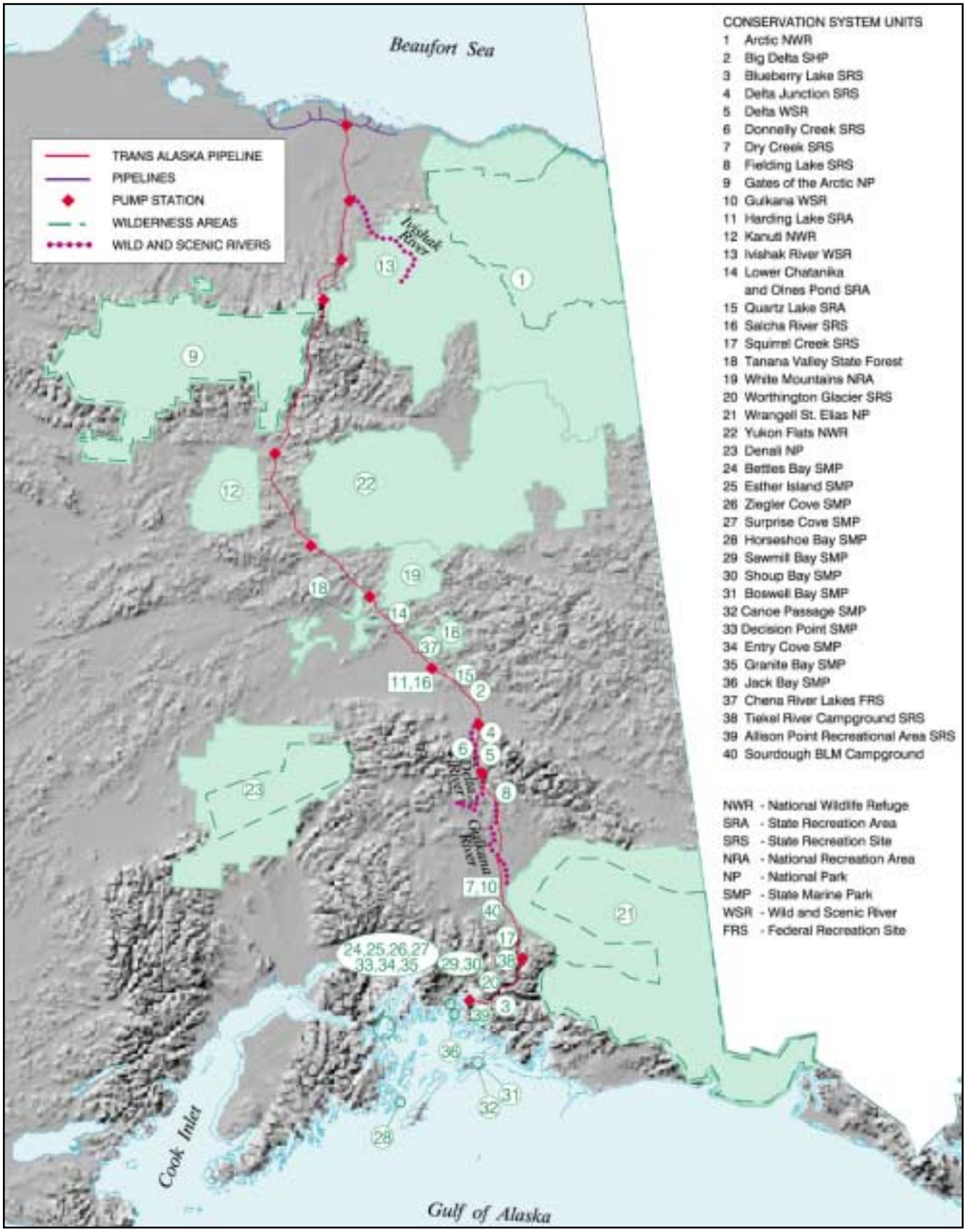


Figure 3.3-37. *Conservation system units in the vicinity of TAPS.*

Such selections have been made and include the North Slope Borough, the Fairbanks North Star Borough, the City of Delta Junction, and the City of Valdez.

Second, the University of Alaska has received title to several tracts of land from the State of Alaska adjacent to TAPS, and these lands are administered by the University of Alaska, Office of Statewide Land Management.

Third, the State of Alaska, Mental Health Trust Authority, has, through the auspices of the Mental Health Trust Land Office, taken title and administration of Mental Health selected lands adjacent to TAPS.

Fourth, there have been developed, by the Alaska Department of Natural Resources, several state subdivisions in the vicinity of TAPS, and these subdivisions have been partially or totally conveyed to private individuals for residential and recreational purposes. These subdivisions include:

- Donnelly Subdivision in Township 14 South, Range 10 East, Fairbanks Meridian, located along the Delta River, from which private lots have been sold to 12 individuals;
- Tazlina Northwest Subdivision in Township 3 North, Range 1 West, Copper River Meridian, located south of the Tazlina River, which includes sales to 7 private individuals;
- Alaska State Land Survey 79-42 located in Township 3 North, Range 1 West, Copper River Meridian, southeasterly of Tazlina Northwest Subdivision, which includes sales to 10 private individuals;
- Tazlina Southwest Subdivision located in Township 3 North, Range 1 West, Copper River Meridian, in the Yetna Creek area, which includes sales to 1 private individual;
- Copper Heights Subdivision located in Township 1 North, Range 1 East, Copper River Meridian, between Klutina River and Willow Lake, which includes sales to 3 private individuals;
- Willowcrest Subdivision located southeasterly of Copper Heights Subdivision in Township 1 North, Range 1 East, Copper River Meridian, which includes sales to 19 private individuals;
- Heiden View Subdivision located in Township 9 South, Range 3 West, Copper River Meridian, at the base of Thompson Pass and easterly from Sheep Creek, which includes sales to 18 private individuals; and
- Lowe River Alaska Subdivision located in Township 9 South, Range 5 West, Copper River Meridian, southerly of the Lowe River, which includes sales to 62 private individuals.

These aforementioned conveyancing activities indicate a significant growth in the use and occupancy of the State of Alaska lands in the period from 1972 through 1999.

Private Land

In 1972 there were 196 parcels of privately owned land interests underlying or adjacent to the TAPS ROW. This number included 78 federal unpatented placer mining claims in the Middle Fork of the Koyukuk mining area, five federal unpatented placer mining claims in the Treasure Creek area, and eight federal unpatented placer mining claims at the Delta River-Phelan Creek confluence. Later, because of federal judicial action and failure of the claimants to follow federal mining regulations, the number was reduced to two valid unpatented federal mining claims in the Middle Fork of the Koyukuk River mining area and 13 additional unpatented federal mining claims in other areas crossed by the TAPS ROW.

There were originally eight Alaska Native Allotments crossed by the TAPS route, the most northerly being on the Middle Fork of the Koyukuk River north of the Hammond River confluence, and the most southerly being along the Tiekel River approximately 50 miles north of the Valdez Marine Terminal.

Of the original 97 privately owned parcels (excluding mining claims and Native Allotments):

- 58 of them were in the greater Fairbanks area (from Old Murphy Dome Road on the north to Johnson Road on the south). These 58 parcels included the lots in the Gurth Subdivision, the only subdivision then crossed by the TAPS ROW.
- Twenty-three of the privately owned parcels were in the Big Delta-Delta Junction area.
- Twelve of the privately owned parcels were in the Copper River Basin.
- Three of the privately owned parcels were in Valdez.
- The other three privately owned parcels were at locations more remote from these centers of population.

By the end of 1999, the urban growth and public desire for remote recreational and residential property resulted in a significant land-use increase along and adjacent to TAPS. With this growth, coupled with the commercial and industrial growth in the Valdez area, there were 419 parcels of privately owned land interests underlying or adjacent to TAPS:

- In the greater Fairbanks area, there are 162 parcels underlying or adjacent to TAPS, including lots in 16 subdivisions — Gilmore Estates, Vienna Woods, Vienna Woods First Addition, Fitz Down Subdivision, South Slope Subdivision, Polar Heights Subdivision, Gurth Subdivision, McNeal Estates Subdivi-

sion, Whispering Pines Subdivision, Cornucopia Farm Subdivision, Woodsmoke Subdivision, Tombur Subdivision, Seavy Subdivision, Diamond Willow Subdivision, Diamond Willow First Addition Subdivision, and Alice Ann Subdivision. This total of 162 parcels takes into account the private parcels lost by the development of the Chena River Lakes Flood Control Project.

- Fifteen of the 419 parcels are mining claims, two of them being in the Middle Fork of the Koyukuk mining area, five in the Treasure Creek area, and eight in the area of the Delta River-Phelan Creek confluence.
- There are now nine Alaska Native Allotments crossed by the TAPS ROW, the increase being the result of the BLM-approved relocation of one Allotment in the Kanuti Flats area.
- Thirty-six of the privately owned parcels are in the Big Delta-Delta Junction area, including parcels in the Big Delta Estates Subdivision, the Stewart Parcelization, and the Malay Parcelization.
- Thirty-nine are in the Copper River Basin.
- Twenty are in the City of Valdez, including lots within the Valdez Industrial Park Subdivision.
- This number also includes the properties owned by Ahtna, Inc., Chugach Alaska Corporation, and CIRI, which properties are counted as one parcel per ANCSA Native Corporation.
- The other three privately owned parcels are more remote from the centers of population.

These 419 privately owned parcels do not include the parcels acquired in fee by the TAPS Owners (these parcels are mentioned in Section 3.3.5.2). These parcels include the 132 lots in the State of Alaska subdivisions mentioned above which have been sold by the State into private ownership.

3.3.6 Recreation and Visual Resources

By ClearWater Environmental, Inc. staff

3.3.6.1 Introduction

TAPS traverses a broad range of climates, landforms, and ecosystems, each with numerous recreation and visual resources. These resources are accessible from public roads within the TAPS study area. As a by-product of its construction in support of TAPS, the Dalton Highway has enhanced access to recreational areas for the northern 400-mile section of the study area. After construction of TAPS, there was a steady increase in use of these recreation and visual resources, and that increase continues through today (Moseby, 1999, pers. comm.).

Frank Flavin for Alyeska Pipeline Service Company

Photo 3.3-28. *TAPS visitor site at pipeline visitors center near Fairbanks.*

3.3.6.2 Recreation

The principal recreation issues are associated with improved access to outdoor recreation areas (parks, refuges, Native holdings, and undeveloped lands) caused by public roads and airstrips lying within the TAPS study area. This primarily involves the 400-mile Dalton Highway. All other roads pre-date the pipeline system, except for the realignment and construction of the Elliott Highway at Livengood and the construction of the Tanana Loop Road between Big Delta and Jack Warren Road, as well as new visitor waysides along the Richardson, Steese, and Elliott highways.

Recreational use of the TAPS ROW for such activities as hiking, jogging, mountain biking, and snowmachining generally is compatible with safe pipeline operations and is accommodated under Alyeska's access policy, which is summarized below:

- The rights of the landowners, both public and private, owning the property under the TAPS rights-of-way must be respected.
- Perpendicular pipeline crossings with vehicles under 1,500 pounds gross vehicle weight or with non-vehicular, low-impact modes of transportation may proceed without Alyeska permission.
- Linear use via any transportation mode of small portions (generally under 1 mile) of the pipeline workpad or of the numerous TAPS access roads can proceed after obtaining a letter of non-objection from Alyeska and permission from the pertinent landowner.
- Depending on TAPS work activities and seasonal conditions, the workpad is closed at times to all traffic, including Alyeska and its contractors. Blocking Alyeska access roads is not allowed under any cir-

cumstances.

- Hunting, trapping, or shooting across, from, or on the pipeline right-of-way is not allowed.

Tourism and recreation opportunities available on the North Slope have been enhanced since the opening of the Dalton Highway to the public in 1995 (BLM, 1998). The Dalton Highway has been integrated into tour packages offered by the major sightseeing companies. Recreationists can access Gates of the Arctic National Park via an abandoned road to an unused material site located along the Dietrich River. Gravel pads that were used during construction of TAPS for temporary housing and other facilities are commonly used as unimproved campgrounds. While BLM or ADNR do not maintain visitor statistics, use of the Dalton Highway as access to the national parks and wildlife refuges has become increasingly popular. Backpackers, skiers, and dog mushers use the Dalton Highway as a starting or ending point for traverses of the Gates of the Arctic National Park and the bordering wildlife refuges. Traveling rivers north of the Arctic Circle for recreational purposes became increasingly popular in the 1990s (Moseby, 1999, pers. comm.), some of which increase is attributable to the cheaper access provided by the Dalton Highway. Most recreation areas accessible from the Dalton Highway are capable of supporting increased use.

Since completion of pipeline construction in 1977, recreational opportunities in the TAPS study area between Livengood and Valdez have been enhanced by construction of the Olnes Pond Recreation Area, the Chena River Lakes Recreation Area, the Big Delta State Historical Site (Rika Wallens), and the Tiekel River Campground. Recreational activities in this portion of the study area include wildlife viewing, nature photography, hunting, sport fishing, mountaineering, backpacking, camping, biking, river running, cross-country skiing, snowmachining, dog mushing, and berry picking. Improvement of public and private recreation facilities which existed before construction of TAPS and the improvement of access infrastructure have enhanced recreational interests, especially near the population centers of Fairbanks, Glennallen, Copper Center, and Valdez.

Impediments to recreational access include the distance to some recreational areas and difficulty of accessing some. Primitive wilderness experiences are much more limited than in the northern half of the pipeline, but can still be found in Wrangell-St. Elias National Park.

The Ivishak, Delta, and Gulkana rivers within or adjacent to the TAPS study area are designated as wild and scenic rivers (WSR) under the Wild and Scenic Rivers Preservation Act of 1968. The Ivishak is designated as a WSR where it flows through ANWR and then joins the Sagavanirktok River at TAPS MP 55 near Pump Station 2. The Delta River was named because of its outstanding scenery and natural and cultural values. Recreational opportunities along the Delta include rafting, kayaking and canoeing, fishing, hunting, wildlife viewing, and photography. The Delta WSR boundary overlies the TAPS ROW between MP 577 and MP 602, where TAPS exits the boundary of the Delta River WSR. The Gulkana River was named a WSR because of its primitive character, abundant fish and wildlife, and geologic, cultural and recreational values. The Gulkana is an excellent resource for wildlife viewing and offers a variety of white-water challenges, solitude, great fishing, and easy road access at both the boating put-in and take-out points. The Gulkana WSR boundary overlies the TAPS ROW between MP 653 and 655.

Recreational opportunities in and around the City of Valdez include viewing of marine and terrestrial wildlife, ocean cruises, sea kayaking, nature photography, hunting, sport fishing, mountaineering, backpacking, camping, river running, power boating, back-country skiing, snowmachining, glacier viewing and travel, and berry picking. Valdez is famous for its opportunities for marine boating, wildlife viewing, and extreme skiing experiences.

Also, TAPS facilities are a major tourist attraction in Alaska. In 1996, approximately 200,000 persons visited established Alyeska visitor sites such as visitor centers, pump stations, and the VMT (APSC, 1999c). According to data from the McDowell Group (1993),[8] TAPS ranked ninth in terms of the number of visitors to various Alaska attractions. In 1993, approximately one of four persons estimated to have visited any of the major Alaska tourist attractions visited some portion of TAPS. Nine viewing stations readily accessible from the Alaska highway system were established along TAPS.[9] These provide information on the history and engineering of the pipeline. The two viewing stations with the highest visitor counts are the Steese Highway site near Fox, and Pump Station 12, at Milepost 64 of the Richardson Highway.

3.3.6.3 Visual Resources

Visual resources are defined as the land, water, vegetation, animals, and structures that are visible on the land. The TAPS ROW passes through areas containing outstand-

[8]This is the latest year for which these data are available.

[9]The visitor counts reported by Alyeska (APSC, 1999c) do not include an estimate of the number of visitors that may stop at the viewing stations to read the descriptive information and/or take photographs.

ing visual resources (Table 3.3-13). Dominant features include TAPS and its associated facilities; the vast treeless tundra of the Arctic Coastal Plain; the mountains of the Brooks Range and Alaska Range; the cities of Fairbanks, North Pole, Delta Junction; the communities of Glennallen and Copper Center; the city of Valdez; and the coastal region of PWS. Alyeska (APSC, 1993) inventoried outstanding visual resources along TAPS. A discussion of visual resources is relevant to TAPS ROW renewal decision because (1) continued operation of the pipeline retains present pipeline-related impacts, including the presence of TAPS and associated facilities and the possibility that oil spills could temporarily affect visual resources, and (2) the no-action alternative could create visual impacts associated with dismantling, removal, and restoration (DR&R) of TAPS.

The TAPS ROW covers approximately 16.3 square miles (APSC, 1999c), less than 1/34,992 of Alaska's land area of 570,374 square miles (DOC, 1992). The potential visual impacts of TAPS were considered in the design, and stipulations were included in both the federal and state ROW agreements. For example, federal Stipulation 2.10.1 states that "Permittees shall consider aesthetic values in planning, construction and operation of the Pipeline System. Where the Right-of-Way crosses a State highway in forested terrain, the straight length of the Pipeline Right-of-Way visible from the highway shall not exceed six hundred (600) feet in length, unless otherwise approved in writing by the Authorized Officer. The Authorized Officer may impose such other requirements as he deems necessary to protect aesthetic values."

With minor wording changes ("Lessees" rather than "Permittees" and "Pipeline Coordinator" rather than "Authorized Officer"), the same stipulation is included in the State lease. Other stipulations that address visual impacts are those related to buffer strips and vegetative screens.

Table 3.3-13. *Visual resources along TAPS (APSC, 1993).*

Pipeline MP	Description
5	Former Dalton Highway checkpoint to Prudhoe Bay: Prudhoe facilities visible on the horizon
15-36	Franklin Bluffs
64	Overlook of the Coastal Plain
73	Overlook of Sagwon Bluffs
106	View of highway, gas line, and PS 3 to the north
112	View of highway, gas line, and PS 3 to the north
118	Overlook of Slope Mountain
125	Special big game crossing of the pipeline
129	Potential BLM overlook of Toolik Lake
136-144	Views of Atigun R., Gailbraith L., PS 4, and pipeline
139-175	Galbraith L., overlooks of Atigun and Chandalar valleys
152	Potential BLM overlook
176	Potential BLM overlook of the Chandalar Shelf
197	Potential BLM overlook of A/Loon ponds
207-211	Sukapak Mountain
246	Panoramic view of the Middle Fork Koyukuk R. Valley
247	BLM Cathedral Lake overlook
253	Overlook of Chapman Lake
262	Grayling Lake
278	Gobblers Knob; view of Prospect Cr./Jim R. drainage, and PS 5
306	Potential BLM Olson's Lake overlook
311	Wayside and Overlook facility
312	Finger Rock
319	Viewpoint of pipeline
323	Potential BLM overlook of Yukon Flats
339	Overlook of Ray River and Ray Mountains
347	Overlook of Dalton Hwy, pipeline, Yukon, and PS 6
353-354	View of the pipeline crossing of Yukon River
388	Overlook of Erickson Creek and pipeline
417	Globe Creek and Grapefruit Rocks viewpoint
420	Pipeline viewpoint
448	Pipeline viewpoint
531	Viewpoint of pipeline crossing Tanana R.
550	Viewpoint of PS 9
562	Viewpont of pipeline and the Alaska Range
578	View of Black Rapids Glacier and Delta R.
584	Viewpoint of PS 10
588	Viewpoint of special designs for fault crossings
599	Photo point of pipeline
607	View of Gulkana Glacier and summit of Isabel Pass
614	Viewpoint of Summit Lake and pipeline
625	Overlook of Paxson Lake
642-645	Overlooks from highway on Hogan Hill west and south
687	Overlook of Copper R. and Wrangell Mountains
711	Overlook of pipeline, Alyeska interpretation signs
770	Photo site for Worthington Glacier National Natural Landmark
774-776	Thompson Pass
780-785	Keystone Canyon, historic railroad tunnel, Bridal Veil Falls, and Horsetail Falls

3.3.7 Wilderness

By ClearWater Environmental, Inc. staff

3.3.7.1 Federal- or State-Designated Wilderness

The passage of ANILCA (Public Law 96-487) on December 2, 1980, provided for the establishment or expansion of the following designated wilderness areas:

- Section 303: Expansion of the Arctic National Wildlife Refuge, which boundary now lies approximately 1 mile east of the Utility Corridor near the headwaters

of the Sagavanirktok;

- Section 201: Establishment of the Gates of the Arctic National Park, which lies west of the Utility Corridor in the Brooks Range;
- Section 302: Establishment of the Kanuti National Wildlife Refuge, which lies west of the Utility Corridor in the Yukon Flats area between the Brooks Range and the Yukon River,
- Section 403: Establishment of the White Mountains National Recreation Area, which lies east of the Utility Corridor in the Wickersham Dome area between Livengood and Fox;
- Section 201: Establishment of the Wrangell-St. Elias National Park, which lies east of the Copper River, several miles east of TAPS in the Copper River Basin.

While there had long been road access alongside these newly defined wilderness tracts, TAPS and the Dalton Highway created new access points for the northern wild and primitive areas from the Yukon to the Arctic Ocean. This access was gained not from the road itself, but the airstrips built to service pipeline construction came to provide staging and jump-off points for recreationists, hunters and fishermen, and subsistence users. Therefore, the wilderness areas absorbed a growth of human entry and use at the moment they were reclassified.

3.3.7.2 Description of Wilderness Character of Remaining Areas

Although not specifically classified by law as wilderness areas, most of the federal (BLM-managed), State of Alaska, and private landholdings (primarily Native corporation and Native allotment tracts) that have not been penetrated by roads or dotted by remote airstrips are classed as undeveloped lands to be managed by their respective agencies in a fashion that preserves wilderness values to the maximum extent possible. Since hunting and fishing, back-country hiking, canoeing, and even in most cases, travel by all-terrain motorized vehicles are regarded as consonant with the preservation of primitive-area values, the managing authorities (BLM, ADNR, National Park Service, FWS, U.S. Forest Service, and Native corporations) allow and encourage such uses in accordance with the appropriate management regulations imposed by agencies such as ADF&G. More permanent developments such as lodges, guiding camps, airstrips, and the like would also be possible in these primitive/undeveloped areas, whereas they would be prohibited in designated wilderness. It is unlikely that mining, oil and gas exploration and development, timber harvesting, and commercial fishing will be allowed in presently designated wilderness areas, but such development is judged on a case-by-case basis for these otherwise undeveloped areas.

3.3.8 Transportation

By ClearWater Environmental, Inc. staff

3.3.8.1 Introduction and History

By the late 1960s, Alaska's transportation systems had evolved on four fronts that grew directly from the historical patterns associated with natural resource extraction, customary uses by its indigenous and settler populations, and the creation of links to and between military installations (Gruening, 1968). Waterborne networks remained critical to the commercial fishing, timber, and mining industries, including the shipments of petroleum products from the oil fields of the Kenai Peninsula and Cook Inlet areas (Gruening, 1968). Road networks were concentrated almost entirely in the southeast quadrant of the state and were linked to the outside by the Alcan (Alaska) Highway constructed in the early 1940s as the military supply lifeline (Gruening, 1968). Built in the 1920s, the Alaska Railroad served primarily as an enhancement to the existing road and trail system of Southcentral Alaska. Apart from the extensive network of trails that for centuries had served as the travel arteries for Alaska's Native inhabitants and subsequently for the miners and trappers, by the late 1960s the airplane had become the key transportation element to knit Alaska together. Although there had long been plans to extend the road and railroad systems to northern and western parts of the state, air travel and freight movement appeared both more efficient and less costly in a place where both people and resources were so widely dispersed.

Fairbanks, which is situated for seasonal shipping along the Yukon and Tanana rivers, is a convergence point of the Alaska transportation system. It is the terminus of both the railroad and the Alaska Highway. Its civil and military airfields are at the strategic center for the rural connecting system. However, the Prudhoe Bay oil discoveries helped make Fairbanks a new hub for land-based transportation. The construction of the Dalton Highway (Haul Road) and TAPS fundamentally reoriented the inland and seaborne transportation system from one that served only a quarter of that area to a north-south artery. The transportation system became capable of conveying massive amounts of material necessary to construct and operate the Prudhoe Bay oil field, and to transport oil south to market.

One of the reasons the Prudhoe to Valdez route was selected for TAPS was to ensure that the pipeline would be

wholly on U.S. soil (BLM, 1972). In addition, the route had the advantage of using the existing transportation infrastructure — especially the roads — already in place from Fairbanks south. TAPS roughly parallels the Alaska Highway from Fairbanks to Delta Junction and the Richardson Highway from that point to Valdez. The required enhancements included construction of a new 400-mile north-south road link from Prudhoe Bay to Livengood, creation of adequate airstrips between Fairbanks and Prudhoe, expansion of the major ports at Anchorage and Seward for material shipments on the railroad, and construction of the tanker terminal at Valdez.

3.3.8.2 Transportation Systems

This subsection includes a description of transportation systems that support TAPS (Figure 3.3-38).

Aviation

Aviation is a key element of Alaska's transportation system,[10] as evidenced by the following statistics:

- In 1996, Alaska had 546 airports, including those for fixed wing aircraft, heliports, etc. (FAA, 1997). Normalized by the state's population, this is equivalent to 90 airports per 100,000 residents — greatest among all 50 states and nearly 9 times greater than the average for the rest of the U.S. Besides these designated landing fields, aircraft use a large number of unprepared fields, lakes, glaciers, etc., to a degree unequaled elsewhere.
- There were 88.5 general aviation aircraft registered in Alaska per 10,000 residents in 1996 (calculated from data contained in FAA, 1997). This was the highest ratio among all 50 states and nearly 10 times greater than the average for the rest of the U.S. Figure 3.3-39 shows the top 10 states ranked in descending order.
- In 1996, there were 14.5 Federal Aviation Administration-licensed pilots in Alaska per 1,000 residents (calculated from data contained in FAA, 1997). This was the highest among all 50 states and 5.9 times greater than the average for the rest of the U.S. Figure 3.3-40 shows the top 10 states by this measure ranked in descending order.

The large distance between cities and relative lack of highway and railroad infrastructure in Alaska provided the economic impetus to continually advance and upgrade aviation systems in the state. Anchorage provides the primary hub for cargo and passenger transport for central Alaska — followed by Fairbanks. Several major domestic airlines provide daily service to the contiguous 48 states and to international destinations. Anchorage and Fairbanks have both become important air-cargo transfer centers for goods to and from Asia. Additionally, several Alaska-based airlines serve internal routes, and many charter/air taxi operations exist.

Aviation support facilities were integral to development of TAPS. Before construction, six public airstrips existed along the ROW: Deadhorse, Sagwon, Fairbanks, Delta Junction, Gulkana, and Valdez. Deadhorse and Sagwon were both established to support oil exploration north of Atigun Pass. Fairbanks and Delta Junction were established aviation hubs that supported military installations and mining operations, and were important staging points for transportation to villages, outposts, and camps. The Gulkana and Valdez airports were small airstrips to service their communities. Aviation support to any destination between these established airstrips was restricted to helicopters or to small fixed-wing aircraft able to land on a gravel bar or lake. Construction of TAPS required additional aviation support for personnel, material, and supplies.

Between 1971 and 1972, 12 improved gravel airstrips were built for TAPS construction. Each supported C-130 Hercules aircraft and DC-3 tankers. Four of these airstrips were later reclaimed and are no longer serviceable as air support facilities. Other airstrips remain under state or private maintenance, and some are used by general aviation but are no longer listed on current FAA sectional charts.

Aircraft transport personnel and supplies to some TAPS-related facilities[11] and to North Slope oil exploration and production facilities. Information on use of aircraft associated with these operations can be found in several sources (e.g., USACE, 1999; MMS, 1998).

The Deadhorse Airport, which is owned and operated by

[10]Since at least the 1930s, air transportation has been important in Alaska. Coates (1993) states: "According to figures quoted for 1938 there was a higher per-capita rate of airplane use in Alaska than anywhere else in the world besides Arctic Canada and Russia."

[11]Alyeska also uses air links to transport employees and contractors to several sites along the pipeline. Workers at Pump Station 1 fly to Deadhorse (and are included in passenger totals shown above); those at Pump Stations 3 and 4 fly to the airport at Galbraith Lake on ERA Aviation; those at Pump Station 5 fly to Prospect airport on ERA or Frontier Airlines; and workers at Pump Station 12 fly to Gulkana Airport on ERA Airlines. Workers at Pump Station 9 live in Delta and environs, and those at Pump Station 7 are able to commute from Fairbanks. The other pump stations have been placed in standby status. Routine deliveries of materials and supplies are made by truck. Air cargo is used only for time-critical parts and supplies. In the proposed action, Pump Stations 7 and 12 will be placed in standby status in the upcoming years, eliminating the need for air travel for workers to Gulkana. For the no-action alternative, air travel to Galbraith and Prospect will no longer be required.

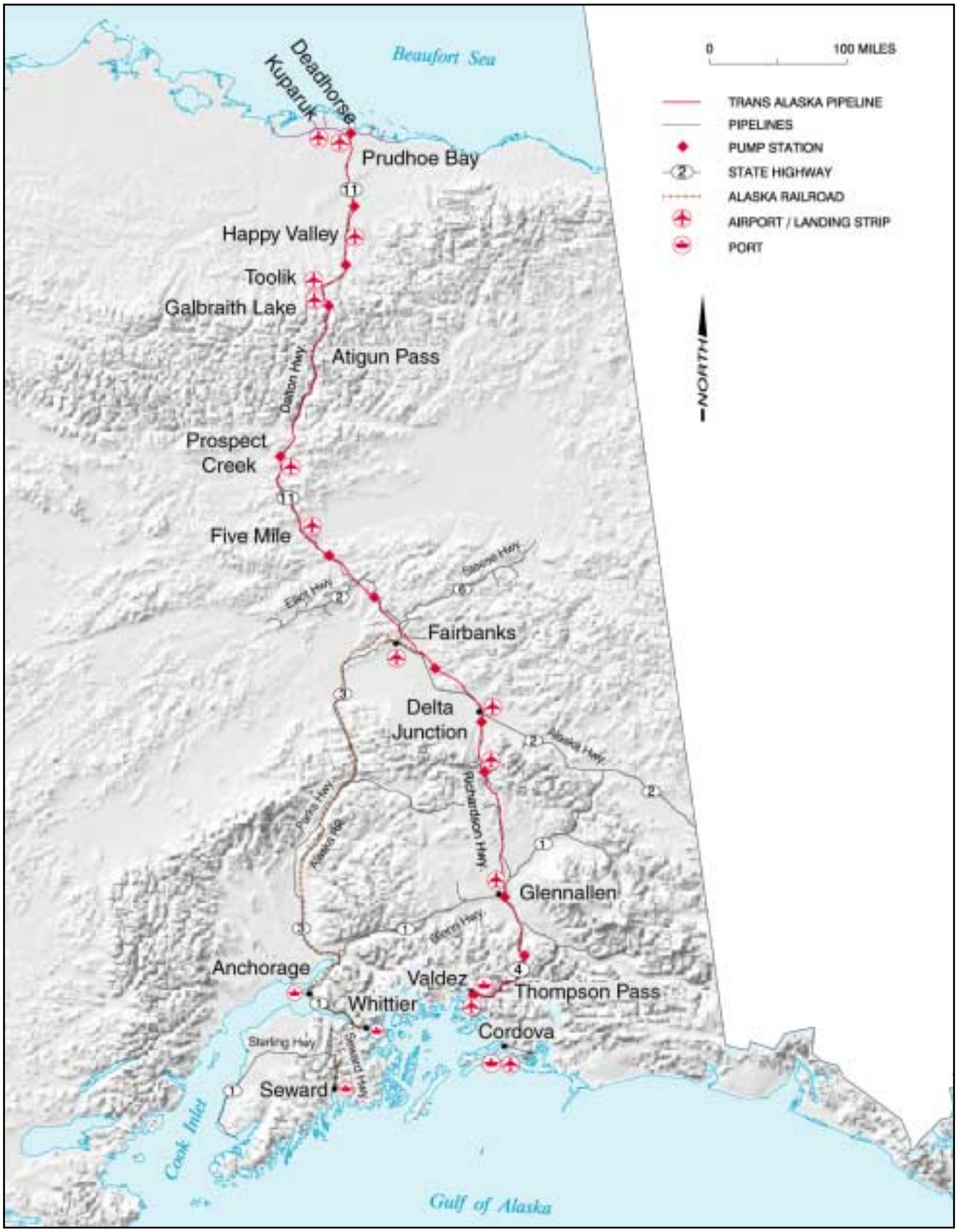


Figure 3.3-38. *Transportation assets of Alaska.*

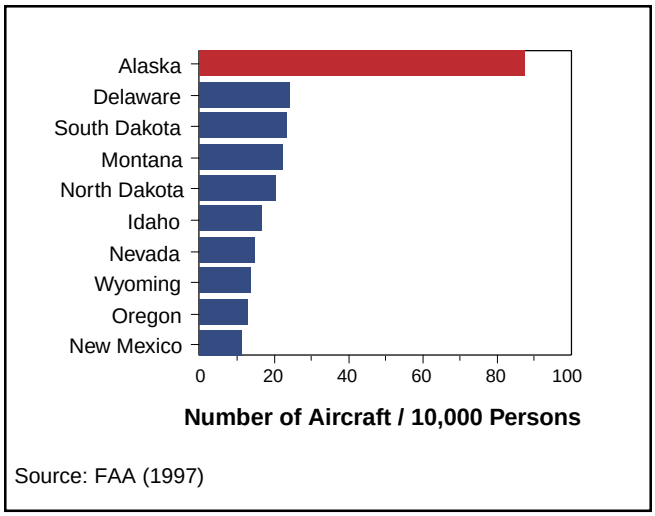


Figure 3.3-39. *Number of general aviation aircraft per 10,000 residents, top 10 states ranked in descending order.*

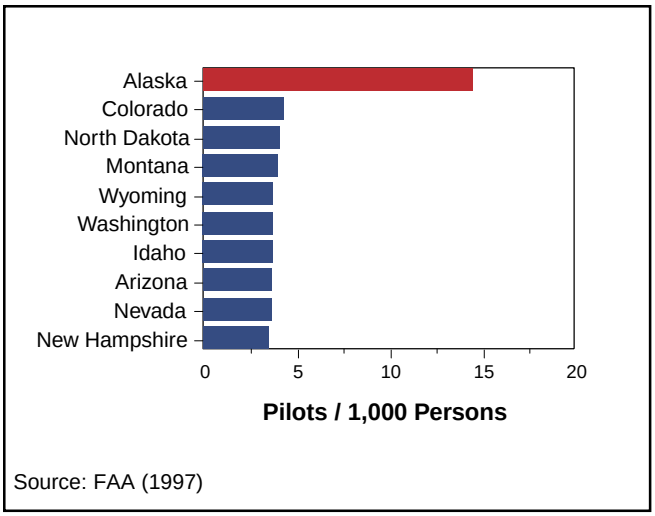


Figure 3.3-40. *Number of licensed pilots per 1,000 persons, top 10 states ranked in descending order.*

the State of Alaska, is served by Alaska Airlines and oil industry charters. Each provides daily service to Deadhorse from Anchorage and/or Fairbanks, with an estimated 200,000 passengers transported to and from Deadhorse annually. Annual freight transport to Deadhorse is estimated at approximately 648 tons (USACE, 1999). The Kuparuk oil field also has its own private airstrip. No evidence exists of traffic-related congestion and/or delays associated with these flights.

Rail Systems

The history of the Alaska Railroad extends back over 80 years, and the railroad is responsible for the creation of Anchorage (ARRC, 1999). In 1912, the Alaska Railroad Commission was created by an act of Congress to "...connect one or more of the open Pacific Ocean harbors on the southern coast of Alaska with the navigable waters in the interior of Alaska...for the transportation of passengers and property." Construction of the rail line from Seward to Fairbanks began in 1915, and soon after, the city of Anchorage was created as the base of operations. The original rail lines between Seward, Anchorage, and Fairbanks were completed in 1923. The rail line was to be operated by the Alaska Railroad, which was established as an agency of DOI. In 1941, construction began on an additional rail line to the port of Whittier, which was a fuel repository necessary to the war effort. Service to Whittier began in 1944 (BLM, 1956). For the next 41 years, the Alaska Railroad remained an agency of the federal government, passing from the DOI to the U.S. Department of Transportation in 1967. In 1987, the Alaska Railroad became property of the State of Alaska, and the newly created Alaska Railroad Corporation was charged with overseeing its operation (ARRC, 1999).

In 1999, the Alaska Railroad provided passenger service to over 676,000 people and moved an estimated 6.5 million tons of freight, transporting cargo to and from the Interior. The Alaska Railroad is an important link for exporting coal and manufactured goods (Carr, 1999, pers. comm.). There is twice-daily freight service between Anchorage and Fairbanks and once daily service between Fairbanks and Seward in summer. Deliveries of coal occur from Healy to Seward two to three times a week in summer (Johnson, 1999, pers. comm.). The railroad also transports petroleum from the Williams Refinery in North Pole to Anchorage, Seward, and Whittier for use at Alaska's airports and military bases and for export overseas (Silverstein, 1999, pers. comm.).

Road Systems

The public road infrastructure is not well-developed in Alaska — one of the factors that helps explain the importance of aviation. In 1996, according to data from the Federal Highway Administration's publication *Highway Statistics* (FHWA, 1996), there were 13,255 miles of public road in Alaska, including both rural and urban and roads under federal, state, and local control. Among all the states, only Rhode Island (6,001 miles), Delaware (5,715 miles), and Hawaii (4,142 miles) have fewer miles of public roads. More relevant is a comparison of the miles of road to land area of the state. Figure 3.3-41 shows states ranked in descending order of the ratio of the state's area to the length of its public roads. Alaska is in a class by itself by this measure.

Roads and highways that provide access to and support TAPS include the Dalton, Elliott, Steese, Alaska,

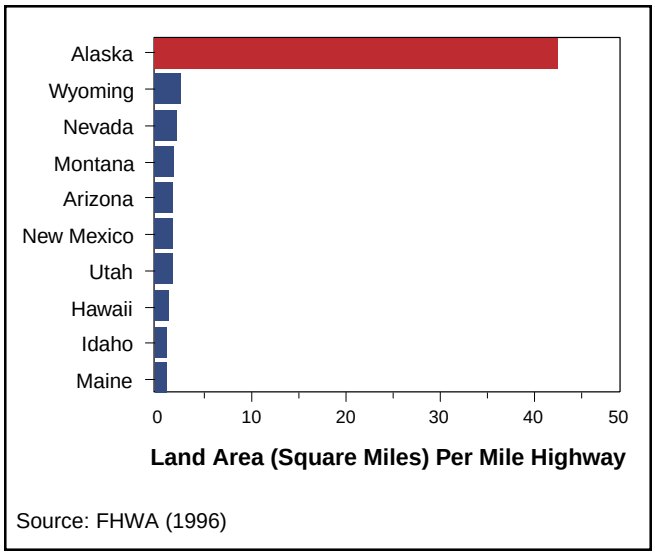


Figure 3.3-41. *Top 10 states ranked in descending order of land areas per mile of road.*

Richardson, and Glenn highways, and Chena Hot Springs and Dayville roads. Additionally, there are approximately 225 secondary roads that provide private access to the pipeline, pump stations, and airstrips. Roads are now used to carry supplies to the North Slope and to various pipeline-related facilities, and roads would be used to haul dismantled sections of the pipeline if the ROW were not renewed.

The Dalton Highway is a 28-foot-wide crushed-gravel road that extends 416 miles from the town of Livengood to the industrial complex of Deadhorse. Construction of what is now known as the Dalton Highway began in the winter of 1969-70 when the TAPS Owners built a 55-mile road from Livengood to the Yukon River. Construction began on the remainder of the highway on April 29, 1974. This 358-mile road from the Yukon River to Deadhorse required 3 million hours of labor, 32 million cubic yards of gravel, and $125 million dollars before being completed on September 29, 1974. Previously known only as "the Haul Road," it was officially dedicated as the Dalton Highway in 1981 after James B. Dalton, a pioneer independent mining engineer and one of the first to haul equipment and supplies overland from Interior Alaska to the Arctic. The Dalton Highway was built to provide an overland route between Fairbanks and Prudhoe Bay for construction of TAPS. Originally, use of the highway was restricted to authorized commercial traffic. The Dalton was opened to the public in 1995 and now provides unrestricted overland access to the northern half of Alaska.

The majority of traffic on the Dalton Highway is commercial freight vehicles associated with oil-field activities, although privately owned vehicles and commercial tour operators also use the highway (MMS, 1998; USACE, 1999). Annual loaded and return truck traffic in 1996 was reported at 45,236 (MMS, 1998), equivalent to a daily average of 124. Traffic counts along this highway fall off rapidly with distance north and are higher in summer than winter.

The TAPS segment from the Yukon River to Delta Junction includes the Elliott, Steese, and Richardson highways and Chena Hot Springs Road and connects to the Alaska Highway. The Elliott Highway extends 152 miles from the town of Fox through Livengood to the community of Manley Hot Springs (Graef, 1999).

The Alaska Highway runs from Dawson Creek, British Columbia, 1,390 miles to Delta Junction, Alaska. Construction of the highway began on March 9, 1942. While an overland route from the contiguous 48 states had been studied as early as 1930, it was not until the assault on Pearl Harbor in 1941 showed Americans how vulnerable Alaska was to attack that construction of the Alaska Highway was deemed a military necessity (Graef, 1999). A network of preexisting airfields known as the Northwest Staging Route determined the general route of the highway. In addition, routing of the highway was planned to incorporate existing winter roads and old Indian trails as much as possible (Graef, 1999). The Alaska Highway is not part of the TAPS study area, except at Delta Junction; however, it provided an important all-season route for overland transportation of material during TAPS construction.

The TAPS segment from Delta Junction to Valdez parallels the Richardson Highway, which begins in Valdez and extends north 368 miles through Glennallen and Delta Junction to Fairbanks. The Richardson was Alaska's first highway. In 1920, the road was improved to automobile

H. Walker for Alyeska Pipeline Service Company

Photo 3.3-29. *Dalton Highway.*

standards and finally paved in 1957 (Graef, 1999).

In 1866, Congress enacted RS2477 (43 U.S.C. 932) allowing the general public to obtain road rights-of-way on unreserved federal land. The federal law was repealed in 1976, but the rights-of-way it created remain in effect. The Alaska Legislature enacted AS 19.30.400-420 in 1998 and nominated 602 routes believed to meet RS2477 qualifications. Many of these public-trail easements were accommodated in the design and construction of TAPS.

Inland Waterways

The use of inland waterways for transportation dates before recorded history in Alaska. Traditionally, Alaska Natives used rivers as a main source of transportation. Beginning in the eighteenth century, Russian fur traders established trading posts on the banks of rivers for storing and moving supplies and for transporting furs to sea for eventual shipment to Russia. Alaskan rivers became even more vital to transportation after the discovery of gold in the mid-1800s (Stern, 1982). Since then, Alaska's inland waterways have continued to be a vital means of transporting supplies from ports and harbors to the Alaskan Interior and exporting natural resources to oceangoing vessels. Only the Yukon and Tanana rivers have been used by barges to transport materials related to construction or operation of the TAPS. Yutana Barge Lines hauled portions of the E.L. Patton bridge during TAPS construction. Currently, materials associated with TAPS operation are not transported via inland waterways. Refined petroleum products and building and construction supplies are still transported on the Yukon and Tanana for purposes unrelated to TAPS.

Marine

North Slope crude oil is shipped by tanker from the Valdez terminal to refineries primarily on the U.S. West Coast (see Section 2.2.2). Other shipping traffic that occurs in PWS and Valdez involves movement of refined oil products from the Petro-Star refinery by smaller tankers and barges to other Alaska ports, as well as general and military cargo traffic to and from other piers in Valdez. Commercial fishing and processing vessels form a significant waterborne industry in PWS. Sport, tour boat, and cruise ship operations are important during summer. The Alaska State Ferry System has regular sailings through PWS (Whittier to Valdez; Valdez to Cordova, Seward, Kodiak, and Homer). The waters of PWS are used extensively by sea kayakers and recreational boaters.

Pipeline Systems

TAPS is a 48-inch-diameter common carrier pipeline system beginning at Pump Station 1 in Prudhoe Bay and extending 800 miles to the tanker-loading terminal in Valdez. A 149-mile-long fuel gas line operated by Alyeska provides natural gas for fuel to the TAPS pump stations north of the Brooks Range. Crude oil is transported from the North Slope gathering centers/processing facilities to TAPS at Pump Station 1 through common carrier pipelines (Figure 3.3-42). In addition, two pipeline systems transfer crude oil from TAPS to Alaska refineries: Williams (formerly MAPCO) and Petro-Star in North Pole, Alaska, and Petro-Star in Valdez.

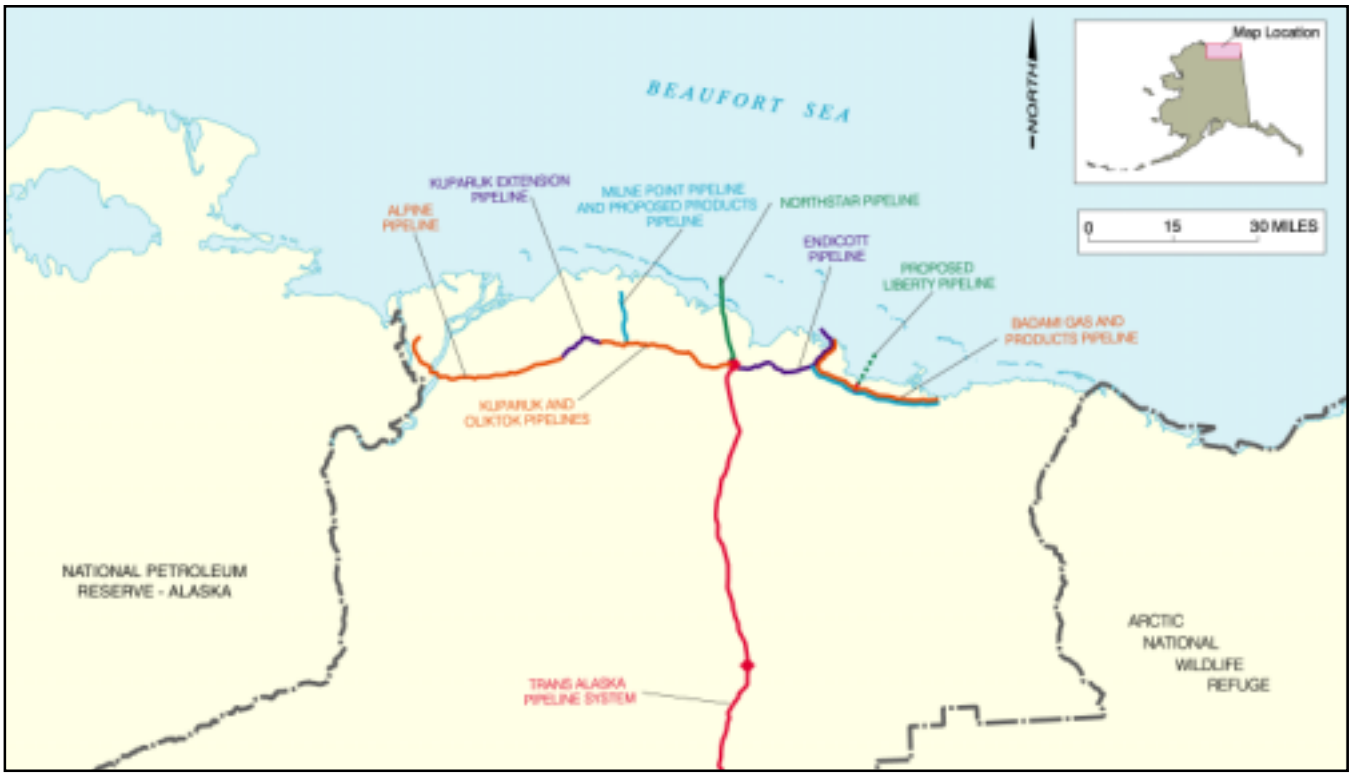


Figure 3.3-42. *Common-carrier pipelines on the Alaskan North Slope.*

SECTION 4

ENVIRONMENTAL CONSEQUENCES OF PROPOSED ACTION AND ALTERNATIVES

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Introduction: Section 4

Organization and Definitions

Section 4 describes the direct, indirect, and cumulative environmental and social-cultural consequences of renewal of the Trans Alaska Pipeline System (TAPS) right-of-way (ROW) (the proposed action) and of expiration of the ROW (the no-action alternative). The projected impacts are well-understood because of the operational history of the project. Section 3 of this Environmental Report describes the existing environment, which includes TAPS.

To provide the basis for the projected impacts, Section 4.1 provides information on the mechanisms of impact, which include ground-impacting maintenance actions such as corrosion digs and workpad maintenance, and oil spills. The discussion on oil spills contains a detailed evaluation of the potential number, size, and location of possible spills. Section 4.2 details the mitigation measures that are already in place on TAPS to address known impacts.

The direct/indirect impacts of the proposed action and the no-action alternative are addressed in Sections 4.3 and 4.4, respectively. Section 4.5 discusses the cumulative impacts of both alternatives in light of other past, present, and reasonably foreseeable development. Finally, Section 4.6 identifies the unavoidable adverse impacts of the proposed action.

The three study areas are treated together in describing the affected environment, but impacts are analyzed separately in Section 4. [Note that the CEQ guidelines consider the terms *effect* and *impact* to be synonymous (40 CFR 1508.8).] The analysis of direct/indirect and cumulative effects follows as closely as possible the definitions provided by the Council on Environmental Quality (CEQ):

- **Direct effects** are "caused by the action and occur at the same time and place" (40 CFR 1508.7).
- **Indirect effects** are "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.7).
- **Cumulative impact** is "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7).

In accordance with these definitions, the direct effects are treated as those directly associated with TAPS as defined above, which includes the pipeline, pump stations, access roads, material sites, VMT, etc. Such effects include ground disturbance from maintenance actions, air emissions from pump stations, and wastewater discharges from ballast water treatment .

For this Environmental Report, the distinction between indirect effects and cumulative impacts is somewhat complex. It would be possible to consider the effects of the Alaska North Slope oil fields and the marine transportation link as indirect effects of TAPS ROW renewal. However, these are treated in the cumulative effects section for two reasons. First, developments on the North Slope require extensive permitting, have undergone NEPA reviews, and thus are considered separate actions from TAPS ROW renewal. The permitting for such developments usually includes an environmental assessment (EA) or environmental impact statement (EIS). Secondly, the marine transportation system, while integral to bringing ANS crude to market, is managed by a separate set of agencies and laws than TAPS itself. For example, the Oil Pollution Act of 1990 and U.S. Coast Guard regulations mandate how tankers operate in Prince William Sound and the Gulf of Alaska. Alyeska Pipeline Service Company provides tanker escort and spill response support in accordance with OPA 90, but the tankers are not under Alyeska control or the control of the Joint Pipeline Office, which regulates TAPS operation.

As a result, development of Alaska North Slope oil fields

and the marine transportation system are treated in Section 4.5 of this Environmental Report as separate actions from TAPS ROW renewal. It would be somewhat academic to debate whether their effects are treated as indirect effects of TAPS because they would not exist without TAPS or as cumulative effects since they are separate actions. It is important to adequately assess their separate and cumulative effects.

In general, Section 4.5 of this Environmental Report treats ANS and PWS effects as cumulative effects because these regions are not directly affected by TAPS as defined in Stipulation 1.1.1.22 of the Federal Grant. However, the specific approach for each technical discipline varies based on the requirements of the analysis. For example, the analysis of economic effects in Section 4.3 includes the effects of North Slope oil development and tanker transportation. The model used for this analysis considers the economics of the entire oil production and transportation system because they are inextricably tied together economically.

Sections 4.7 through 4.13 cover the following miscellaneous impact considerations required by CEQ guidelines and other guidance documents:

- Relationship Between Local Short-Term Uses and Maintenance and Enhancement of Long-Term Productivity,
- Irreversible and Irretrievable Commitment of Resources,
- Energy Requirements and Conservation Potential
- Environmental Justice,
- Impact on Sacred Sites (with mitigation),
- Impact on Wetlands, and
- Invasive Species.

Summary of Environmental Consequences

Most EAs and EISs deal largely or exclusively with future projects. The principal focus of this analysis is the continuation of a system that has been in operation since 1977. Because the system has been in operation for so many years, it is possible to extrapolate from prior experience to develop relatively accurate estimates of possible future effects. Estimates of the incremental effects resulting from future projects (e.g., gas commercialization) are more uncertain but are believed to be reliable nonetheless.

The direct, indirect, and cumulative impacts of both the proposed action and the no-action alternative will vary geographically and will depend on the implementation of mitigation and prevention measures. Section 4 focuses primarily on the TAPS ROW, but also considers the potential impacts on the Alaska North Slope and Prince William Sound in the cumulative effects analysis. In general, as long as mitigation and prevention measures are implemented, the direct impacts of TAPS will be limited and manageable. TAPS activities are strictly regulated by the Joint Pipeline Office, other government agencies, and Alyeska policies. Indirect impacts associated with use of the TAPS ROW and adjacent areas by the public may be more substantial than direct impacts, but this activity is also regulated by government. The cumulative impacts — considering the ANS oil fields, tanker operations in Prince William Sound, and other actions — are more extensive because of the increased geographic scope and different types of developments. Following is a summary of important physical, biological, and social effects of both the proposed action and no-action alternative.

Proposed Action

The proposed action involves continued operation of TAPS for an additional 30 years.

Physical Characteristics

TAPS operation affects the terrestrial, aquatic, and atmospheric environments. Because the pipeline system has been in continuous operation since 1977 under stringent regulatory controls, its effects on the physical environment — terrestrial, air quality, and water quality — are familiar and can reasonably be expected to continue without significant change under the proposed action. Justification for predictions of low impact is detailed in the remainder of Section 4 and can be summarized in the following conclusions:

- The TAPS pipeline and related facilities already exist with known, observable impacts;
- Major changes to the pipeline system or to the affected physical environment are not expected during the ROW renewal period;
- New surface-disturbance areas associated with TAPS will be small and isolated;
- There would be no unavoidable adverse effect on the physical environment that would not be mitigated to the fullest extent technically feasible.

Terrestrial Environment: Continued operation of TAPS will impact some parts of the terrestrial environment because of maintenance activities, corrosion digs, construction projects for pipeline-related facilities, and the continued presence of a buried warm-oil pipeline in permafrost terrain. Maintenance since startup has caused localized

temporary land disturbance but has generally stabilized the ground in and adjacent to the ROW. Since nearly all maintenance activities occur on or along existing stabilized embankments, new major long-term changes to the terrestrial environment are not anticipated.

The pipeline will not affect seismicity, although seismic activity may impact the pipeline. However, seismic risk and mitigation measures to reduce this risk remain and are not expected to increase.

Global climate change may cause more warming on the ground surface, but subsurface permafrost thaw will not advance appreciably more than current projections and will be well within maintenance efforts anticipated for pipe support features.

The impact of the pipeline on the behavior of rivers and floodplains depends on whether river training structures are used and the type of structure used. Buried river crossings with no river training structures have little or no impact on the behavior of rivers. Bridged crossings have little or no impact, except for the local impact of the piers on flow.

Water Resources: Continued operation of TAPS will require continued use of water resources to support operations and maintenance activities. Wastewaters will continue to be treated, discharged, and assimilated by upland and freshwater receiving environments along the pipeline. Marine waters of Port Valdez will continue to be used to assimilate treated discharges from the VMT, including sanitary wastewater and ballast water. Wastewater discharges are strictly regulated, and there is no evidence that these discharges have negatively affected the physical environment. Discharges will continue to be regulated, and impacts are not expected.

Atmospheric Environment: TAPS throughput is in decline, and there is a strong likelihood that there will be a corresponding TAPS-wide net decrease in emissions and emission impacts. This prediction is supported by the results of several air quality permit applications and modeling studies, as well as the effect of plant improvements that have occurred at the pump stations and the VMT. Widespread point-source emissions are strictly regulated, and there is no evidence of deterioration in air quality as a result of TAPS. Future emissions are not expected to cause air-quality concerns.

Cumulative Effects: None of the potential physical cumulative effects is considered significant by this analysis. Other issues did not meet the intensity and probability criteria for significance because:

- TAPS pipeline and related facilities already exist;
- Major changes to the pipeline system or to the affected physical environment are not expected during the ROW renewal period;
- New surface disturbance areas associated with TAPS will be small and isolated;
- Future North Slope development and potential gas commercialization projects would not cause significant disturbance to the physical environment, with the exception of the transitory construction disturbance.
- Pump stations, potential compressor stations, and marine terminals (VMT and LNG) would be widely separated, and their emissions would be relatively small and strictly regulated; and
- There would be no unavoidable adverse effect on the physical environment that would not be mitigated to the fullest extent technically feasible.

With continued regulatory compliance by TAPS and any associated future project, potential cumulative effects on physical resources are not expected to become significant issues during the life of the proposed action.

Biological Resources

Biological resources potentially affected by continued TAPS operation include vegetation and wetlands, fish, birds, and terrestrial and marine mammals. If one examines the ecosystems impacted by the construction and operation of TAPS and associated activity for almost 30 years, their health and integrity is remarkable. With the exception of local impacts described in this section, the vegetation, fish, and wildlife along TAPS have not been impacted at the population level. TAPS can be viewed as another feature on the landscape, to which the flora and fauna have habituated. Even the ANS, with extensive oil fields, has a healthy community of flora and fauna. Populations of large and small mammals, birds, and fish are healthy despite development of the oil fields (Truett and Johnson, 2000). Likewise, Prince William Sound is a vibrant environment full of life, despite tanker traffic, operation of the VMT, and the *Exxon Valdez* oil spill in 1989. Some populations of seabirds and sea otters were reduced substantially by mortality from the oil spill. However, despite concerns over lingering toxicity from residual oil, populations are generally recovered or recovering. In all three areas — the TAPS ROW, the ANS, and Prince William Sound — there are local impacts, but overall, vegetation communities and fish and wildlife populations have fared well and will continue to thrive in the future.

Vegetation and Wetlands: Impacts include loss under gravel fill and changes from water impoundments and thermokarst. These impacts will not increase much in the TAPS ROW because no major new construction is antici-

pated. New oil and gas developments on the ANS will add to these impacts, but the footprints of new developments are relatively small. The cumulative loss of vegetation and wetlands is small relative to the overall land area along TAPS and on the ANS. Concerns over vegetation and wetlands often stem from their value as fish and wildlife habitat. The lack of negative population-level effects from TAPS and the ANS oil fields on fish and wildlife populations suggests that impacts have not included significant losses of habitat.

Fish: Impacts on fish include obstruction of movements in low water crossings or culverts along TAPS, injury or habitat loss from potential oil spills, and recreational fishing harvests. Obstruction of movements is a continuous problem because of the dynamic nature of the TAPS ROW and associated waterbodies. Adequate monitoring and maintenance of the low water crossings and culverts can mitigate this problem. Oil spills can impact fish, although the duration and extent of impacts are usually limited. The impacts of the *Exxon Valdez* oil spill on fish are widely debated, and the extent of impacts on populations is uncertain. Regardless, prevention of oil spills and rapid response when they occur are necessary to minimize impacts. With the tanker escort system and use of double-hulled tankers, the probability of a large marine spill has been reduced significantly. Sport and subsistence harvest of fish can reduce populations, and this may have occurred in some lakes along the TAPS ROW. Regulation and monitoring by the appropriate agencies is needed to manage this impact.

Birds: Increased predation on waterfowl by mammalian and avian predators may occur if predator populations increase due to access to garbage. This may have impacted colonial nesting geese and shorebirds on the ANS during the 1990s. This issue has been addressed with proper refuse management along TAPS, and is being addressed with new refuse management systems in the ANS oil fields. Oil spills, such as the *Exxon Valdez* oil spill, can kill large numbers of birds, and prevention and rapid response are very important. As indicated above, the Ship Escort/Response Vessel System (SERVS) in Prince William Sound and double-hulled tankers will minimize the probability of this impact during the proposed action period.

There are also positive impacts of habitat creation and enhancement on gravel structures and water impoundments.

Terrestrial Mammals: Important impacts include disturbance and displacement from preferred habitats, mortality from roadkills, increased predator numbers from access to anthropogenic foods, and sport hunting. Along the TAPS ROW, only the impacts of sport hunting appear important, although harvest is well-regulated by government agencies to achieve population management objectives. The impact of highway and rail roadkills has not been large along the TAPS ROW. However, it is significant in Southcentral Alaska, and it would be prudent for regulatory agencies to consider mitigation measures for other areas, including that around TAPS, if traffic increases in the future. On the ANS, disturbance and displacement of caribou during the calving period is a potential impact. Although the Central Arctic herd has increased and maintained good calf productivity despite oil field development, there are concerns that at some point development will have a negative impact. Monitoring calving distributions and restricting certain activities can effectively mitigate this impact. Increased predator numbers are thought to have occurred on the ANS due to access to anthropogenic foods. Steps have been taken to prevent access to garbage and intentional feeding of bears, foxes, gulls, and ravens. Continued development of these practices is needed.

Marine Mammals: Important impacts include disturbance and displacement during offshore exploration and development, and mortality or injury from oil spills. Extensive monitoring of noise and marine mammal behavior and distribution during offshore operations is mandated in regulations, and mitigation measures have been implemented (e.g., restricting timing of operations) to minimize disturbance and displacement. Oil spills in the Beaufort Sea or Prince William Sound could potentially impact marine mammals, and as for birds and fish, prevention and rapid response are important.

Social Systems

The renewal of the TAPS ROW will provide the opportunity to produce an additional 7 billion barrels of oil from the ANS oil fields, will increase the likelihood of commercializing some 30 trillion cubic feet of currently stranded gas, and result in great economic benefits for the U.S., the state of Alaska, local governments, and residents of Alaska. About 20 percent of current U.S. oil production flows through TAPS, and its continued operation will reduce the U.S. balance-of-payment deficit by approximately $150 billion in 1998 dollars (based on U.S. Department of Energy energy price forecasts) during the renewal period. The economic projections do not include potential gas commercialization and are based on a low oil price of $16 per barrel. Employment opportunities will be far greater than in the no-action alternative for Alaska Natives and non-Natives. Social change will continue with both positive and potentially negative effects. Subsistence resources could be affected if there is a large oil spill, but the SERVS system and

the phase-in of double-hull tankers greatly reduce the risk of such an event.

Effects on the economy (national, state, and local), environmental justice, sociocultural systems, subsistence, cultural resources, and environmental justice are summarized below.

Economic Effects: Renewal of the TAPS ROW would result in the continuation of substantial economic benefits at the national, state, and local levels. Crude production is expected to decline in the future as ANS fields are gradually depleted but, because the scale of operations is so large, economic benefits will be substantial. (Note that the economic analysis was based on an oil price of $16 per barrel. If oil prices are higher, the impacts will increase proportionately.)

At the national level, future operation of TAPS (and ANS fields) means that an important source of domestic crude production — now accounting for approximately 20 percent of domestic crude production — will continue. The importance of ANS production will decrease as production declines, but is expected to be substantial. The cumulative value of ANS crude production is projected to be approximately $150 billion in 1998 dollars (based on U.S. Department of Energy energy price forecasts) during the renewal period. Renewal of the ROW would decrease the balance-of-trade deficit by this amount.

ANS output generates federal revenues from income taxes, royalties, and other sources. Continued operation of the ANS fields is estimated to generate approximately $10.8 billion in additional federal revenues. Because of the federal requirement for double-hull tankers, additional tankers will have to be built for the marine transportation link. These tankers must be U.S. flagged and built, and serviced by U.S. crews. It is estimated that purchase of replacement tankers for the ANS trade will generate 162,000 worker-months of employment at U.S. shipyards.

The State of Alaska receives revenues in the form of royalties and severance taxes on crude oil. Over the renewal duration, these revenues are estimated to total $14.2 billion. These revenues are used to fund continuing state services and to contribute to the Permanent Fund. Since 1977, revenues from the oil and gas industry have accounted for the majority of contributions to Alaska's unrestricted General Fund revenues.

The property tax of North Slope oil-production-related facilities and TAPS continue to be an important source of local government revenues. Local government tax revenues from continued operation of these facilities is estimated to generate more than $2 billion.

The oil and gas industry is a leading component of gross state product and a major economic driver of the economy. Continued operation of TAPS and the ANS fields is essential to the Alaska economy and provides time for a gradual transition from a petroleum-based to a more diversified economy.

The above estimates do not include the potential economic benefits of various projects for commercialization of presently stranded ANS gas reserves. Each of the three gas commercialization options identified above could contribute significantly to the Alaska economy.

Sociocultural Systems: Sociocultural systems continue to evolve in response to many factors, including development of the oil and gas industry in Alaska. Effects have been both negative and positive (e.g., development of improved health care, growth in educational opportunities and attainment, expansion of specific programs for Alaska Natives). Social change is expected to continue whether or not the TAPS ROW is renewed. Renewal provides additional funds to the state and to local communities for maintenance of social programs, and creates employment opportunities.

Subsistence: Subsistence is important to many communities in Alaska, both for economic and sociocultural reasons. Continued operation of TAPS and ANS fields could adversely affect the availability of subsistence resources if there is a large spill in the future. The severity of these effects depends on the quantity of oil spilled, location, season, and other factors. The risk of a large spill from a tanker has been reduced by the SERVS system, by the mandated phase-in of double-hull tankers, and by the reduced volume of oil to be transported over the renewal period. Increased hunter access via the Dalton Highway could increase pressure on subsistence resources, but this issue will remain if the TAPS ROW is not renewed.

Cultural Resources: Adverse effects on cultural sites could result from ground-impacting activities and oil spills. Construction of the pipeline is long-since completed, and impacts associated with maintenance/repairs are not expected to be significant because most ground-impacting activities will occur on previously disturbed soils. Cumulative effects of continued ANS development and of gas commercialization could occur, although new technology has reduced the size of the footprint of exploration and production facilities and construction would be subject to provisions of Section 106 of the National Historic Preservation Act and its state equivalent.

Environmental Justice: Renewal of the ROW enables the continuation of the Permanent Fund Dividend — which has disproportionate benefits for large, low-income families — and continued revenue to state and local governments for maintenance of social programs. Disproportionately ad-

verse impacts on low-income or minority populations may occur if an oil spill impacts subsistence resources.

No-Action Alternative

The no-action alternative involves the end of TAPS operation and the dismantling, removal, and restoration (DR&R) of TAPS facilities. DR&R of TAPS will also result in the end of the ANS oil production.

Physical Environment

In the no-action alternative, it is assumed that above ground facilities related to TAPS will be removed during a 3-year period of DR&R. During that time, major activities will involve the physical removal of equipment and subsequent transportation to disposal sites. For a relatively short time, these activities will result in disruption to the terrestrial environment. These short-term impacts along the TAPS ROW include the potential for spills, increased use of heavy vehicles and traffic with attendant increase in emissions and dust, and increased water discharges from the work camps and from cleaning pipe and equipment. After DR&R, it is likely that some of the workpad, access roads, and the Dalton Highway will remain in place.

Short-term impacts to the physical environment can be identified and mitigated since the impacts are similar to those of original construction. Essentially, DR&R would be a large-scale construction project in reverse. Following the three-year DR&R effort, impacts would diminish to insignificance.

Terrestrial Environment: Potential short-term impacts to the terrestrial environment may be caused by construction associated with dismantling, by those items left in place, such as pipe in buried river crossings, or by modifications to the terrain that occurred during original construction and continue to have an effect.

Seismic hazards relating to an operating pipeline system would be eliminated, and the pipeline seismic risk is minimal during dismantling.

DR&R of TAPS will have no adverse effect on global warming. However, the increase of air temperature associated with global warming will have an impact on soil temperatures and thus may affect soils in permafrost terrain after the pipeline has been removed and the ground restored.

There is a potential for the lasting presence of the pipeline workpad, rehabilitated material sites, access roads, pump station sites, and other visible signs of the former pipeline system for approximately two decades after restoration. These visible signs will add to the visible presence of future construction that might occur.

Water Resources: Cessation of operation of TAPS will require continued use of water resources along the ROW to support dismantling. Wastewaters will be produced at accelerated rates by virtue of the intensive labor effort involved. Freshwater receiving environments will have increased potential for adverse impacts from the large camp populations and extensive earth-moving activities involved in dismantling TAPS.

Atmospheric Environment: After DR&R, all TAPS-related air emissions would cease. For most facilities, the direct ambient impact levels would revert to pre-construction levels.

Cumulative Effects: No significant cumulative effects on the physical environment were identified.

Biological Resources

The direct, indirect, and cumulative impacts of the no-action alternative will be different during the DR&R period and the post-TAPS period. As long as mitigation and prevention measures are implemented, the direct impacts of DR&R on biological resources will be limited and manageable. After DR&R, there will be no direct impacts of TAPS. Indirect impacts associated with use of the TAPS ROW and adjacent areas by the public may be more substantial, but this activity is regulated by government. The primary impact after DR&R may be increased pressure from sport and subsistence harvest (legal and illegal) because of decreased employment following the close of TAPS operations. The following paragraphs summarize the important impacts that warrant consideration under the no-action alternative.

With the exception of some disturbance during the DR&R period, the environment along TAPS, on the ANS, and in Prince William Sound will essentially return to its pre-oil-industry state through a combination of active restoration and natural ecosystem succession under the no-action alternative. The use of natural resources, primarily fish and wildlife, may increase following the closing of TAPS as employment and the state economy dramatically decline. Effective management will be necessary to ensure these resources are not over-harvested and fare as well after, as they have during, the operation of the pipeline.

A potentially important impact on fish, birds, terrestrial mammals, and marine mammals is increased harvest, legal and illegal, sport, subsistence, and commercial, after TAPS operations cease. The end of operations of the oil industry in the ANS oil fields, TAPS, and the VMT will be accompanied by significant reductions in statewide employment and incomes. This may increase the pressure on fish and wildlife if residents use wild foods to compensate for the

loss of income. This could include hunting of terrestrial mammals along TAPS and on the ANS, marine mammals in the Beaufort Sea and Prince William Sound, and waterfowl on the ANS. Sport, commercial, and subsistence fishing could also increase. If decreased state revenue results in less enforcement of fish and game regulations, this impact could be intensified. However, it is also possible that the human population (and fish and wildlife harvests) will decrease in response to the economic decline. Regulation and monitoring by the appropriate agencies is needed to manage this impact.

Vegetation and Wetlands: Important impacts on vegetation and wetlands include disturbance of vegetation during DR&R, introduction of exotic vegetation, and loss of vegetation under gravel fill left in place along the TAPS ROW and in the ANS oil fields. Along the TAPS ROW the primary impact will be disturbance of vegetation during DR&R. Revegetation of disturbed sites will result in a short-term impact, but also improvement of habitat for some wildlife species that use early-stage vegetation. The impact of introduction of exotic vegetation can be removed with the use of native plants for revegetation. The extent of impacts on the ANS depends on the amount of gravel fill left in place and whether it is revegetated. Because the amount of land covered with gravel is relatively small, this impact will not be significant.

Fish: Obstruction of fish movements in low water crossings or culverts during DR&R, and harvest of fish are potentially significant. Obstruction of movements, and habitat changes due to erosion, during and after DR&R could occur. Adequate design of restoration and monitoring during DR&R can mitigate this problem.

Terrestrial Mammals: An important impact on terrestrial mammals is disturbance and displacement during DR&R. DR&R activities can be timed to minimize impacts in sensitive areas, such as calving areas.

Social Systems

Non-renewal of the TAPS ROW will have devastating effects to the economy of Alaska and will significantly impact the U.S. balance of trade. The opportunity to produce an additional 7 billion barrels of oil from the ANS oil fields will be eliminated. The likelihood of commercializing some 30 trillion cubic feet of currently stranded gas on the ANS will be significantly reduced without the oil production infrastructure. Lost revenues to the state of Alaska ($14.2 billion), local governments ($6.5 billion), and residents of Alaska will cause a severe drop in employment, loss of social services, and economic hardships. About 20 percent of current U.S. oil production flows through TAPS, and without ROW renewal those reserves would be stranded, and the U.S. balance-of-trade deficit would increase by approximately $150 billion in 1998 dollars (based on U.S. Department of Energy energy price forecasts) during the renewal period.

The economic projections are based on an oil price of $16 per barrel and could be much more severe if oil prices are higher. Employment opportunities will decline dramatically, particularly for Alaska Natives. Social change will continue. The only potentially positive benefit will be the reduction of the potential impact of crude oil spills on subsistence resources, but this might be offset by the increased pressure on subsistence resources as the economy declines, and potentially, spills of refined products which would have to be brought into the state with the closure of in-state refineries.

Key effects of the no-action alternative include the following.

Economic: Selection of the no-action alternative would result in substantial adverse economic effects at the national, state, and local levels. DR&R activities would create some short-lived employment opportunities, one of the few positive elements in an otherwise bleak economic landscape.

At the national level, closure of TAPS and the ANS fields would result in lower federal revenues (e.g., from taxes and royalties), reduced self-sufficiency in crude petroleum, an increase in the balance-of-trade deficit, and adverse impacts on the domestic shipbuilding industry, as well as further losses in employment for domestic seafarers.

The state would receive sharply lower revenues (reduced by $14.2 billion), lower economic activity, reduced employment, personal income, and net out-migration. A severe and prolonged economic contraction is projected to result, which is much more severe in terms of magnitude and duration than the recessions of 1976 and 1985. Indirect and multiplier effects of TAPS shutdown would be felt in many sectors of the state, property values would decline, mortgage defaults would probably increase, and the state would be forced to take draconian measures to bring revenues and expenditures into balance. The Permanent Fund Dividend would be eliminated, and significant pressures would be placed on state budgets, which ultimately would result in fewer and less generous social services.

Local revenues would fall because of the removal of a significant portion of the tax base and the elimination of certain state transfers. From 2004 to 2015, revenues to local governments would be over $6.5 billion less than under the proposed action. Local governments also would face in-

tense pressures to reduce budgets (and, therefore, services) to bring these into line with revenues.

Economic impacts, as measured by employment and personal income, would be severe for residents of many communities, but particularly so for those on the North Slope and Valdez. Reduced revenues for the North Slope Borough would put pressure on municipal jobs, as well as eliminating those in the oil and gas industry.

The lack of infrastructure after DR&R of TAPS would foreclose gas commercialization in the foreseeable future, which would leave at least 30 trillion cubic feet of domestic gas reserves "stranded" on the ANS. Three refineries in Alaska (two near Fairbanks and one at Valdez), which presently use ANS crude, would be closed and the state would have to import crude oil and/or refined products to satisfy in-state demand.

Sociocultural Systems: Social change will continue even if the no-action alternative is selected. Closure of TAPS and ANS fields will not result in a restoration of the pre-oil culture. To the extent that social ills are related to economic ills, social problems are likely to be exacerbated. Moreover, reduced revenues at all levels of government are certain to reduce the scope and size of social programs designed to ameliorate social programs.

Subsistence: Effects of the no-action alternative on subsistence would be mixed. Closure of oil and gas facilities would eliminate the potential for oil spills on the North Slope or pipeline route, a potential benefit. (Because Alaska would have to import crude and/or refined products to satisfy internal demand, the risk of some oil spills remains.) However, income losses would limit expenditures for arms, ammunition, boats, motors, snowmachines, and other equipment used for hunting and fishing. Moreover, income and employment losses may mean that there would be more pressure on subsistence resources because more persons would adopt the subsistence lifestyle out of economic necessity.

Cultural Resources/Recreational/Wilderness: The no-action alternative would reduce the potential for adverse impacts. DR&R activities, for example, would remove most visible traces of oil and gas development. Cessation of operations would eliminate possible impacts associated with oil spills of ANS crude.

Environmental Justice: The no-action alternative has environmental justice implications. On the positive side, the probabilities of adverse impacts on subsistence would be reduced (though not eliminated). However, there are also negative effects. Elimination of the Permanent Fund Dividend would have disproportionate adverse effects on large, low-income families, including those of Alaska Natives. The no-action alternative would result in adverse impacts on Native corporations. For example, the Arctic Slope Regional Corporation owns the subsurface rights on selected areas of the North Slope. Foreclosure of exploration and production activities on these lands would adversely impact this corporation and its Alaska Native shareholders.

4.1 Mechanisms of Impact

Section 4.1 examines the mechanisms by which continued operation of TAPS may cause environmental and socio-economic effects. Section 4.1.1 describes possible ground-impacting maintenance actions, including excavations for investigating corrosion of below-ground pipe, maintenance of slopes and the workpad, potential pipe replacement projects, valves maintenance, remediation of cathodic protection, maintenance and repair of river crossings and training structures, surveillance actions, maintenance and repair of the fuel gas line, and gravel mining.

Section 4.1.2 presents a summary analysis of oil spill potential during the ROW renewal period. This analysis includes potential spills from North Slope exploration and production activities, TAPS operation, and marine tanker transportation. Appendix B contains the full detail of the spill analysis.

4.1.1 Ground-Impacting Maintenance Actions

By J.D. Norton and J. Harle

Ongoing maintenance activities will occur during the ROW renewal period (2004-2034) as TAPS operation continues. Significant activities affecting the environment are summarized in the following sections. For each activity, typical maintenance expectations based on historical data are covered and the project scale estimated.

Alyeska Pipeline Service Company

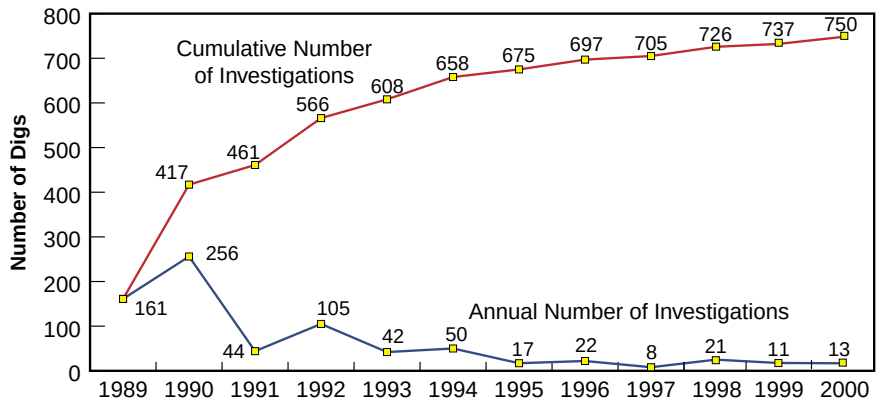
Photo 4.1-1. *Typical TAPS corrosion investigation project.*

4.1.1.1 Corrosion Repair of Below-Ground Mainline Pipeline

External corrosion investigations ("digs") of buried mainline pipe occur annually based on review of data gathered from instrumented-pig runs. Mainline pipe sections where pipe-wall thinning is detected are excavated and examined. Pipe coatings and cathodic protection systems are repaired to arrest additional wall thinning from corrosion. In some cases, full-encirclement pipe sleeves are installed to reinforce the pipe where anticipated hydraulic pressures require additional measures of safety.

Uncovering mainline buried pipe for examination and repair usually results in an engineered excavation of about 60 linear feet of pipe (Tart and Hughes, 1998). The excavations usually disturb a surface area of about 50 by 200 feet within the existing workpad area. Depth of cover of soil over the top of the pipe varies from 4 to 20 feet, with side slopes generally at a ratio of 2 to 1. For personnel safety, the slopes are no steeper than 1.5 to 1. Some corrosion problems are detected in wet areas, and these excavations are more complex and are carried out in winter to reduce the need for dewatering excavations. Dewatering may be required at any time of the year, and ditch water is discharged in accordance with state and federal permits. At approximately two sites each year, the dewatering discharge is expected to exceed 500,000 gallons (gal) total for both sites.

Impacts from this activity are localized and of short duration and include equipment noise, water quality changes from discharges, and excavation fill and regrading of the site. An estimated 15 digs will initially occur each year, potentially increasing to 20 by the end of 2034 (Flanders, 2000, pers. comm.). Figure 4.1-1 shows the numbers of Alyeska corrosion investigation digs since 1989.



Source: Flanders (2000, pers. comm.)

Figure 4.1-1. *TAPS corrosion investigation projects for underground mainline pipe.*

4.1.1.2 Slope/Workpad Maintenance

Slopes must be monitored for adverse movement, and occasional maintenance and repair of the slopes or the affected sections of mainline pipe are necessary. Fifty slopes are monitored every two years for change. Five areas are currently instrumented and monitored for movement and ground temperature change: Squirrel Creek, Klutina, Tazlina, Pump Station 11, and Treasure Creek.

Maintenance activities include workpad regrading, revegetation, clearing of drainage structures, adjustment of above-ground pipeline elevation, and installation of passive thermal-transfer devices (heat pipes) to maintain slope stability. This activity generates noise, requires use of heavy equipment on the slope or workpad, and creates the potential for erosion runoff.

4.1.1.3 Potential Pipeline Replacement

Mainline pipe replacement is rare since most pipe repair work is accomplished by installation of full-encirclement pipe sleeves over damaged sections. In addition, ongoing refurbishment of pipeline coatings and cathodic protection systems reduces pipeline repairs or replacements. Four pipeline reroutes/replacements have occurred since 1977:

- 3,600 linear feet at MP 200 near the Dietrich River in 1985,
- 234 linear feet at MP 166 at Atigun Pass in 1987,
- 200 linear feet at Pump Station 3 in 1990, and
- 8.5 miles at MP 157 to MP 165 near the Atigun River in 1991.

These projects were initiated because pipe replacement was determined to be a more economical solution than the expected number of site-specific repairs in these areas.

Impacts from pipeline replacements are greater than those from normal maintenance activities. Pipeline replacements are major construction projects that approach original construction impacts in scale for a localized area. Costs range from $1 million to $10 million per mile. Because of pipeline integrity monitoring, major reroutes due to corrosion are not expected during the ROW renewal period.

Less significant pipeline rehabilitation efforts may be required at mechanically refrigerated sites. The impacts would be similar to those from below-ground corrosion investigations. Small excavations may be needed at the three mainline refrigeration sites. The refrigeration units or pipeline insulation at all three sites may need to be replaced in order to maintain pipe support.

4.1.1.4 Mainline Below-Ground Valve Maintenance

Mainline valves undergo extensive performance testing, and increased maintenance efforts are expected (Jackson and White, 2000). Forty mainline valves are in below-ground pipe, and all may be excavated for inspection and repair — at a rate of about 5 valves per year (Aus, 2000, pers. comm). Vaults are likely to be installed at each site to

provide access for future inspections. Impacts expected are similar to those from below-ground corrosion investigations.

Some below-ground valves may be replaced and refurbished, as was done with three valves in 1990, one in 1998, and one in 2000 (Pomeroy, 2000, pers. comm.).

4.1.1.5 Remediation of Mainline Cathodic Protection

Cathodic protection mitigates corrosion of buried mainline pipe. Alyeska monitors cathodic protection by "coupon" testing, close interval survey, and test stations. Remedial action is taken if cathodic protection is determined to be inadequate.

If remediation is required, impressed-current cathodic protection or sacrificial galvanic cathodic protection is installed. Impressed-current cathodic protection has been applied by installation of deep-well anodes, linear anodes, or horizontally distributed anode beds.

At remote sites, one of the most difficult problems with an impressed-current system is obtaining electrical power. Commercial power is normally available at pump stations and for areas south of Fairbanks. Where commercial power is not available, a generator is needed to operate an impressed-current system.

Deep-well ground beds are installed vertically from the surface and may be several hundred feet deep. The beds are effective in areas where the surface soil resistivity is high. Deep-well impressed-current systems can affect cathodic protection for several miles on each side of the ground bed. Deep-well ground beds are often installed remote from the pipeline and therefore require additional right-of-way.

Linear anodes are placed near the pipeline and distribute current effectively to the pipeline in the vicinity of the anode. Trenching near the pipeline is required, and a rectifier must be installed.

Horizontally distributed anode ground beds, such as those at pump stations, can affect the pipeline for several miles in each direction. Because the anodes are distributed relatively near the surface, the ground bed is larger than a deep-well ground bed.

Impacts from remedial cathodic protection of any kind are localized and include noise and potential minor lubricant spills from support equipment. The need for remediation is determined by evaluating a combination of cathodic-protection data, corrosion-pig data, and mitigation history. During the period 2004-2034, the addition of 20 to 30 new impressed-current rectifiers can be expected. Each year, 6 to 10 anode ground beds will need to be repaired, replaced, or improved (Williams, 2000, pers. comm.).

Alyeska Pipeline Service Company

***Photo 4.1-2**. Coating mainline pipe.*

As the pipeline ages, the coating degrades, more bare metal is exposed, and greater demands on the cathodic protection system result. The system may ultimately not be able to supply sufficient corrosion protection to TAPS. At this point, either additional protection must be added or the coating must be refurbished. Coating refurbishment requires excavation of the pipeline one segment at a time to allow placement of a new coating (Photo 4.1-2). It is estimated that rehabilitation of less than 5 miles of pipeline will occur during the ROW renewal period (Klechka, 1999, pers. comm.).

4.1.1.6 River Crossings and River Training Structure Repairs

During design, it was anticipated that maintenance of existing river-training structures would be necessary and that new structures might be needed in response to major floods or stream migration. Some repair and new structures are required almost every year. A typical repair may involve adding riprap to a washed-out spur nose or to bank riprap.

Impacts from maintenance or construction of river training structures are primarily noise, dust, gravel and rock mining (either local or remote), and sediment generation from instream activities. All work is done in accordance with environmental permits. Emergency or temporary repair work is done in accordance with methods practical at the time for the specific location with oversight by regulatory agencies.

In addition to maintenance of river training structures to ensure pipeline integrity, repairs or additions may also be made to facilitate right-of-way access. For example, a dike was constructed along McCallum Creek in 1999 to mitigate workpad overflows caused by icings. In the Atigun River

floodplain, repairs to the workpad were necessary in the 1990s to maintain access to a check valve.

4.1.1.7 Surveillance Actions

Surveillance has minimal ground-impacting mechanisms, because surveillance uses conventional vehicles on established work areas. Much of the surveillance during summer is by helicopters or by four-wheel-drive trucks on the workpad and access roads. In winter, snow vehicles and helicopters are used.

4.1.1.8 Fuel Gas Line Maintenance and Repair

Annual regrading and backfilling of the cover over the fuel gas line are required because of seasonal temperature variations and water runoff. Sections of the line are subject to thermal uplifting (jacking) each year due to cold gas temperatures. These sections are analyzed for stress and corrosion, and evaluated using an integrity-based approach. Several hundred feet of the line are reburied each year (Sorenson, 2000, pers. comm.).

Rectifiers located at Pump Stations 1, 2, 3, and 4 provide cathodic protection for the fuel gas line, and the 74 test stations are monitored annually. Remediation of this system is based on a risk assessment and U.S. Department of Transportation requirements.

Impacts result from excavation equipment, trucks, and vehicles on the right-of-way of the fuel gas line. After repairs are complete, the right-of-way is regraded and revegetated. Impact is minimized by performing most work in the winter. Most of the fuel gas line was built from snowpads, and no permanent gravel workpad exists. However, the fuel gas line runs adjacent to the oil pipeline workpad or adjacent to the Dalton Highway, both of which provide access.

4.1.1.9 New Material Sites/Rock Quarries

Gravel materials will be needed for the maintenance and repair of the ROW. Rock quarries produce riprap to maintain and repair river and floodplain bank-protection dikes and levees. The impact mechanisms are earth-moving equipment removing vegetation and soil overburden from the area of the site and construction of access roads. Heavy trucks will travel the access road to deliver materials to the maintenance areas. After the material sites and access roads are no longer needed, these sites will be contoured and revegetated in accordance with permit requirements. For additional discussion on the impact of gravel/rock mining, see Section 4.3.1.1.

4.1.2 Spill Analysis

By IT Corporation staff, L.D. Maxim, and R. Niebo

Of the possible adverse impacts of continued operation of TAPS, a large oil spill is potentially of greatest concern. This section summarizes the results of an historical analysis of oil spills from North Slope oil production and transportation Operations[1] from 1977 to 1999 and uses these data, together with estimates of possible improvements in spill prevention measures, to estimate probable spill volumes and the likelihood of large [>1,000-barrel (bbl)] spills occurring for the ROW renewal period (2004-2034). See Appendix B for a more comprehensive technical analysis.

Since the statistical characteristics of oil spills differ among the activities that produce or transport oil, data are provided for each of four distinct segments of Operations:

- Alaska North Slope (ANS) exploration and production (E&P),
- The pipeline,
- The Valdez Marine Terminal (VMT), and
- The marine transportation (tanker) link.

Based on the definition of TAPS in the Federal Grant (Stipulation 1.1.1.22), neither E&P nor marine transportation is part of TAPS. However, these are elements in the production and transportation system and are included for use in the impact discussions in Section 4. Table 4.1-1 identifies the spill potential associated with each segment.

Past Operations have resulted in spills of various materials, including the following:

- Crude oil.
- Refined products (“product”), such as aviation fuel, diesel fuel, gasoline, turbine fuel, motor oil, lubrication (lube) oil, and hydraulic oil.
- Other substances, such as acetone, mercury, propane, antifreeze, Therminol, Halon, and corrosion inhibitor.
- Water (e.g., ballast water, oily water, saltwater).

In accord with the spill analyses presented in recent documents such as the environmental assessment (EA) for the Alpine Development (USACE, 1997), the environmental evaluation documents for NPR-A (BLM and MMS, 1998), and the Beaufort Sea and Chukchi environmental impact statements (EISs) prepared by the Minerals Management Service (MMS, 1987a, b, 1990, 1996a), this spill analysis focuses on crude spills, although data and projections are given for both crude and product spills. Crude spills result from some loss of system integrity in events such as a tank valve failure, pipeline cracks, and tanker

[1]The term *Operations* is capitalized in this discussion and refers to North Slope oil production and transportation.

Table 4.1-1. *North Slope production and transportation system segments employed in oil spill analysis.*

Segment	Segment Boundary	Where Spilled	Sample Major Spill Events	Principal Data Sources
Exploration and Production (E&P)	North Slope oil fields to Pump Station 1	North Slope oil wells, feeder pipelines, and other Alaska North Slope facilities	• Leaks on pads • Well workover/ maintenance spills • Loading/unloading spills at crude oil topping units	BP/ARCO; ADEC
Pipeline	Pump Station 1 to metering station at VMT	Distributed along length of pipeline, at pump stations, associated tanks farms, and access roads	• Steele Creek sabotage incident • Atigun Pass pipe settlement • Tank valve failure at Pump Station 10 • Check Valve 92 failure	APSC; ADEC
Valdez Marine Terminal (VMT)	Metering station to loading arm(s)	Within VMT	• Valve leak at East Tank Farm • Sump bleed line spill from fuel offloading rack	APSC; ADEC
Marine Transportation	Tankers	At loading dock, harbor, harbor approaches, and domestic destination ports (e.g., California, Hawaii, Washington state)	• *Thompson Pass* hull crack • *Exxon Valdez* grounding • Loading/unloading spills	APSC; ADEC; USCG

groundings leading to penetration of crude tanks. Product spills generally result from ancillary or supporting activities — e.g., diesel spills from fueling vehicles.

4.1.2.1 Data Sources and Compilation

IT Corporation compiled a master database of spills for all segments from 1977 when the first oil flowed through TAPS until the cutoff date for this analysis (August 1999)[2]. This database includes spills of crude, product, "other," and water. The principal sources of E&P spill data are spill databases maintained by ARCO Alaska, Inc., BP Exploration (Alaska) Inc., and Alyeska Pipeline Service Company. The principal source of pipeline and VMT spill data is the Alyeska database. The principal sources of marine transportation spill data are databases maintained by Alyeska for Valdez and Prince William Sound (PWS) and by the U.S. Coast Guard (USCG) for U.S. waters. These data were augmented by and checked against data available from other agencies, including the Alaska Department of Environmental Conservation (ADEC), U.S. Environmental Protection Agency (EPA), and the Office of Pipeline Safety (OPS), Research and Special Programs Administration, U.S. Department of Transportation. Likewise, tanker spills at U.S. destination ports (not originally contained in the Alyeska database) available from the USCG were included. Consistency checks among the various databases enabled deletion of duplicate records and other adjustments.

The database contains information on the number and volume of spills. Many spills — particularly small ones — occurred inside buildings, within secondary containment structures, or on gravel pads, and/or were otherwise contained. The size threshold for spill reporting varies with the segment (see Appendix B), but many spills in the database are less than 1 teaspoon.

4.1.2.2 Data Analysis

Appendix B presents several statistical analyses of historical crude and product spills, including a study of the number and volume of spills by segment, the development of descriptive statistics, comparisons of spill volumes with original estimates and various benchmarks, evaluation and characterization of the size distribution of spill volumes, and an examination of relevant time trends.

Since spills are accidental events that are probabilistic rather than deterministic, it is essential to characterize them in statistical terms. This analysis provides estimates of the average spill volume either for the entire duration of the ROW renewal period or on an annual basis. The spill histories of Operations and other oil production and transpor-

[2]Since August 1999, no large oil spills have been associated with TAPS; the last large (>1,000 bbl) spill occurred in 1990 (Table 4.1-2). The oil spill analysis has not been updated to include small spills that may have occurred since August 1999. Since small spills account for only a minor portion of the total volume spilled over the life of TAPS (Figure 4.1-5), it is not useful to repeat the analysis after each small spill. These small spills have little or no material impact on the outcome of the analysis.

tation systems exhibit substantial year-to-year variability in spill volumes. Even though future spill volumes are likely to decrease in aggregate, largely as a result of prevention measures applicable to the marine transportation segment, such variability is likely to continue.

The statistical analysis reflects current knowledge about oil spill statistics found in applicable literature (see, e.g., Amstutz and Samuels, 1984; Anderson, C.M. and LaBelle, 1990, 1994; CONCAWE, 1998; LaBelle and Anderson, 1985; Lanfear and Amstutz, 1983; Smith, Slack et al., 1982). Key findings are highlighted below.

Aggregate Spill Totals and Distribution by Operations Segment

For all Operations segments, approximately 10,600 spills occurred involving a total volume of approximately 327,100 bbl (14,870 bbl/yr) of either crude or products over 22 years. The total spill volume is dominated by a single catastrophic event, the *Exxon Valdez* oil spill (EVOS) in 1989. This single event accounts for 78.6 percent of the total volume of crude and product spilled.

Figure 4.1-2 shows how the spill *volume* varies with material spilled (crude and product) by segment, and Figure 4.1-3 presents similar information for the *number* of spills. The respective shares of the total volume of crude and product spilled by segment are:

- E&P, 3.36 percent (50.87 percent of total number);
- Pipeline, 9.56 percent (29.94 percent of total number);
- VMT 1.26 percent (11.16 percent of total number); and
- The marine transportation link, 85.82 percent (8.04 percent of total number).

Product spills are more numerous (77.1 percent of the total number of spills), but because these typically involve smaller spills, account for only 3.21 percent of the total volume of crude and product spilled.

Figure 4.1-4 shows a histogram of the total number of crude and product spills in gallons for all Operations segments. The class intervals are shown in orders of magnitude. About 32 percent (3,338 of 10,577 spills) fall in the range of 0 to 1 gal. Another 43 percent of these spills fall into the 1 to 10-gal range. Beyond this, the number and percentage of spills fall off rapidly with spill size. Small spills are thus most numerous. However, while few in number, large spills account for most of the total volume spilled.

Statistics on Large Oil Spills

Perhaps the most striking feature of the Operations oil spill data is the relative importance of large oil spills. Table 4.1-2 shows summary information about the 10 largest oil spills, including both crude and product spills, over the operating history of TAPS. MMS uses a threshold of 1,000 bbl for a large spill. Expanding this list by one additional spill (Table 4.1-2, bottom) includes all spills greater than or equal to 1,000 bbl. Several features of this table are noteworthy:

- Collectively, these spills account for a very large percentage of the total volume of oil spilled. The top ten range in size from 1,700 bbl (the *Thompson Pass* spill) to 257,143 bbl (the EVOS) and account for approximately 93.5 percent of the total volume spilled. If all spills greater than 1,000 bbl are included, the 11 largest spills account for 94 percent of the total volume. As noted above, there are 10,577 recorded spills from 1977 to 1999. Thus, only 11 out of 10,577 (0.1

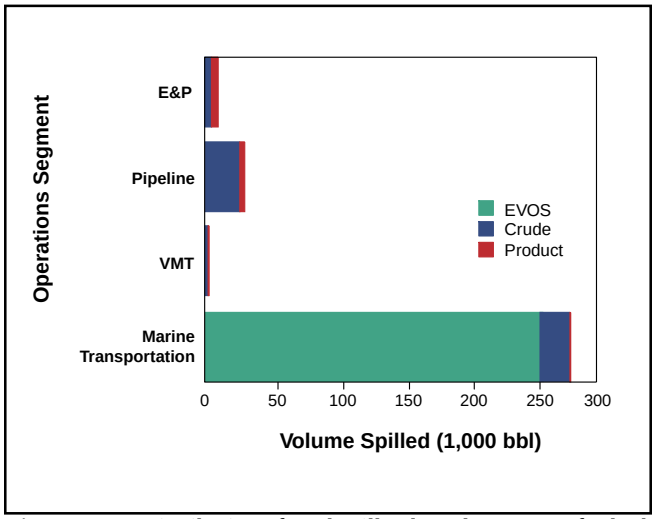


Figure 4.1-2. *Distribution of total spill volume by segment for both crude and product spills (1977-1999).*

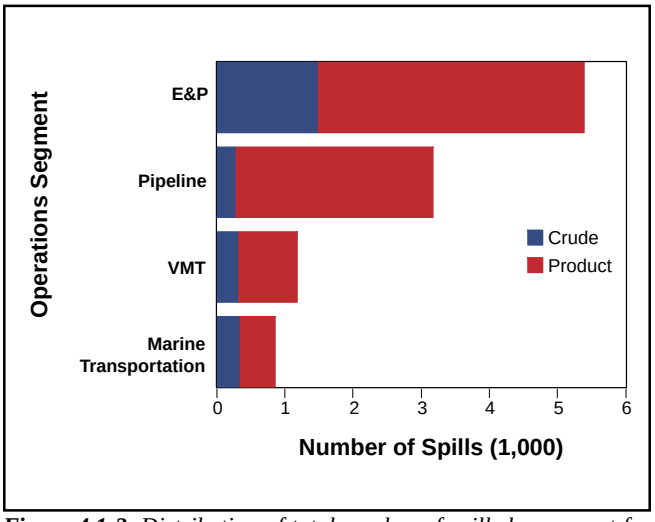


Figure 4.1-3. *Distribution of total number of spills by segment for both crude and product spills (1977-1999).*

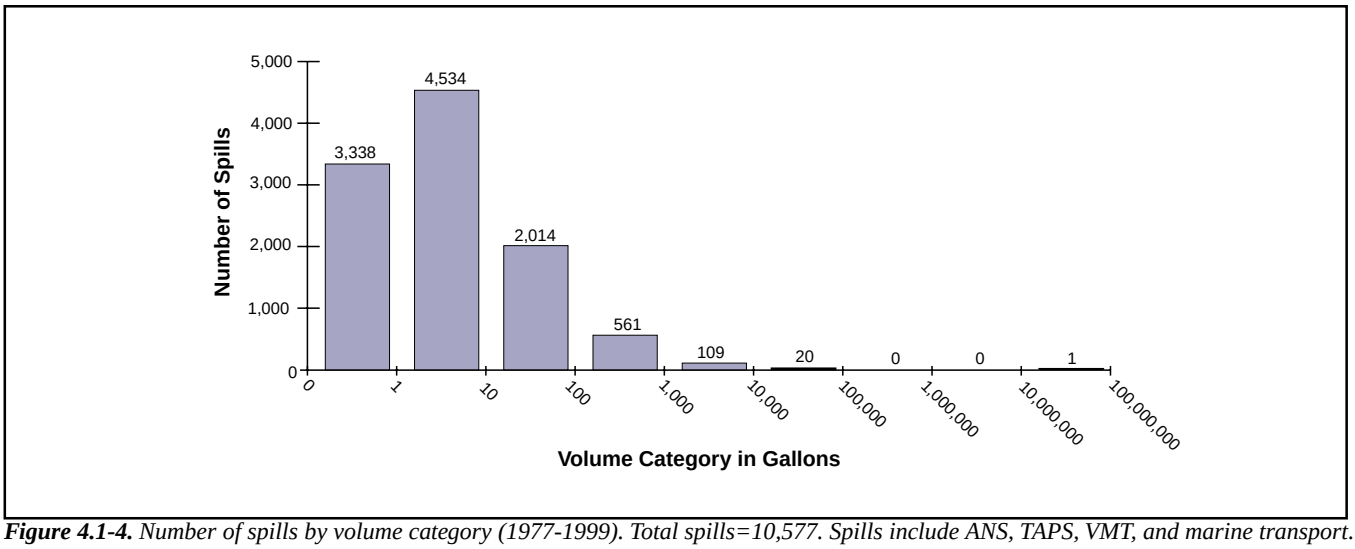


Figure 4.1-4. *Number of spills by volume category (1977-1999). Total spills=10,577. Spills include ANS, TAPS, VMT, and marine transport.*

percent) of the spills account for 94 percent of the total spill volume. Figure 4.1-5 shows the fraction of total crude and product spills accounted for by the largest spill, next largest 10 spills, 100 spills, 1,000 spills, and the remaining 9,466 spills.

- Five of the largest ten spills (EVOS, *American Trader, ARCO Anchorage*, *Glacier Bay,* and *Thompson Pass)* occurred on the marine transportation segment. There were four large pipeline spills (five >1,000 bbl) and one large VMT spill. E&P spills, though most numerous, accounted for only 3.4 percent of the total spill volume.
- Of the marine transportation spills, the EVOS and *Thompson Pass* spills occurred in Port Valdez or Prince William Sound. The *American Trader, ARCO Anchorage,* and *Glacier Bay* spills occurred at destination ports. The likelihood of oil spills at destination ports is proportional to the volume of oil imported, not to TAPS throughput. Even if TAPS were not in operation, import-related spills would still occur. It cannot be said that these three specific spills would have occurred without TAPS, but when oil is being handled, the statistical chance of oil spills exists.

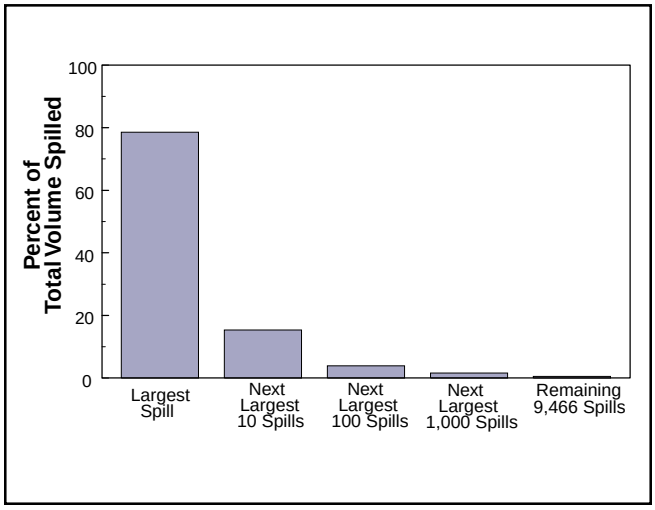


Figure 4.1-5. *Fraction of total volume (crude and product) spilled accounted for by largest spills.*

Operations Spills in Context

While the total volume of crude and product spilled since TAPS operation started is substantial, it is much lower than estimated in the original TAPS EIS (BLM, 1972). The authors of the original EIS did not consider E&P spills and lacked the data to project pipeline or VMT spills. Instead, they estimated a range of values for marine-transportation spill volumes. When adjusted for year-to-year variations in throughput and totaled over the 22-year period, the original estimate would range from 2.6 million to 5.9 million bbl, substantially greater than the 0.33 million bbl actually spilled.

The total volume of crude and product spilled in Operations is small compared to the amount of material produced and handled. One measure often used to characterize spill performance is the *volumetric spill rate,* defined as the number of barrels of material spilled divided by the barrels handled. These rates are typically calculated in units of bbl spilled per million bbl of throughput. Volumetric spill rates are as follows:

- All segments, 25.6;
- E&P, 0.86;
- Pipeline, 2.45;
- VMT, 0.323; and
- Marine transportation, 22.03.

Table 4.1-2. *Crude or product spills >1,000 bbl for Operations (1977-99).*

Event	Date Material Spilled	Quantity Spilled (bbl)	Material Spilled	Operations Segment	Description
Exxon Valdez	March 24, 1989	257,143	Crude oil	Marine	Tanker went aground on Bligh Reef, Prince William Sound
Steele Creek, MP 473.53	February 15, 1978	16,000	Crude oil	Pipeline	Leak caused by sabotage
American Trader	February 7, 1990	9,458	Crude oil	Marine	Vessel grounded on own anchor during mooring at Golden West Marine Terminal off Huntington Beach, CA.
ARCO Anchorage	December 21, 1985	5,690	Crude oil	Marine	Tanker ran aground in Port Angeles, WA
Glacier Bay	July 2, 1987	4,942	Crude oil	Marine	Tanker struck rock and went aground in Cook Inlet
MP 734	June 15, 1979	4,000	Crude oil	Pipeline	Pipe wrinkled and cracked due to settlement
Valdez Marine Terminal (VMT) East Tank Farm	February 11, 1980	3,200	Crude oil	VMT	Leaking valve, East Tank Farm
Check Valve 23	January 1, 1981	2,000[a]	Crude oil	Pipeline	Leak due to drain connection failure
Check Valve 7	July 19, 1977	1,800	Crude oil	Pipeline	Front-end loader accidentally broke check valve
Thompson Pass	January 3, 1989	1,700	Crude oil	Marine	Crack in tanker hull at Valdez, AK
		Cumulative volume of ten largest crude or product spills			305,933 bbl
		Total volume of crude and product spilled			327,107 bbl
		Cumulative volume of ten largest crude or product spills as percent of total spilled			93.5 percent
Note: The Operations oil spill data base lists 11 spills larger than 1,000 bbl. These spills include the 10 listed above and the spill listed below:					
Milepost 166.433 Atigun Pass	June 10, 1979	1,500	Crude oil	Pipeline	Pipeline support loss
		Cumulative volume of 11 largest crude or product spills			307,433 bbl
		Total volume of crude and product spilled			327,107 bbl
		Cumulative volume of 11 largest crude or product spills as percent of total spilled			94.0 percent

(a)Spill volume was 1,500 barrels per Alyeska records, but 2,000 barrels per JPO records. The larger volume was used in this analysis.
For additional material on marine spills, see the following:
Exxon Valdez: ADEC (1993), Nadler (1994), NRC (1991, 1998), Davidson (1990), Keeble (1991), NTSB (1990)
American Trader: NRC (1991), Nadler (1994), Epler (1990)
Glacier Bay: Davidson (1990), Nadler (1994), Little (1999), Wohlforth (1991), Bernton (1987a, b), Chappel (1987), Foster (1987), Kizzia (1990)
ARCO Anchorage: Nadler (1994)
Thompson Pass: Nadler (1994), Davidson (1990), Keeble (1991), Epler (1989a, b)

Operations spill experience can also be put in context by another measure. To project spills, MMS uses a spill rate defined as the number of >1,000-bbl spills per billion bbl of throughput. Because no large E&P spills have occurred, the spill rate for this segment is 0. For the pipeline and VMT together, the combined spill rate is 0.47. For the marine transportation link, this spill rate is 0.39. In analyzing outer continental shelf platforms and pipelines, MMS developed estimates of spill rates of 0.45 for platforms and 1.32 for pipelines (Anderson and LaBelle, 1994). Both rates are considerably greater than those for corresponding segments of Operations (Figure 4.1-6). These comparisons help provide quantitative perspective.

As noted above, small spills are most numerous, but large spills account for the vast majority of the total spill volume. This is true in aggregate and on a segment-by-segment basis (see Appendix B). A brief summary of relevant spill statistics for each segment from 1977 to 1999 is pre-

sented below.

E&P Spills. Spills from this segment range from 0.0015 to 925 bbl for crude and 0.0006 to 450 bbl for product. Fifty percent (the median) of E&P crude spills are ≤0.238 bbl (slightly less than 10 gal), while 50 percent of E&P product spills are ≤0.119 bbl (slightly less than 5 gal).

The smallest 90 percent of E&P crude spills account for approximately 13 percent of the total volume spilled, while the smallest 90 percent of product spills account for 16 percent of the total volume spilled.

The cumulative distribution function (CDF) provides another perspective on spill volumes. Figure 4.1-7 shows the CDFs for E&P crude and product spills. The CDF plots the fraction of spills with a volume less than or equal to a specified value V (on the y-axis), against the value of V (on the x-axis). Because of the large variability of spill volumes, only a portion of the CDF is plotted in Figure 4.1-7: that for spills ≤2 bbl. For E&P spills, 84.1 percent of crude spills and 92 percent of product spills are <2 bbl.

Pipeline Spills. Spills from this segment range from essentially zero to 16,000 bbl for crude and zero to 238 bbl for products. Fifty percent (the median) of pipeline crude spills are ≤0.0476 bbl (2 gal), while 50 percent of the pipeline product spills are ≤0.071 bbl (3 gal).

The smallest 90 percent of pipeline crude spills account for approximately 0.25 percent of the crude volume spilled, while the smallest 90 percent of product spills account for 6.2 percent of the product volume spilled.

Figure 4.1-8 shows the CDFs for crude and product pipeline spills. For pipeline spills, 88.0 percent of crude spills and 96.3 percent of product spills are <2 bbl.

VMT Spills. Spills from this segment range from essentially zero to 32,100 bbl for crude and zero to 29 bbl for products. Fifty percent of VMT crude spills are ≤0.0238 bbl (1 gal), while 50 percent of VMT product spills are ≤0.00595 bbl (0.25 gal).

The smallest 90 percent of VMT crude spills account for approximately 0.81 percent of the total volume of crude spilled for this segment, while product spills account for 4.2 percent of the total volume of product spilled.

Figure 4.1-9 shows the CDFs for VMT spills, of which 95.3 percent of crude spills and 97.4 percent of product spills are <2 bbl.

Marine Transportation Spills. Spills from this segment range from essentially zero to 257,143 bbl for crude and zero to 681 bbl for products. Fifty percent of marine transportation crude spills are ≤0.0476 bbl (2 gal), while 50 percent of marine transportation product spills are ≤0.006 bbl (0.25 gal).

The smallest 90 percent of marine transportation crude

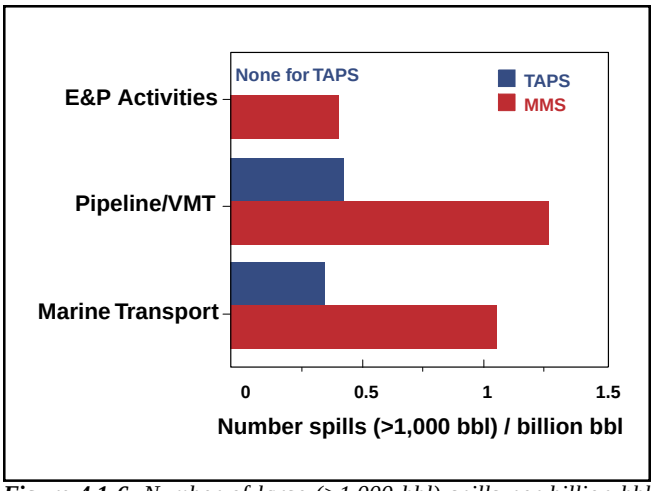


Figure 4.1-6. *Number of large (>1,000 bbl) spills per billion bbl throughput for Operations segments compared to MMS data.*

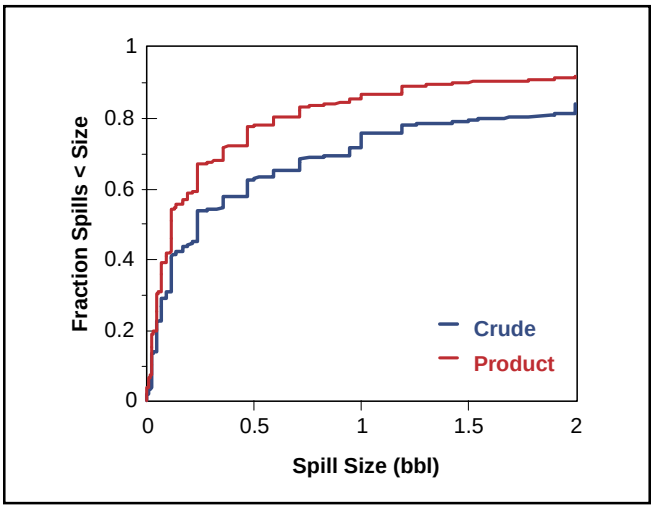


Figure 4.1-7. *Cumulative distribution function for E&P spills (1977-1999).*

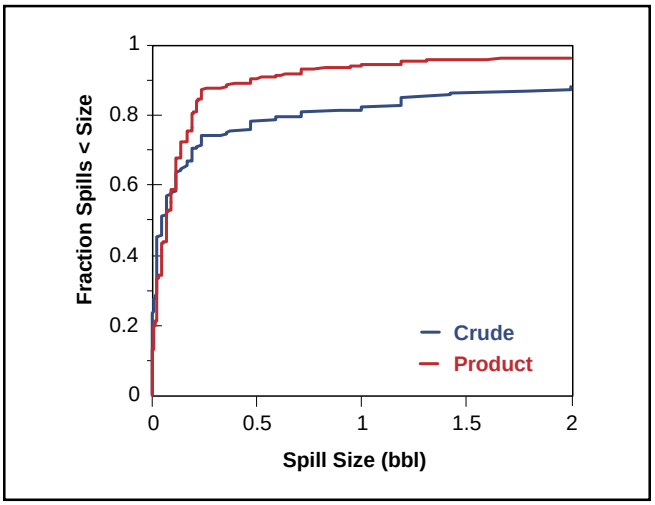


Figure 4.1-8. *Cumulative distribution function for pipeline spills (1977-1999).*

spills account for 0.03 percent of the total volume of crude spilled on this segment, while the smallest 90 percent of product spills account for 0.87 percent of the product volume spilled.

Figure 4.1-10 shows the CDFs for marine transportation spills: 87.2 percent of crude spills and 95.4 percent of product spills are <2 bbl.

Conclusion. The large spill rates for various segments of Operations compare favorably with MMS estimates for outer-continental-shelf platforms and pipelines. Analyses of spill data from both sources indicate that the *total number of spills* is not a statistic of particular relevance. Rather, analytical effort should be focused on large (defined by MMS as >1,000 bbl) spills and/or on the total volume of material spilled. Small spills, though numerous, do not account for an appreciable fraction of the volume spilled.

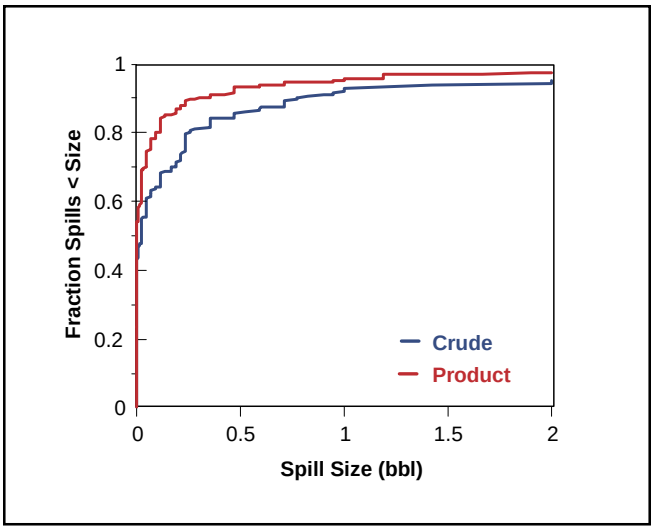


Figure 4.1-9. *Cumulative distribution function for VMT spills (1977-1999).*

4.1.2.3 Projections of Future Spill Volumes

Time Trends

This section analyzes spill rates, based on spill volumes per million barrels handled, to see if there are trends over time. Time trends provide a useful basis for making informed projections of future spill volumes associated with continued operation of TAPS if the ROW is renewed. Consequences of the no-action alternative are discussed in a later section.

This analysis develops conservative projections of spill volumes over the period of ROW renewal (2004-2034). Management of Alyeska and E&P operators have expressed commitment to reducing spill volumes. To the extent that these efforts are successful, future spill volumes will be less than those estimated here.

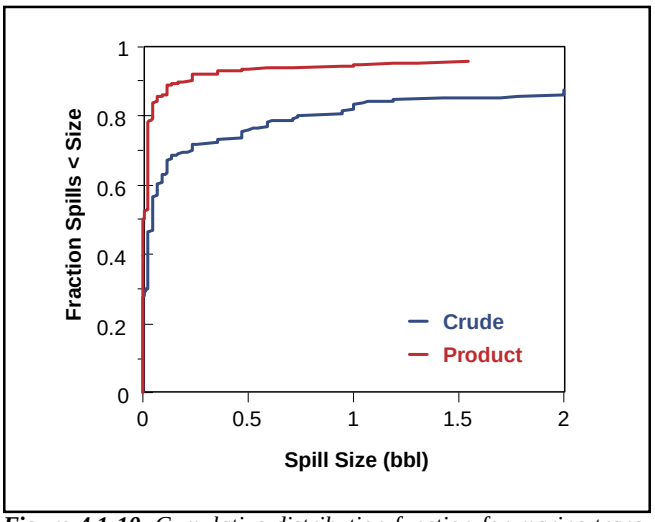


Figure 4.1-10. *Cumulative distribution function for marine transportation spills (1977-1999).*

E&P

Figure 4.1-11 presents volumetric spill rates in bbl spilled/million bbl throughput by year for the E&P segment from 1977 to 1999. The y-axis is the volumetric spill rate defined as the total annual volume of crude and product spilled divided by the total annual crude throughput. There is substantial variability (approximately one order of magnitude) in year-to-year volumetric spill rates over this period and little apparent trend — an impression supported by statistical regression analysis. Absent a trend or persuasive evidence of a step change, the historical average volumetric spill rate provides the best estimate of future spills for this segment. Dividing the total amount spilled by the total throughput from 1977 to 1999 yields an average annual spill rate of 0.86 bbl/million bbl throughput.

Because TAPS throughput volumes are projected to de-

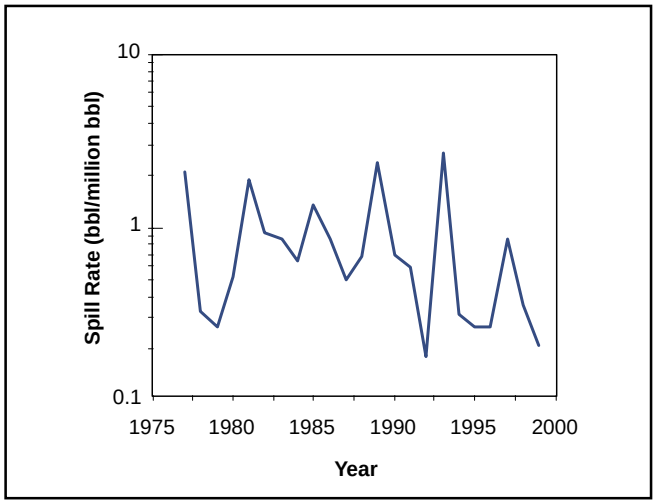


Figure 4.1-11. *Volumetric spill rate for ANS E&P operations (1977-1999).*

crease in the future (see Appendix A), the assumption of a constant average volumetric spill rate (per million bbl throughput) means that future E&P spills will decrease in proportion to throughput. Based on the baseline future TAPS throughput assumption from the year 2004 to 2034 of 7.02 billion bbl, the projected volume of E&P crude and product spills is approximately 6,050 bbl for the period — an average of 202 bbl/year.

Pipeline

There is some debate about the magnitude of future pipeline spills as TAPS ages. Available evidence from Europe (CONCAWE, 1998) suggests that older pipelines have the same spill rates as newer pipelines. However, some TAPS critics have expressed concern that spills may be more likely in the future (Fineberg, 1997).

Figure 4.1-12 presents volumetric spill rates by year for the pipeline segment. As with the data from all other segments, there is substantial variability (approximately three orders of magnitude for this segment), but evidence of a downward trend in volumetric spill rates in later years. (All large pipeline spills occurred during first five years of operation of TAPS. None has occurred since 1987). A linear regression line (the dashed line in Figure 4.1-12) has a negative slope, which is significantly different from zero ($p = 0.001$), confirming the visual impression offered by Figure 4.1-12. Nonetheless, the predictive power of the linear trend model is not high, indicating that year-to-year variability is large relative to any time trend. For this reason, it is conservatively assumed that the volumetric spill rate is constant over time.

The average volumetric spill rate of crude and product is 2.45 bbl spilled/million bbl throughput. From the baseline throughput assumption, the estimated average future pipeline spill volume is 17,200 bbl over the ROW renewal period — an average annual spill volume of 573 bbl. If the observed time trend persists, the actual volume spilled would be substantially lower.

VMT

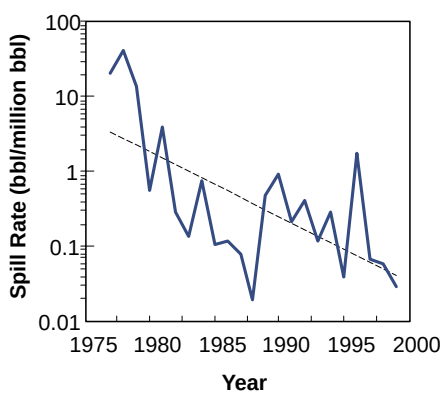
Figure 4.1-13 presents calculated volumetric spill rates for the VMT segment. Volumetric spill rates are highly variable (about four orders of magnitude), and there is no evident time trend. The annual average spill rate is 0.32 bbl crude and product spilled/million bbl throughput, which translates to a total spill volume of 2,270 bbl and an average of 76 bbl/year over the ROW renewal period.

Marine Transport

Figure 4.1-14 presents comparable rates for the marine transportation segment. Variability is nearly six orders of magnitude, and there is no statistically significant time trend, although the post-1990 decrease is believed to be real. The annual average volumetric spill rate for this segment is 22 bbl crude and product spilled/million bbl crude throughput — for a projected spill volume of approximately 154,400 bbl (5,147 bbl/year) over the ROW renewal period. Because marine transportation spills are potentially so important, this projection is examined in more detail.

Future Marine Transportation Spills

The historical importance of marine transportation spills justifies a more careful examination of the prospects of future spills than concluding, based solely on the lack of an obvious time trend in spill data, that the future will be like the past. It is not reasonable to claim that it is impossible for



Note: Dashed line is linear regression line.

Figure 4.1-12. *Volumetric spill rate for pipeline (1977-1999).*

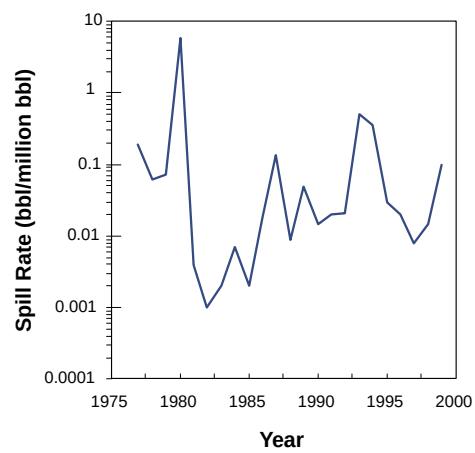


Figure 4.1-13. *Volumetric spill rate for VMT (1977-1999).*

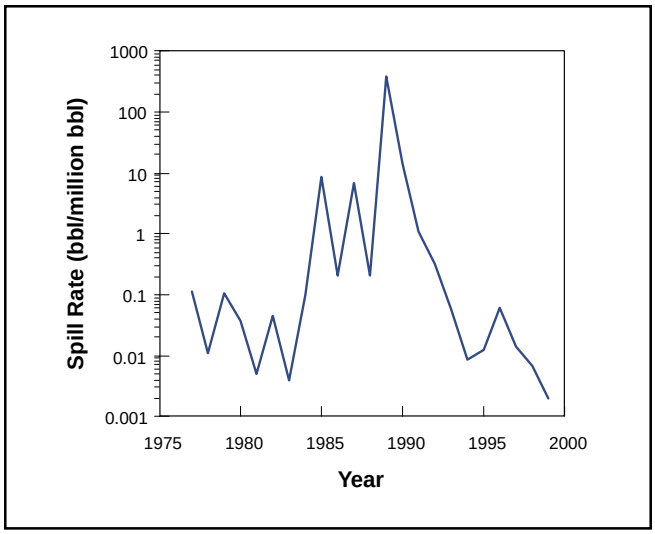


Figure 4.1-14. *Volumetric spill rate for marine transportation (1977-1999).*

a very large tanker spill to occur during the period covered by the ROW renewal. However, based on lessons learned from the 1989 EVOS, on new legislation such as the Oil Pollution Act of 1990 (OPA 90), and on new regulations, numerous improvements have been made that are likely to reduce the probability of a major marine transportation accident and/or the projected spill from one. Marine transportation companies have used detailed risk assessments to identify critical areas for improvement. These measures fall into two main classes:

- Improvements in spill prevention and response capability for PWS made by Alyeska, including the creation of the Ship Escort/Response Vessel System (SERVS).
- Phase-in of double-hull tankers under OPA 90.

Key spill-prevention measures include provision of tanker escorts, an enhanced USCG-staffed Vessel Traffic Service, more stringent weather constraints on tanker operation, use of ice routing measures, and mandatory alcohol testing of tanker officers. Other measures are discussed in Section 4.2.3.3. Collectively, these measures are designed to substantially reduce the likelihood of a tanker accident and subsequent spill.

Among other things, OPA 90 established a schedule for closing U.S. ports to single-hull tankers. By 2014, all tankers calling at the VMT will have double hulls. Thus, for the final 20 years of the 30-year ROW renewal period, the tanker fleet for transporting Alaska North Slope (ANS) crude oil will consist exclusively of double-hull tankers. Of 26 tankers now serving VMT, three are double-hull, 13 have double bottoms, and an additional seven double-hull tankers are on order and scheduled to enter service before the existing ROW expires.

Shortly after the EVOS, a National Transportation Safety Board report (NTSB, 1990) stated that had the *Exxon Valdez* been fitted with a double hull, "the risks of oil spills owing to collision or grounding would have been significantly reduced."

Table 4.1-3 provides several estimates of the benefits of double-hull tankers in terms of a reduced probability of an oil spill and/or reduced outflow from a spill. Of these, the most recent National Research Council study (NRC, 1998) offers the most authoritative estimates of measures of effectiveness of double-hull tankers compared to existing single-hull tankers. This study estimates that the probability of a spill would be reduced by an "improvement factor" ranging from 4 to 6, and the expected spill outflow reduced by an improvement factor between 3 and 4.

Taken together, improvements in spill prevention measures and phase-in of double-hull tankers should appreciably reduce spill probabilities and spill outflows in PWS. There is already statistical evidence from other parts of the world that tanker spills are becoming less likely. USCG Commandant Admiral James Loy recently reported to Congress that the number of major tanker spills has dropped by two-thirds since passage of OPA 90 (Whitney, 1999).

For these and other reasons, future marine transportation spills are expected to be less likely — perhaps much less likely — than past experience would indicate. For illustrative purposes, this analysis assumes a range of possible spill-reduction factors. Double-hulls alone should reduce spills by more than 80 percent (NRC, 1998). To be conservative and reflect the fact that single-hull tankers will be used for a portion of the ROW renewal period, it is assumed that the future spill rate (expressed as the number of spills of volume >1,000 bbl/billion bbl throughput) will be less than that observed by an improvement factor ranging between 1 and 4.

Spill Projections

Projections of the likelihood and volume associated with large spills during the ROW renewal period were developed based on the spill projection methodology employed by MMS, on TAPS experience, on estimates of the possible reduction of spill rates brought about by Alyeska measures taken in PWS, and on the benefits of replacing the existing fleet of single-hull tankers with double-hulls. In brief, the methodology is as follows:

- Marine transportation data are analyzed to estimate the base-case spill rate (number of spills >1,000 bbl/billion bbl throughput).
- The base-case assumption of future throughput over

Table 4.1-3. *Potential benefits of double-hull tankers.*

Statement	Summary	Source
"If a vessel experiences a collision or grounding that penetrates the outer hull, double-hull tankers are four to six times less likely than single-hull tankers to spill oil. Expected or average outflow is three to four times less with a double-hull compared to a single-hull tank vessel."	Probability of spill reduced by factor of 4 to 6. Expected spill volume reduced by factor of 3 to 4.	National Research Council (NRC,1998)
"After the Exxon Valdez grounded on Bligh Reef, the Coast Guard estimated that 25 to 60 percent of the spilled oil . . . could have been contained if vessel had a double hull."	Expected spill volume reduced by factor of 1.33 to 2.5.	Davidson (1990)
"It is estimated that if the Exxon Valdez had had a double-hull structure, the amount of the spill would have been reduced by more than half."	Expected spill volume reduced by factor >2.	Exxon Valdez Oil Spill Trustee Council web site (www.oilspill.state.ak.us)
"If the Exxon Valdez tanker had been protected by a double hull, 80% less oil would have spilled . . . a marine architect told a house panel . . . "	Expected spill volume reduced by factor of 5.	Whitney (1999)
"A risk assessment study done in 1995 found the risks of another spill have been reduced by 75%, according to Michelle Brown, Commissioner of the State Department of Environmental Conservation."	Probability of spill reduced by factor of 3.	Clark (1999) Det Norske Veritas et al. (1996)
"Oil outflow for a double-hull tanker for composite accident reduced to 29% for large tankers."	Expected spill volume reduced by factor of >3.	NRC (1991)

the ROW renewal period is multiplied by the base-case spill rate to determine the projected number of large spills.

- This estimate is multiplied by several possible improvement factors to reflect the changes made to the spill prevention and response systems to calculate a revised estimate of the projected number of future spills.
- The Poisson model is employed to calculate the probability of any number of spills over the ROW renewal period based on the revised estimates of the mean number of spills.
- Estimates of the average size of the large spills are presented.

The Poisson model has been found applicable for oil spill statistics (Smith, Slack et al., 1982) and is employed in the standard MMS methodology for projecting spill probabilities. Denoting the spill rate (spills >1,000 bbl/billion bbl throughput) by λ and the estimated future throughput over the ROW renewal period by T (billion bbl), the projected number of large spills, μ, is equal to λT. Given μ, the probability of exactly k spills (k = 0, 1, 2, etc.) over the future production period is:

$$p[k, \mu] = e^{-\mu} \frac{\mu^{-k}}{k!}$$

Figure 4.1-15 shows the probability of 0, 1, 2 . . . large spills for improvement factors of 1 (base case — no improvement), 3 (67 percent reduction in spill rate), and 4 (75 percent reduction in spill rate).

For the base case, the probability of one or more spills >1,000 bbl is nearly 94 percent over the ROW renewal period. The corresponding probabilities for improvement fac-

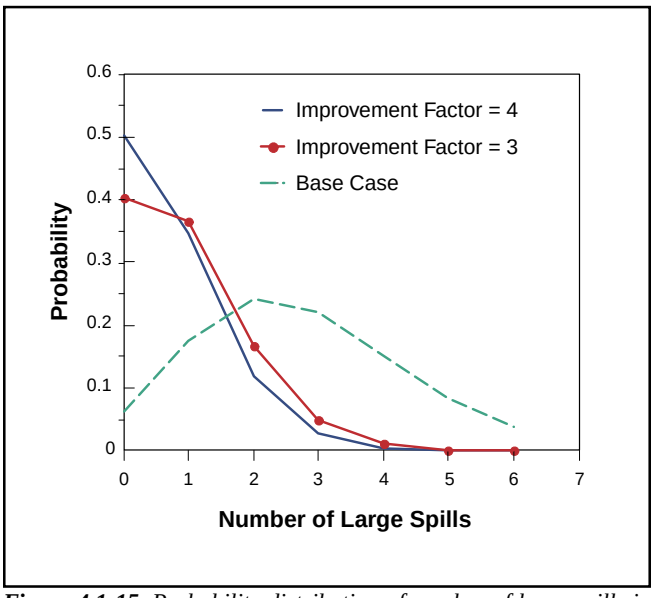


Figure 4.1-15. *Probability distribution of number of large spills in ROW renewal period (2004-2034).*

tors of 3 and 4 are 60 percent and 50 percent, respectively.

Although a large spill is defined as >1,000 bbl, the average volume of such spills is greater than this threshold. Based on observed marine-transportation spills for Operations from 1977 to 1999 (including EVOS), the average size of all spills >1,000 bbl (the conditional mean) was approximately 55,800 bbl. However, as noted above, it is likely that the size of any large spill would also be reduced by the same measures that reduce the spill probability. For example, a recent EIS posits an average large spill volume of 30,000 bbl for ANS tankers (MMS, 1996a).

Based on the MMS oil spill methodology and conservative estimates of possible improvement, this analysis concludes that over the ROW renewal period from 2004 through 2034:

- The likelihood of one or more large (>1,000 bbl) crude spills for the marine transportation link ranges from 50 percent (improvement factor 4) to 94 percent (no improvement).
- The projected number of large spills ranges from 0.69 (improvement factor 4) to 2.75 (no improvement).
- The estimated volume of a large tanker spill is 30,000 bbl.
- The estimated total volume of oil spilled over the ROW renewal period ranges from 20,700 bbl (0.69*30,000) to 82,500 bbl (2.75*30,000). Spread over 30 operating years, the average volume spilled over the marine transportation segment ranges from 690 to 2,750 bbl/yr.

These projections present a more optimistic picture of future marine transportation spills than that determined solely from an analysis of past data. The specific improvement factors assumed here are conservative relative to the range of improvement factors reported in the literature.

Future Small Spills

Because large spills account for the vast majority of the oil spilled in the marine transport segment, the consequences of omitting small spills from the analysis are likely to be negligible in terms of projections of the volume of future oil spills. Nonetheless, for the sake of completeness, these are included.

Figure 4.1-16 shows a time series of the annual volumetric spill rate (crude and product total) from 1977 to 1999 for spills <1,000 bbl. There is no statistically significant time trend, although it is possible that these have decreased since 1991. Some of the post-1990 measures discussed above, though targeted at large spills, may also reduce the frequency and/or volume of small spills. These potential benefits are disregarded in this analysis.

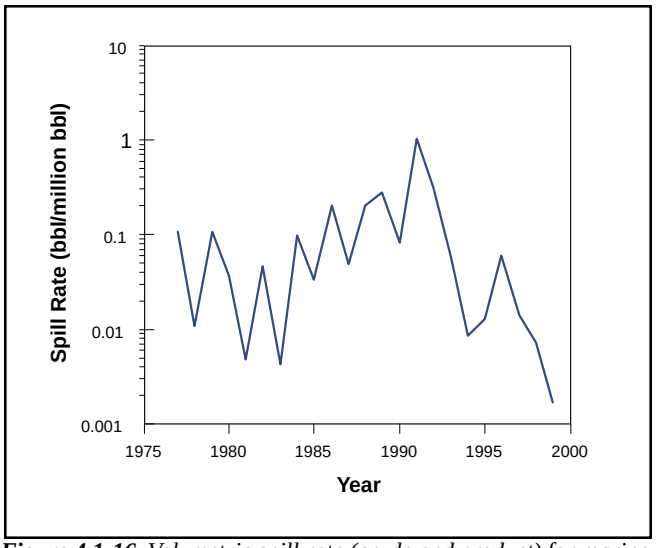


Figure 4.1-16. *Volumetric spill rate (crude and product) for marine transportation spills <1,000 bbl.*

The average volumetric spill rate for the period from 1977 to 1999 (0.1404 bbl/million bbl) is used to project future spills. Based on future projected throughput of 7.02 billion bbl (Appendix A) over the ROW renewal period, the total volume of small spills is estimated to be approximately (1000*0.1404*7.02) = 987 bbl, or 32.9 bbl/yr. As expected, this is very small compared to the projections for large spills (690 to 2,750 bbl/yr).

Spill Projections

Tables 4.1-4 and 4.1-5 summarize the above quantitative analysis and present estimates of the future spill volumes from the proposed action. Table 4.1-4 is based solely on historical data, while Table 4.1-5 is based on historical data and an allowance for the effects of preventive measures implemented in recent years.

Based solely on historical data, the average annual spill volume for the ROW renewal period for all segments of Operations is approximately 6,000 bbl. The marine transportation segment accounts for nearly 74 percent of this.

The estimate of 6,000 bbl/yr does not reflect any allowance for improvements to the system. As noted in Section 4.2.3.3 and Appendix B, since 1990 there have been many changes made to the marine transportation system — and more in prospect — that are designed to reduce the likelihood of an accident and/or the amount of oil spilled in the event of an accident. Some of these were implemented as early as 1990, others throughout the 1990s, and yet others are scheduled to be implemented during the ROW renewal period. For example, Sections 4.2.3.2 and 4.2.3.3 provide information on the measures used to control spill frequency and amount at VMT and along various segments of the ma-

Table 4.1-4. *Estimates of future oil spills based on historical data only.*

Segment	Total Volume 2004-2034 (bbl)	Average per Year 2004-2034 (bbl)	Remarks
E&P Operations	6,050	202	Based on average volumetric spill rate and projected throughput
Pipeline	17,200	573	Based on average volumetric spill rate and projected throughput
VMT	2,270	76	Based on average volumetric spill rate and projected throughput
Marine Transportation	154,400	5,147	Based on average volumetric spill rate and projected throughput
TOTAL	179,920	5,998	Sum of above

Table 4.1-5. *Estimates of future marine transportation spills based on allowance for mitigating measures.*

Segment	Total Volume 2004-2034 (bbl)	Average per Year 2004-2034 (bbl)	Remarks
Marine Transportation	20,700 to 82,500	690 to 2,750	Based on analysis of large (>1,000 bbl) spills, range results from use of various improvement factors
	986	33	Based on average volumetric flow rate (small spills) and projected throughput
Subtotal	21,686 to 83,486	723 to 2,783	Sum of small and large spill estimates
TOTAL ALL SEGMENTS	47,206 to 109,006	1,573 to 3,634	Sum of marine transportation and other segments taken from Table 4.1-4 above

rine transportation link.

One way to estimate the impact of these spill prevention and response measures is to partition the data set into time segments (i) 1977 to 1989 and (ii) 1990 to 1999 (the post-EVOS period). This partition is designed to reflect the effects of the enhancements made to various Operations segments made from 1990 onwards.

Using the same methodology described above but limiting data to the period from 1990 to 1999 results in a revised projection of the annual spill volume (all segments) for the ROW renewal period of approximately 750 bbl/yr (see Appendix B, Table B-9) rather than the 6,000 bbl/yr estimate shown in Table 4.1-4 — an 88 percent reduction. This difference is largely accounted for by a substantial reduction in the spill volume projection for the marine transportation link. To avoid any possible understatement of future spill volumes, this projection is not used elsewhere in this Environmental Report. Nonetheless, it is plausible and provides some idea of the possible conservatism in the estimates given in Table 4.1-4.

Another approach for factoring in the possible improvements made — particularly in the marine transportation segment — is used in this analysis. Projections for E&P, pipeline, and VMT spills are based on volumetric spill rates derived above. However, projections for the marine transportation link are based on methodology used by MMS for large (>1,000 bbl) spills and volumetric spill rates for small spills. This approach uses data for the entire time period (1977 to 1999), but makes allowance for the system enhancements using a range of possible improvement factors based on literature estimates of the benefits of new technology. For all segments of Operations, the estimated annual spill totals for the ROW renewal period range from approximately 1,600 to 3,600 bbl (Table 4.1-5). These estimates represent the average annual spill volume (all segments) based on conservative assumptions:

- No improvements are reflected in the estimates for E&P, pipeline, and VMT.
- A range of possible improvement is assumed for the marine transportation link, which translates into a corresponding range of average annual spill volumes from 723 to 2,783 bbl. The upper end of this range assumes very conservatively that no system improvements result, the lower end reflects plausible (but still conservative) estimates of possible improvement. Thus, not all values in this range should be thought of as equally likely. Values at the lower end are more likely.

The analysis of historical large (>1,000 bbl) spill frequency (number of large spills per billion bbl throughput), future throughput projections (Appendix A), and estimates of the average size of large spills leads to the following:

- Based on a range of improvement factors, there is a 50 to 94 percent probability of one or more large spills during the ROW renewal period. The lower end of this range is more probable.
- The average size of a large spill (MMS, 1996a) is assumed to be 30,000 bbl. Both this and the above estimates are also conservative. If the historical database is limited to those marine transportation spills that have occurred from 1990 to 1999, both the estimated probability of one or more spills and the projected size of a large spill decrease substantially (Appendix B). For example, based on the number of large spills since 1990 and estimates of possible improvement resulting from double hulls and other measures, the probability of one or more large spills during the ROW renewal period ranges from 28 to 73 percent. A precise estimate of the projected spill volume per large spill is difficult because only one large spill *(American Trader*, a single-hull vessel) occurred during this period and also because it is believed that much less (and possibly no) oil would have spilled in this accident if this vessel were double-hulled.

As discussed in Appendix B, annual spill rates in this analysis are conservative when compared to a study by Det Norske Veritas et al. (1996) for the tanker trade and a study sponsored by MMS (Hart Crowser Inc., 2000) for ANS production and TAPS transportation.

Choice of the no-action alternative will lower but not eliminate the estimated spill volume in Alaska because TAPS, VMT, and North Slope E&P activities will be shut down. However, the no-action alternative will only displace these spills to other production and distribution systems — perhaps those with fewer environmental safeguards. The Cook Inlet refinery, for example, does not have a SERVS fleet to escort tankers, nor a VTS. Most E&P and pipeline spills would be displaced to the country of origin of U.S. crude oil imports. Shutting down ANS operations may lower, but will not eliminate spills in Alaskan waters, because either crude oil or refined products would have to be imported to Alaska to satisfy internal demand. Additionally, there would be some product spills during dismantlement, removal, and restoration of the North Slope production facilities, pipeline, and VMT.

Moreover, spills occurring at U.S. destination ports (e.g., refineries in Hawaii or the West Coast) would not be eliminated if ANS operations were terminated. As shown in Table 4.1-2, three of five of the largest marine spills for ANS tankers occurred at destination ports.

4.2 Existing Mitigation Measures

Measures to mitigate the impacts of TAPS were incorporated in the original design and in the operational procedures for the pipeline system. These measures include design features; a trained, experienced operating staff; and organized surveillance, monitoring, preparedness, and contingency response programs.

Furthermore, TAPS has been subject to oversight and regulation by the U.S. Congress, the State of Alaska, state and federal regulatory agencies, and the public since construction was proposed in early 1969. Regulation and oversight of TAPS began with creation of the Federal Division of Pipeline in 1971 to oversee construction of TAPS.

The 1974 Federal Grant and State Lease contain environmental and technical stipulations to mitigate impacts of both construction and operation of TAPS (see Appendix F for a copy of the Federal Grant. State Lease stipulations are essentially the same as the federal ones, and all references to stipulations below are to the Federal Grant.) Since these stipulations are part of the original agreement, they will continue to provide mitigation during the renewal period.

The Federal Grant named an Authorized Officer in the Department of Interior to oversee construction and operation of the pipeline on federal lands. In 1974, the State Pipeline Coordinator's Office (SPCO) was also established to ensure best available environmental and engineering practices were applied to the design and construction of TAPS on state land. From 1974 to 1979, the federal Authorized Officer was supported by the Alaska Pipeline Office (APO), which consisted of personnel from several federal agencies and from consultants. In October 1979, the APO was reorganized as the Office of Special Projects in BLM. The SPCO was disbanded and reconstituted several times between the end of construction and 1990. After the *Exxon Valdez* spill, both state and federal agencies were joined to form the Federal/State Joint Pipeline Office (JPO) in 1990. The JPO now includes the following agencies:

State of Alaska Agencies:

- Department of Natural Resources
- Department of Environmental Conservation
- Department of Fish and Game
- Department of Labor
- Division of Governmental Coordination
- Department of Transportation/Public Facilities

Federal Agencies:

- Bureau of Land Management
- Department of Transportation/Office of Pipeline Safety
- Environmental Protection Agency
- U.S. Coast Guard
- U.S. Army Corps of Engineers

The BLM and the Alaska Department of Natural Resources jointly manage the JPO, which is charged with overseeing pipeline operations to ensure compliance with the Federal Grant and State Lease and with applicable laws and regulations. Agency representatives conduct unannounced inspections of facilities, review permit applications, and oversee every aspect of TAPS operations.

Alyeska has programs and procedures in place to comply with the stipulations and other applicable requirements, including laws, agreements, codes, standards, and regulations. These systems monitor and maintain TAPS, provide for feedback and analysis, and document environmental threats requiring mitigation. This process guides maintenance and repair of TAPS and helps to reduce environmental impact.

Numerous changes to the pipeline system have been made in response to information gained from over 20 years of operation. Existing mitigation measures discussed here include the most important of those changes, as well as original measures that are still used.

Separate from mandated mitigation measures, technological progress often facilitates implementation of measures that can reduce impacts. For TAPS, examples of such advancements are the development of more advanced ultrasonic "pigs" to measure pipeline corrosion more accurately, the availability of more exact data analysis, and improved cathodic protection systems (APSC, 1997b). For ANS development, technological advances have included closer wellhead spacing, reduction in area of gravel pads, construction from ice roads and pads, etc. (It is possible that not all new technological advances can be incorporated into all new developments because of technical, environmental,

or economic considerations.)

The following discussion of mitigation measures assumes that the TAPS design functions as intended and the TAPS operations and maintenance follow the procedures and programs outlined. Where appropriate, known problems are discussed.

This section is divided into three main subsections:

- Design features,
- Operational programs and procedures, and
- Spill contingency planning.

4.2.1 Design Features

Designing and constructing a warm-oil pipeline in arctic and subarctic environments requires special design features to mitigate the effect of heat transfer to the environment. Seismically active zones in the southern part of the pipeline route require special designs to mitigate risk from earthquake damage. Environmentally sensitive stream crossings coupled with sparse flood records create special design challenges. Crude vapor control designs are required to mitigate the effect of tanker loading operations on air quality. Treatment of tanker ballast water mitigates the effect of discharge on water quality in Port Valdez. TAPS is designed to detect leaks and to minimize the amount of oil that could be released in the event of a pipeline spill.

Most design features that mitigate the effects of TAPS on the environment were required by special stipulations in the Federal Grant and State Lease. The following sections describe some of the major design features with emphasis on environmental mitigation.

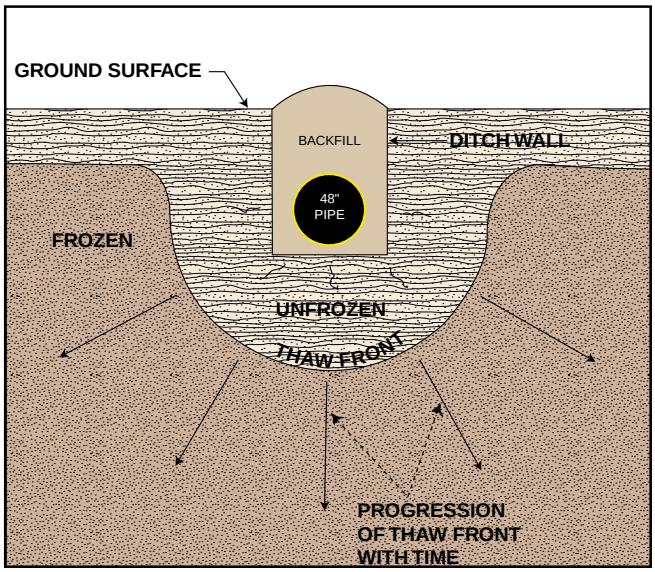


***Figure 4.2-1**. Below-ground thaw bulb.*

4.2.1.1 Special Foundation Designs for Permafrost Soils

By R. Dugan

Construction and operation of a buried warm-oil pipeline tend to induce thaw in permafrost soils. The strengths of different soil types vary widely in response to thawing. Granular soils with little excess ice are considered "thaw-stable" because they do not lose significant volume or strength when thawed. Fine-grained, ice-rich permafrost, however, may undergo a large volume decrease upon thaw and have a very low shear strength during and after thaw. Subsidence of the ground surface, downslope movement of the thawed mass, and susceptibility to liquefaction can result. These soils are considered "thaw-unstable."

Warm oil flowing in a buried pipeline results in thawing of permafrost and creation of a "thaw bulb" around the pipe Figure 4.2-1). The thaw bulb grows with time at a rate affected primarily by the temperature of the pipe, temperature and water content of the surrounding soils, and climate, but eventually stabilizes. Special designs were developed to deal with the problems imposed by the subsurface conditions and climate.

Stipulation 3.3.1 sets criteria governing which construction mode was used at any given location.

Conventional Buried Pipe

In areas where the ice content of the permafrost is very low or absent, or where no permafrost exists, the pipe is buried in a conventional below-ground mode (Figure 4.2-2). Three hundred seventy-six miles of TAPS pipe are buried in this manner.

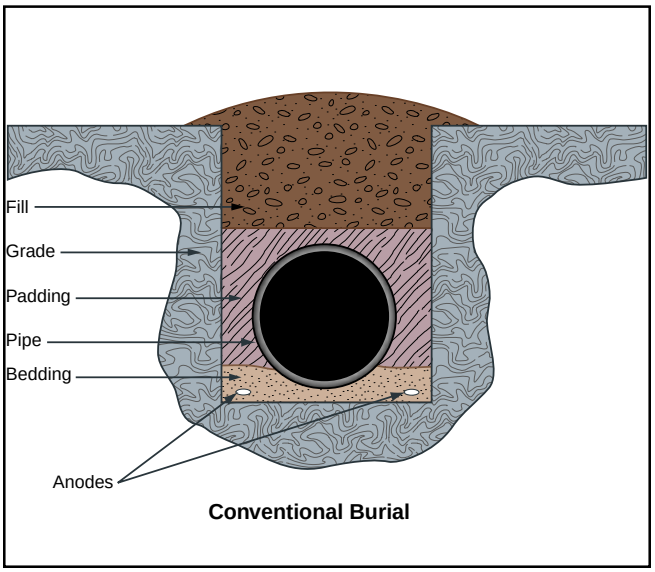


***Figure 4.2-2.** Typical pipeline details for conventional burial.*

Buried Animal Crossings

Buried-pipe animal crossings are provided where there are long sections of above-ground pipe to ensure free passage of big game animals (Stipulation 2.5.4.1). The animal crossings typically consist of about 50 feet of level buried pipe in thaw-unstable soils. The buried pipe has an insulated jacket and is installed in an insulation-lined trench.

Special Burial

At three locations, sections of the pipeline are buried in a "special burial" (refrigerated) mode for a total of about 4 miles. This mode involves insulation and active refrigeration of the pipe in thaw-unstable permafrost. Refrigerated brine lines are installed under the pipe to keep the underlying ice-rich soils from thawing (Figure 4.2-3).

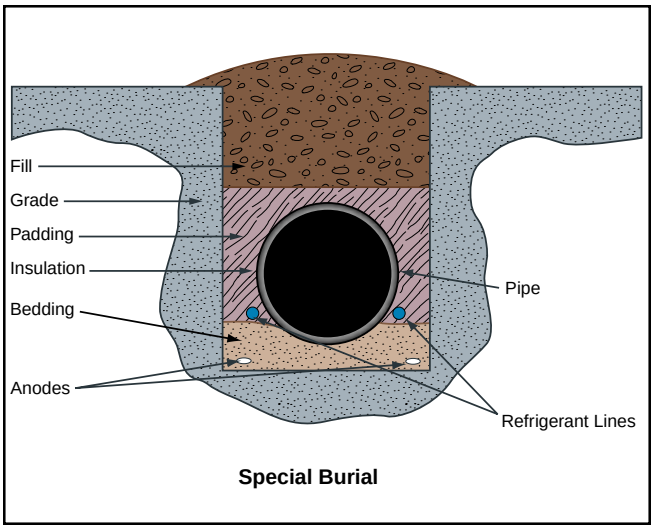


Figure 4.2-3. *Typical pipeline details for special burial.*

Insulated Box

In a few places, the pipe is installed in an insulated box at locations where the underlying soils are thaw-unstable (Figure 4.2-4). This mode is used primarily where avalanches would threaten the pipe if it were above-ground.

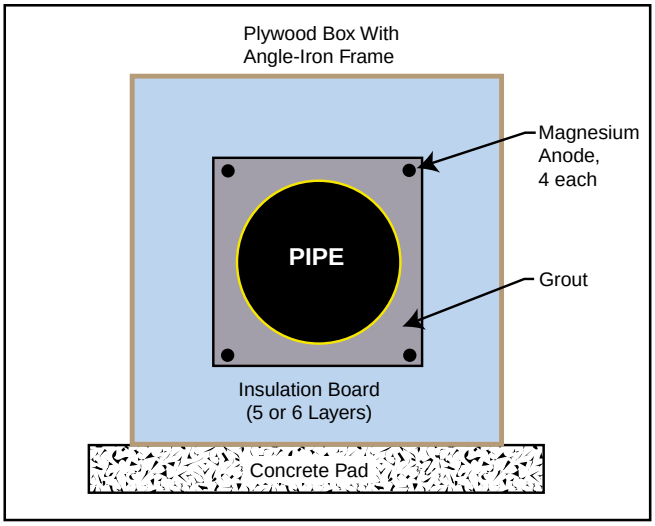


Figure 4.2-4. *Typical insulated box.*

Conventional Elevated Pipe

In areas where soils are typically thaw-unstable and thus unfavorable for conventional burial, the pipe is elevated on crossbeams attached to vertical support members (VSMs) (Figure 2.1-1 in Section 2). The VSMs consist of 18-inch-diameter steel pipe embedded deep enough to support the loading and to resist frost heave. Several types of VSMs are used, each designed for special soil and loading conditions.

South of the Brooks Range, designers expected a high potential for thawing the permafrost around the VSMs, thus leading to potential instability. Movement of VSMs due to settling or jacking can cause the crossbeam to tilt or to move up or down at one support relative to adjacent supports (Figure 4.2-5). Either case may cause non-uniform loading of the pipeline. Tilting of VSMs due to settling or lateral earth pressures causes the crossbeam to move longitudinally so that the shoe may not be adequately supported by the crossbeam. To avoid this instability, many VSMs are equipped with thermal devices called *heat pipes* (or *thermo-siphons*), which use non-mechanical circulation of ammonia in a pressurized tube to remove heat from the soil during winter when the air is colder than the soil (Figure 4.2-6).

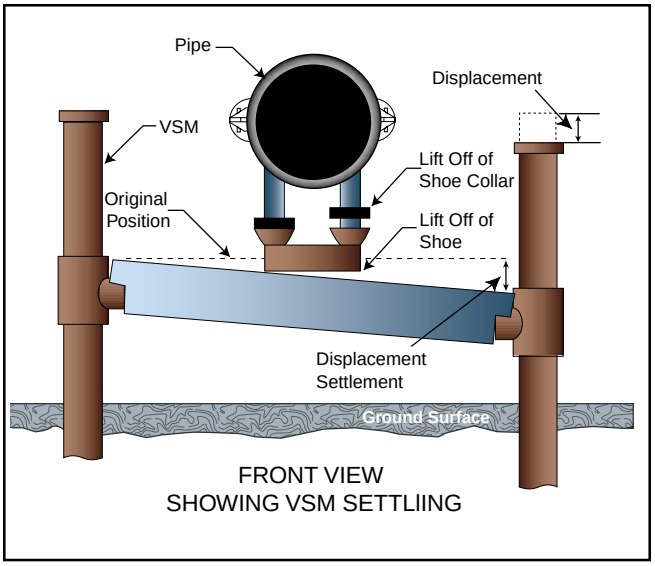


Figure 4.2-5. *Potential VSM movement (APSC, MS-31, 1995).*

Other Facilities

Numerous other facilities associated with TAPS have foundations in permafrost. These include refrigeration plants, the fuel gas line, pump station facilities, storage

buildings, communications sites, and others. Foundation designs for these structures include active and passive refrigeration in thaw-unstable soils and more conventional designs in thaw-stable soils (Stipulation 3.9.1).

The fuel gas line is buried in cold permafrost throughout its length, and the temperature of the gas is regulated to keep it below freezing. The line was constructed in winter from an ice road, and there is no workpad. A typical burial diagram is shown in Figure 4.2-7.

4.2.1.2 Design Features to Mitigate Earthquake Effects

By D. Nyman

Stipulation 3.4.1.1 of the Federal Grant sets criteria governing the design features to mitigate the effects of earthquakes and fault displacement. The stipulation divides TAPS route into five seismic zones (Figure 3.1-10) based on studies by the U.S. Geological Survey (USGS), with independent validation by engineering experts engaged for the pipeline project. A design earthquake magnitude (based on the Richter scale) has been established for each seismic zone. Design parameters (i.e., ground motions and design response spectra) also were established for each zone (APSC, 1973b).

Faulting that results in surface rupture is an important consideration for pipelines, because pipelines crossing fault zones must deform longitudinally and in bending to accommodate ground-surface offsets. A comprehensive fault study was conducted to identify and delineate active faults that cross the pipeline route (Cluff et al., 1974). The study involved a review of pertinent available data and technical literature, as well as extensive field investigations, including review of aerial photographs, low-sun-angle photography, and reconnaissance by fixed-wing aircraft and helicopters.

Three active faults that cross the pipeline alignment were identified: Denali (MP 589), McGinnis Glacier (MP 587), and Donnelly Dome (MP 558). The McGinnis Glacier and Denali fault crossings are located within 3 miles to the south of Pump Station 10. The Donnelly Dome fault crosses the pipeline where it passes east of Donnelly Dome, about 15 miles south of Pump Station 9 (Figure 3.1-10).

The main objective of TAPS seismic design is to prevent environmental damage and to provide life/safety protection from the effects of seismic activity. Other important objectives include minimizing capital loss and disruptions of pipeline operations. A 1995 review of the adequacy of the TAPS seismic criteria confirmed that the specified earthquake magnitude and design ground motions are adequate

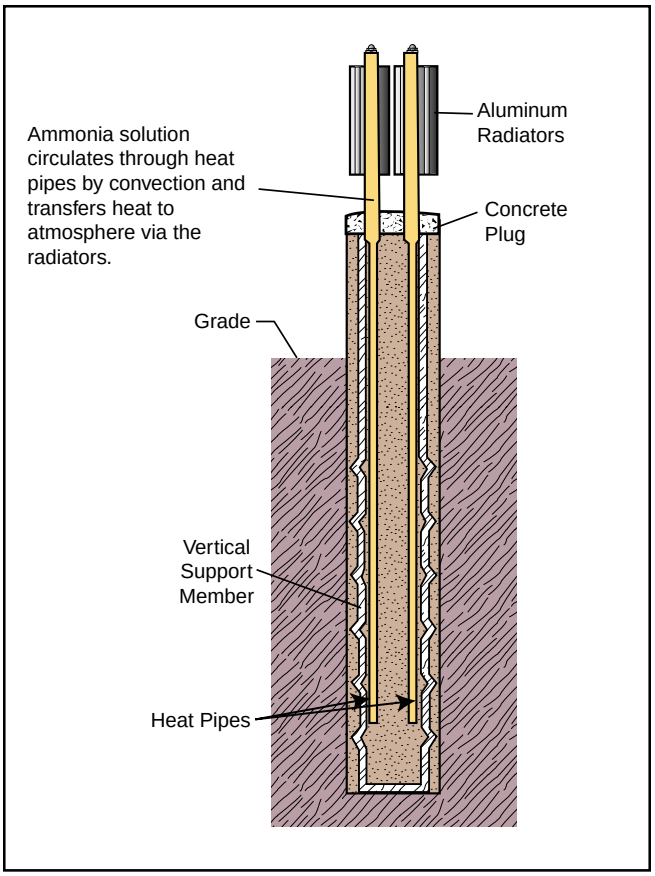


Figure 4.2-6. *Typical thermal VSM (APSC, MR-48, 1998).*

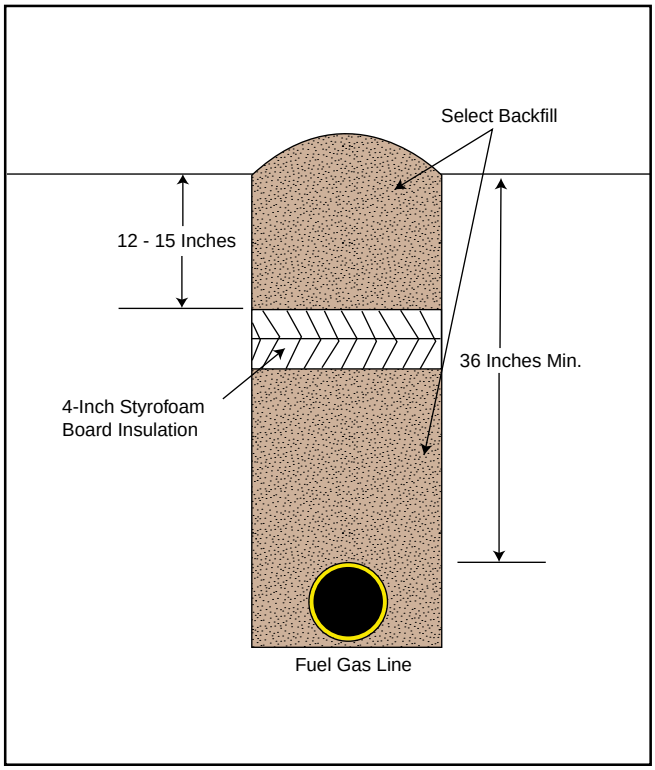


Figure 4.2-7. *Typical cross-section of fuel gas line (APSC, MS-31, 1994).*

in the most seismically active regions along the pipeline route — i.e., Valdez and in the Alaska Range — and are conservative for other areas along the route (Nyman et al., 1995). The analysis and design procedures originally used for TAPS remain consistent with current building codes and widely accepted practice in seismic engineering.

The seismic design of TAPS includes two levels of earthquake hazards: the *design contingency earthquakes* (DCE) and the *design operating earthquakes* (DOE). The DCE, which corresponds to the design earthquake magnitude specified in Stipulation 3.4.1.1 for the five seismic zones along the pipeline route, is a rare, intense earthquake with an estimated return period of several hundred years or more. The DOE is a lower-intensity earthquake that has ground motion amplitudes one-half those associated with a DCE and is more likely to occur during the design life of the pipeline than a DCE.

The philosophy underlying the original design of TAPS was that for the DCE, considerable inelastic behavior and limited damage would be expected, but that there should be no structural collapse, loss of function of essential facilities, or release of crude oil or hazardous substances. The amount of permissible damage varies according to the type of structure or component and its function. The functionality of essential control, communications, and emergency systems should be maintained without interruption during and after a DCE. In the event of a DOE, the pipeline and facilities should be capable of withstanding the prescribed seismic motions without damage, significant deformation, or interruption in operation.

The pipeline, pump stations, terminal facilities, remote gate valve facilities, and control and communication systems were originally designed to withstand the effects of earthquake ground-shaking and permanent ground deformation. In addition, the tanker loading berths at the VMT have been designed for estimated maximum tsunami wave and wave run-up conditions that can be expected at Jackson Point (Stipulation 3.7). Where possible, the pipeline was routed to avoid areas having significant potential for large ground displacement; otherwise, the pipeline was engineered to accommodate permanent ground movements without rupture. At the three fault crossings — Denali, McGinnis Glacier, and Donnelly Dome — the pipeline was placed above ground with oversize pipe shoes and support beams to accommodate design movements. To accommodate extraordinarily large design movements of 20 feet horizontal slip and 5 feet vertical slip at the Denali Fault crossing, the pipeline was placed on beams embedded in a gravel berm (Photo 4.2-1).

Seismic integrity will be sustained for the ROW renewal period because of Alyeska's engineering design control programs and standard maintenance. The cumulative effect of damaging earthquakes is not a factor, because no earthquakes approaching the DOE level have occurred since startup. If a DCE occurs in the future, it may be necessary to shut down the pipeline for inspection, repair, and possible replacement of pipe and hardware before resuming operation. The ramping-down of pump stations reduces the exposure of TAPS facilities to seismic hazards, particularly considering that Pump Station 10, which is about 3 miles from the Denali Fault, has been placed on standby.

4.2.1.3 Mitigation of Effects of Stream Crossings and Instream Alignments

By W. Veldman

The pipeline crosses 80 major rivers in either buried or above-ground mode and is in or adjacent and parallel to a number of river valleys. These crossings were designed to accommodate foreseeable erosion, scour, ice conditions, and river meanders (Stipulation 3.6.1.1). The USGS undertook surveys primarily before operation to assess the rate of bank erosion and bed scour, (USGS, 1972, 1975, 1976, 1977). About 12 percent of the pipeline consists of buried or elevated river crossings, instream alignments, or alignments near major river channels, especially the Sagavanirktok, Atigun, Dietrich, Middle Fork Koyukuk,

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Photo 4.2-1. *Pipeline crossing of Denali Fault showing beams embedded in a gravel berm to allow large pipe movements.*

Delta, and Phelan rivers. Pipeline design at river crossings and in floodplains was based on quantitative assessments of flow and scour and a qualitative analysis of potential channel changes over the life of the system. The pipeline was designed for the *pipeline design flood* (PDF), a theoretical flood magnitude computed for every significant river and creek crossing (Stipulation 3.6.1.1.1.2). South of the Brooks Range, the flow was computed using 50 percent of the *probable maximum precipitation* (PMP), whereas 100 percent of the PMP was used north of the Brooks Range, reflecting that little flow data for the North Slope existed at the time of construction. The flows thus computed using the U.S. Army Corps of Engineers' HEC-1 model were calibrated to known and existing major floods along the pipeline route. The flow data now available are considerably more extensive. These data, combined with the lessons learned during operation of the pipeline, are valuable for the continued safe operation of TAPS.

Figures 4.2-8 and 4.2-9 illustrate the magnitude of floods experienced to date, compared to the 1:200 year flood event. (Although the PDF computed for TAPS does not have a specific return period, the 1:200 year flood was used by regulators as a check on flood flows computed for the recently completed Badami project on the North Slope).

The August 1992 flood on the Sagavanirktok River was the highest recorded flow since construction of TAPS. From a post-flood hydrologic analysis, it was apparent that rainfall in the Ivishak River watershed was the major reason for the very high flows in the lower Sagavanirktok River system. As the Ivishak enters the Sagavanirktok downstream from the USGS flow-monitoring station near Sagwon, the relative magnitude of the 1992 flood on the lower Sagavanirktok was even significantly greater than that illustrated on the graphs on Figures 4.2-8 and 4.2-9.

The flood necessitated the immediate placement of riprap, and large, gravel-filled bags and a short rock spur at MP 47 to protect the overland buried pipeline from bank erosion. In the winter of 1992-93 , three gravel spurs with rock-armored ends were built to permanently deflect the main channel from the eroding west bank.

The 1992 flood of record illustrated that:

- Where the pipeline is close to, or in or parallel to, a wide river system for a long distance, there could be a number of locations where bank erosion and channel changes require the construction of remedial measures. (In wide river systems such as the Sagavanirktok, there will also be numerous locations where the river changes affect the opposite bank and are therefore of no concern for the pipeline.)
- Various emergency measures can be constructed after the flood peak recedes. Even on a large system such as the Sagavanirktok, the flood peak generally recedes after several days.
- From a river-engineering viewpoint, the integrity of the pipeline has been protected, particularly in view of the TAPS monitoring program during major floods and Alyeska's ability to respond quickly to an emergency — for example, gravel bags and/or stockpiles of riprap are available at a number of locations along the line.

At several locations, pipeline exposure has occurred as a result of flow. In the early 1980s in the Tiekel River area near MP 752, trees stockpiled from clearing for an adjacent, parallel and uphill powerline blocked a small unnamed creek. This caused the flow in the creek to be diverted onto the TAPS ROW. The relatively steep downhill grade of the ROW toward the south caused erosion and pipe exposure for hundreds of feet. Coating repairs were necessary, but the integrity of the pipeline was not a concern. The 1992 flood on the Sagavanirktok River caused bank erosion and pipeline exposure in a small overflow channel in the MP 25 area. The short exposed pipeline section was protected after the flood. Pipeline integrity was not a concern due to the short length of exposure that occurred. In the 1990s, a short length of pipe was exposed in a small alluvial fan in the Pump Station 10 area. Bank and bed armoring was undertaken in a timely fashion, and the pipe was not damaged.

Figure 4.2-10 illustrates the time and location of major maintenance and new works constructed along TAPS (minor repairs are not included). Major widely distributed floods such as the 1992 Sagavanirktok flood may necessitate repairs at a number of locations. Work required in 1998 and 1999 on the Dietrich River and Middle Fork Koyukuk River at several locations was due, at least in part, to the river changes induced by the major 1994 flood. Other floods, like the high flows in the Pump Station 4 area in July 1999, have a very local effect. In that case, only a few creeks in the immediate area south of the station had very high runoff for several days.

In summary, large segments of TAPS are in or close to the rivers, the pipeline crosses numerous rivers and streams, and many areas are influenced by aufeis, glacier-dammed lakes, and major bedload movement in alluvial fans. However, most TAPS river crossings and floodplain segments have experienced no significant change and have required no repairs or new structures despite experiencing a number of high-flow events. The TAPS river and floodplain design methodology — as well as the annual and post-flood monitoring and maintenance — have been successful in protecting the pipeline.

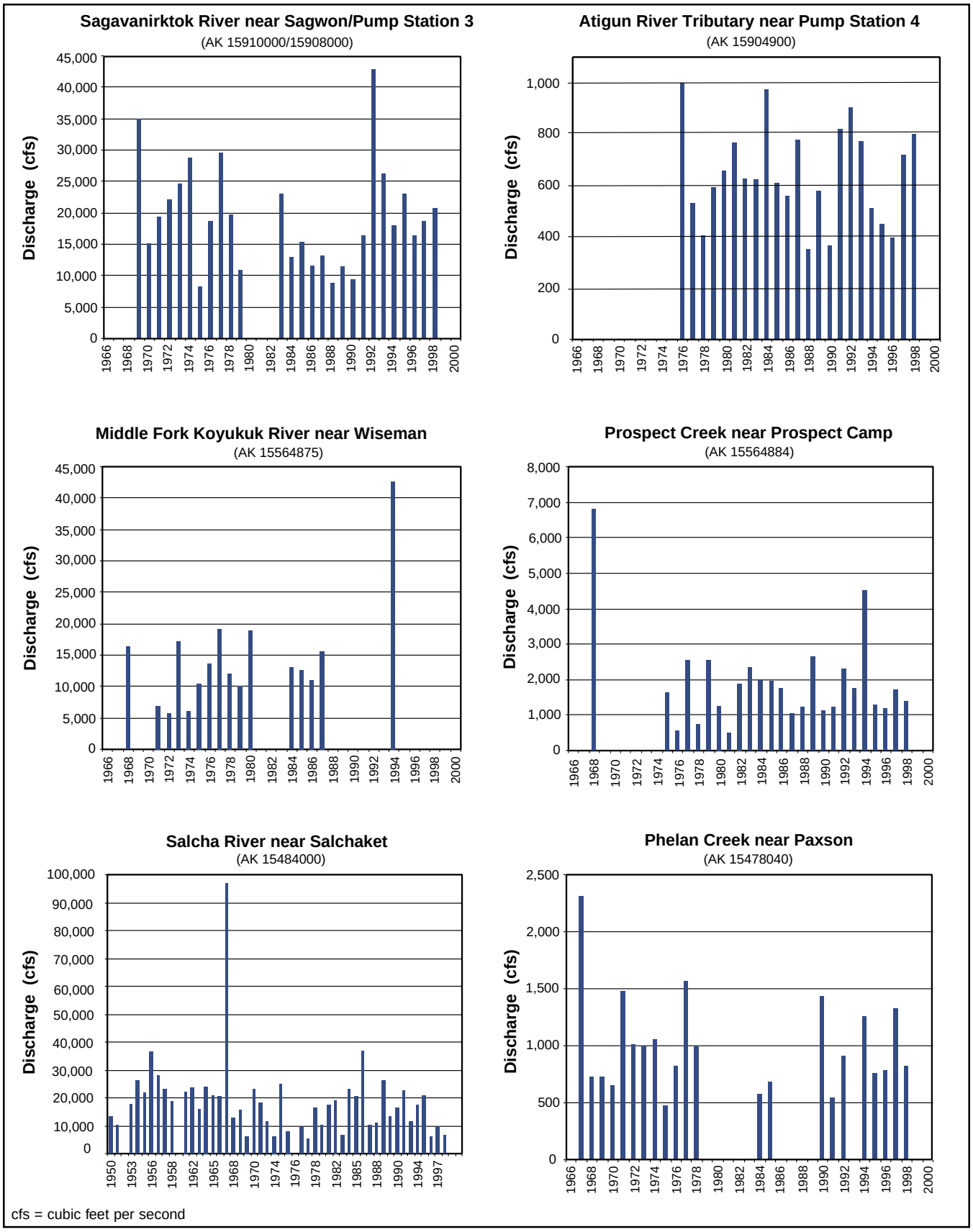


Figure 4.2-8. *Comparison of maximum annual peak flows.*

4.2.1.4 Hydrocarbon Emissions Control

By E. Haas

Major sources of crude-oil vapor emissions are controlled through vapor recovery systems at Pump Station 1 and at the VMT. At Pump Station 1, a vapor recovery system routes displacement vapors from the two receiving tanks (Tanks 110 and 111) to a vapor incineration flare. The tanks receive crude from the various North Slope production areas. The tanks also function as crude breakout or pressure-relief tanks when crude has to be diverted during pipeline upsets or slowdowns. In those cases, large amounts of crude have to be diverted into Tanks 110 and 111. The vapors are collected in a common vapor header and routed to the tank-vapor incineration flare. During 1994-95, Alyeska installed a new flare tip and a gas-assist combustion system. This upgrade helped improve the combustion characteristics of the flare in all cases except during full tank inrush situations resulting in occasional exceedances of the permitted opacity limit.

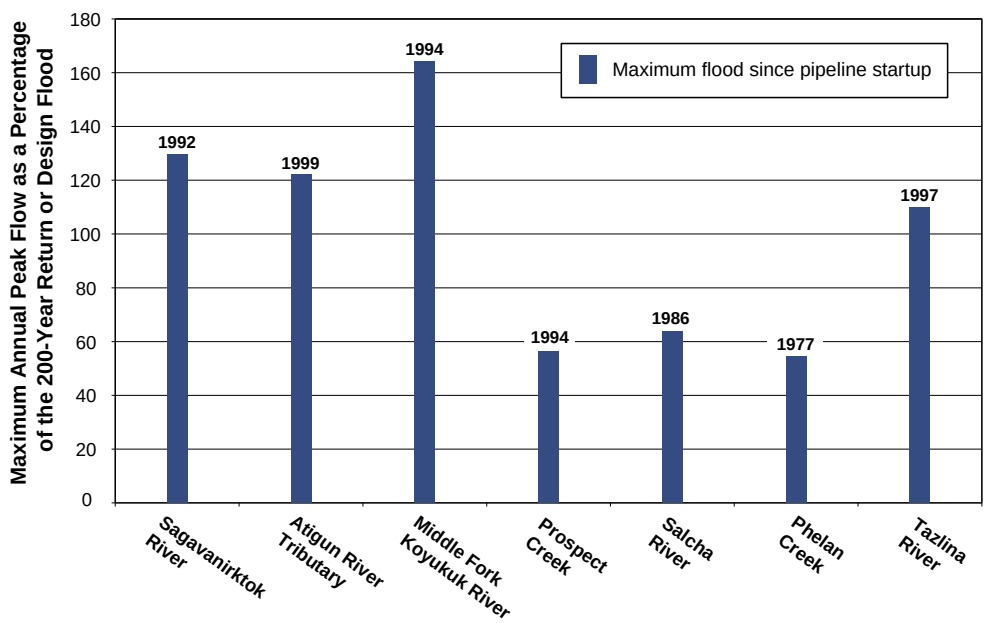
The VMT is equipped with a system that controls the crude oil vapors from both the onshore tank farm and the marine loading operations. Crude vapors are generated when fresh crude enters the tanks and displaces an equal amount of the internal tank vapor space. The tank displacement vapors are controlled by low-pressure vapor collection lines and are primarily used for vapor balancing to replace tank vapors when tanks are being emptied. Excess tank vapors are used as fuel gas in the VMT power boilers. Surplus vapors are incinerated in one of the three vapor incinerators.

The tanker vapor control system operates in a similar fashion to capture vapors during tanker loading operations at two of the four existing tanker berths. It was built and tied in with the existing system in 1997.

4.2.1.5 Ballast Water Treatment

By B. Jokela and V. Gates

Oily ballast water from tankers and other wastewaters from the VMT are treated at the Ballast Water Treatment Facility (BWTF). When originally built in 1976 as required by Section 23B of the Federal Grant, the BWTF used three 18-million-gallon steel primary gravity-separator tanks and six 240,000-gallon secondary dissolved-air-flotation cells to remove oil before discharging the saline ballast water to Port Valdez under the terms of a National Pollutant Discharge Elimination System (NPDES) permit. The waste discharge limitations imposed on the BWTF in the NPDES permit were later revised to include a limit on benzene,



Notes: 1. 200-year flood from Jones and Fahl (1994).
2. Tazlina River ratio relative to the pipeline design flood of 110,000 cubic feet per second (cfs).

Figure 4.2-9. *Comparison of maximum flood since startup to 200-year return or design flood.*

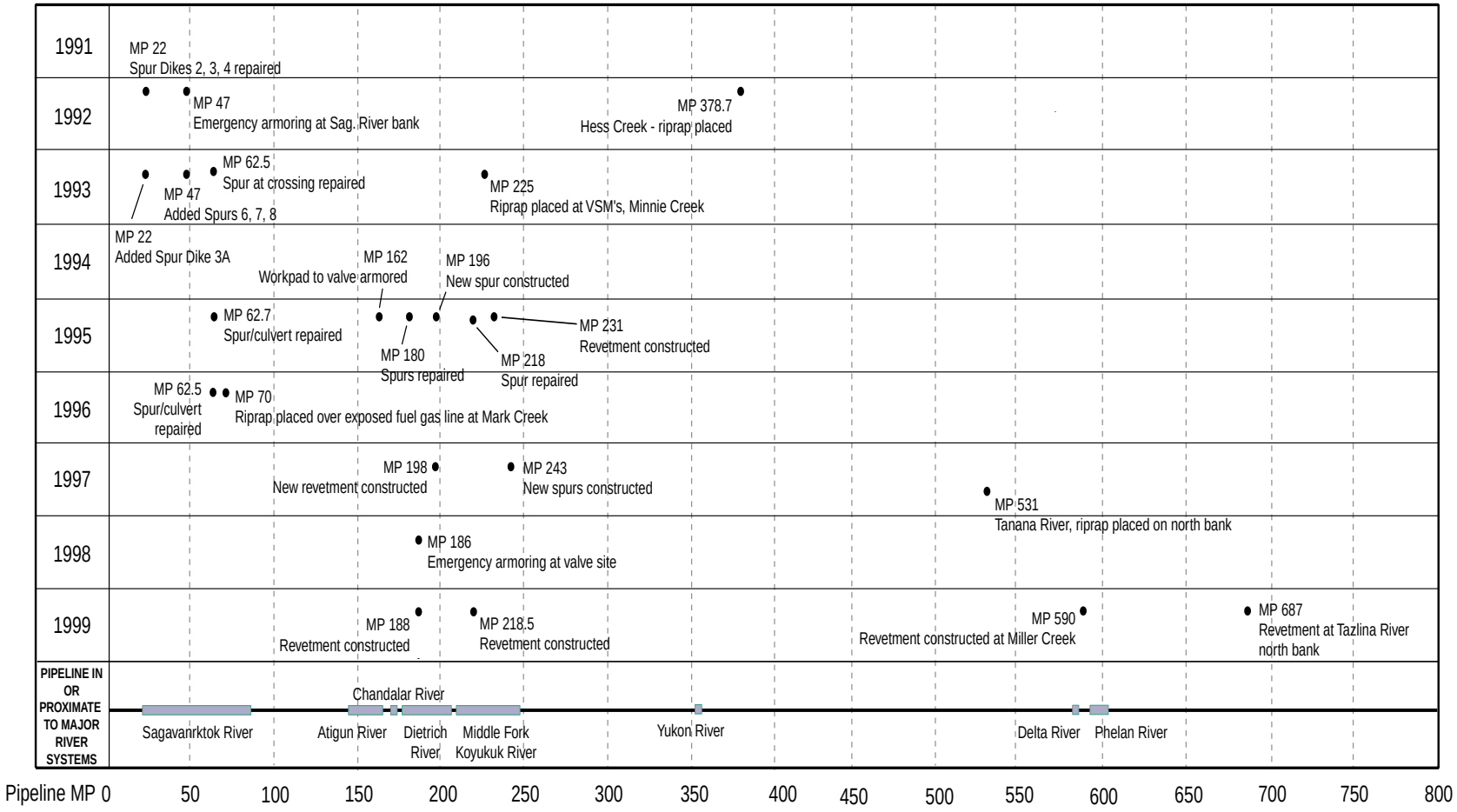


Figure 4.2-10. *Timeline of the major repairs and new structures for river training structures along TAPS, 1991-1999.*

toluene, ethylbenzene, and xylene (BTEX). In response, two aerated impound basins were replaced in 1990 by a permanent biological treatment facility consisting of two 5.5-million-gallon concrete aeration tanks equipped with a submerged-jet aeration and mixing system (Rutz et al., 1991. To provide additional reliability, a polishing air stripper was installed downstream of the aeration tanks to remove occasional spikes of BTEX in the event of biological upset (Rutz et al., 1992; Norton et al., 1991). The entire BWTF is controlled by a computerized supervisory control and data acquisition system in a centralized control room (see Section 4.3.1.2).

4.2.1.6 Pipeline Spill Control

By J. Riordan, J. Endell, and J.D. Norton

Valves

Valves controlling the operational functions of TAPS are located on the mainline, in pump stations, and at the VMT. Pipeline valves have three purposes: to minimize spills in the event of a leak in the mainline, to prevent overpressure of the pipeline, and to isolate pump station and terminal facilities.

During design of TAPS, the maximum static oil-spill volume was set at 50,000 bbl of crude oil. Valve locations were selected based on this volume and sensitive-area factors. If a valve "leaks through," the leakage must not result in an increase over the initial design spill volume (Weber and Malvick, 2000; Aus et al., 2000.).

The pipeline valve system of 177 valves includes 63 remote gate valves (RGVs)[1] and 81 check valves (CKVs). Where the oil flows uphill, CKVs prevent backflow in the event of a rupture or break. RGVs prevent flow in either direction. (CKVs are preferred over RGVs on uphill slopes. They are more economical while serving the same purpose, but more importantly, they are less complicated than RGVs and require less maintenance.)

Nine manual gate valves (MGVs) are placed near CKV sites to provide more positive isolation when required. They are included for pipeline maintenance and secondary spill response.

Battery limit valves comprise the final 24 pipeline valves. These gate valves are located on either side of each pump station to isolate the station from the pipeline in the event of a pump station fire or other emergency.

All mainline valves are subject to annual preventive maintenance to refurbish lubricants and ensure mechanical functionality. In addition, all mainline valves are subject to performance testing to ensure that the valves maintain the ability to seal off flow (minimum "leak through") (Jackson and White, 2000). This function is key to minimizing the amount of oil that could theoretically leak from any pipeline segment (Stipulation 3.2.2.1).

Valves that do not meet minimum sealing-performance standards are replaced or repaired (Pomeroy and Norton, 2000) Four mainline valves have been replaced or repaired because of sealing-performance deficiencies: two above-ground gate valves and two below-ground check valves. Similar repair or replacement of other valves may be expected to occur in the future, although currently there is not enough data to estimate timing or numbers of valves to be addressed. Currently, all valves have been tested and all deficient valves have been addressed.

Leak Detection

The TAPS leak detection systems, which provide early notification of potential pipeline leaks, consist of three independent networks: deviation alarms for pressure and flow rate, line volume balance (LVB), and transient volume balance (TVB). Each capitalizes on unique leak characteristics. The intent is to detect leaks as early and as small as possible to minimize environmental damage. To supplement leak detection systems, regular and frequent visual field observations are performed both from the air and from the ground.

Deviation Alarms: Two types of deviation alarms are used: pressure and flow rate. The leak detection system looks for deviations from preset values or sudden changes in flow or pressure. This tool has been in service since 1977 to rapidly detect large leaks. The leak-loss sensitivity threshold is about 10,000 bbl per day (1 percent of flow), with a response time of 1 to 5 minutes.

The *pressure deviation alarm* is based on pump station suction and discharge pressure readings. Approximately every 3 to 4 seconds, the SCADA host computer retrieves pressure readings at each pump station. The current pressure reading is compared against the previous one. A drop in pressure greater than one percent of range generates a deviation alarm, as does a value outside the acceptable range of pressures. This method would detect large leaks between adjacent pump stations and between Pump Station 12 and the VMT.

Flow rate deviation alarms are based on readings from each pump station's leading-edge flow meter (LEFM) and the incoming meters at the VMT, all of which are scanned approximately every 10 seconds by the SCADA system. Each new reading is compared against the previous one.

[1] One ball valve, at Pump Station 11, performs the same function as the RGVs and is included in the count of 63 RGVs used throughout this report.

Any deviation greater than one percent of range causes an alarm to sound. Flow rates outside preset limits also generate an alarm. This method would detect large leaks between adjacent pump stations and between Pump Station 12 and the VMT.

Line Volume Balance: LVB leak detection is based on readings from the custody-transfer meter at Pump Station 1 and incoming meters at the VMT. The SCADA computer gathers LEFM readings approximately every 3 to 4 seconds and calculates a real-time average flow rate at each end of the pipeline. With this data, the LVB system calculates every 30 minutes the average oil volume entering the pipeline at Pump Station 1 and the average volume leaving it at VMT and into the breakout tanks at the pump stations.

LVB leak detection compares the relative volumes of oil in and out of the pipeline to detect a leak. If more oil is entering the pipeline than exiting, a leak is declared. LVB is a long-term, sensitive leak detection system good for finding small leaks. The leak-loss sensitivity threshold is about 2,000 bbl per day (0.2 percent of flow), and the response time is 6 to 24 hours. For larger leaks, the system can be used to identify the pipeline segment (section between pump stations) of concern. This system has been employed since just after pipeline startup.

Transient Volume Balance: A 1998 enhancement to TAPS leak detection capabilities, the TVB system is a computerized method that uses mathematical models to detect leaks based on field measurements.

Every 60 seconds, the TVB system calculates flow characteristics derived from actual field pressures, temperatures, flow rates, and crude oil properties. Based on this information, the TVB system can produce a reliable flow-rate model. This information is compared against the actual line flow rates measured by the LEFMs. Deviations between the modeled flow and measured flow indicate potential leaks. This method takes just minutes to detect a spill that the LVB system requires hours to detect. The leak-loss sensitivity threshold is about 4,000 bbl per day (0.4 percent of flow). The response time is about 30 minutes depending on leak size, and the system is used to identify the milepost location of the leak. TVB has become Alyeska's primary leak detection system.

4.2.1.7 Designated Big Game Crossings

By H.A. Whitlaw and M. Cronin

Several Federal Grant stipulations pertain to the conservation of terrestrial mammals and require mitigation of wildlife impacts associated with TAPS construction, operation, and maintenance. For example, concerns for the free passage of terrestrial mammals were addressed in Section 2.5.4.1 (Big Game Movements), which states: "(the contractor) shall construct and maintain the Pipeline, both buried and above ground sections, so as to assure free passage and movement of big game animals."

Concern for potential obstruction to the migration patterns and local movements of caribou, moose, and bison resulted in construction of designated big-game crossings (DBGCs) (JSFFWAT, 1977). DBGCs constructed as elevated pipes were a minimum of 10 feet high and 60 feet long. Also, many were built as short buried sections (i.e., sagbend crossings), or as long refrigerated buried sections. A total of 554 DBGCs were constructed along the pipeline in areas known by state and federal biologists to be regularly used by bison, moose, and/or caribou, based on traditional use and/or habitat characteristics. Studies in the 1970s and 1980s showed no indication that large mammals were selectively crossing in these areas; however, it was hypothesized that the DBGCs would be necessary for big-game movement during winters with severe snow depth (Carruthers and Jakimchuk, 1987; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Van Ballenberghe, 1978) (see Section 4.3.2.5).

4.2.2 TAPS Monitoring, Surveillance, and Maintenance Programs

By J.D. Norton and J. Harle

The purpose of TAPS monitoring, surveillance. and maintenance programs is to ensure reliability of the system while complying with applicable laws, regulations, and right-of-way agreements (Stipulations 1.18, 1.20, and 1.21).

Alyeska's *Procedure Manual for Operations, Maintenance, and Emergencies* (OM-1) provides procedures for operating and maintaining the pipeline during normal and critical conditions in accordance with the ROW agreements and federal DOT requirements. A similar manual (FG-78) addresses operation of the fuel gas line.

The Alyeska *Quality Program Manual* (QA-36) provides overall policy and guidance for ensuring quality in critical TAPS systems (Section 9 of the Federal Grant and Section 16 of the State Lease). The individuals performing work are responsible for the quality of the work and for complying with the procedures governing the work. Each supervisor and manager is responsible for ensuring that all work done under their supervision satisfies applicable requirements, including laws, agreements, codes, standards, and regulations. Individuals performing quality functions have the authority to report conditions adverse to quality.

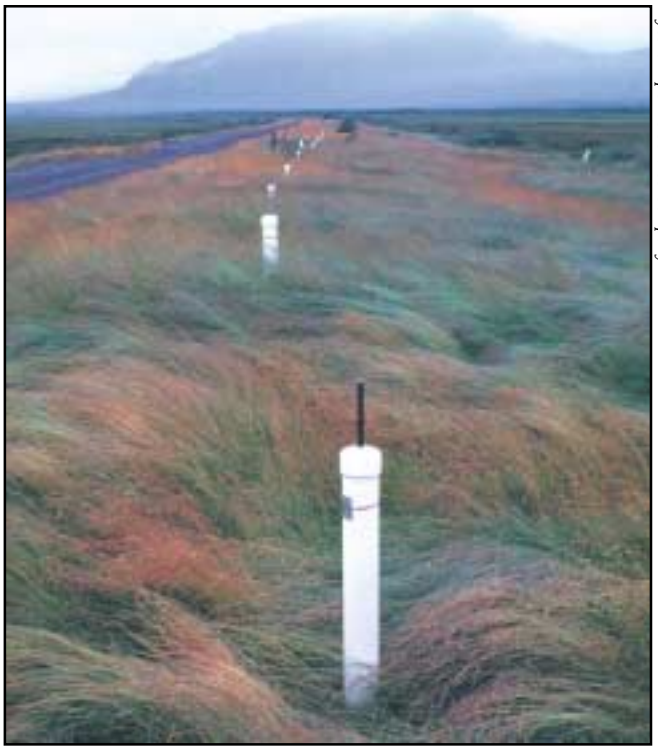


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Photo 4.2-2. *Settlement monitoring rods along buried section of TAPS.*

Alyeska Pipeline Service Company

Photo 4.2-3. *Smart pig.*

QA-36 describes the responsibilities, methods, and processes to comply with this policy.

Alyeska's *Inspection Services Manual* (IP-218) provides inspection procedures for modifications or additions to critical TAPS systems (Stipulation 3.2.2.4). Work done on TAPS is inspected to provide independent verification that the work conforms to requirements of instructions, procedures, specifications, and drawings. These inspections are performed by qualified inspectors who are independent of responsibility for the cost or schedule of the work being performed. The inspectors work in accordance with established inspection and implementing procedures. The Inspection Group maintains the necessary records that document work which has been accomplished.

The *TAPS Engineering Manual* (PM-2001) provides overall policy and guidance to engineers that produce project designs for modifications or additions to critical TAPS systems. In addition, the *Alyeska Design Basis Update* (DB-180) requires that such changes receive prior approval of the Alyeska engineering standards manager.

4.2.2.1 Integrity Monitoring Programs

Alyeska's *System Integrity Monitoring Program Procedures* (Manual MP-166) cover planned monitoring of critical TAPS systems. The goal is to determine the integrity of the facility being observed. Pipeline elements are monitored to ensure that the features perform within predefined engineering limits. This monitoring is accomplished on predetermined schedules to identify performance trends which determine when maintenance intervention is required (Hart et al., 1998). When the monitoring results identify trends which would jeopardize integrity of a pipeline facility, a maintenance project is prepared to repair the deficiencies (APSC, 2000c).

The following systems have monitoring programs to ensure their integrity:

Mainline Pipeline Integrity Monitoring

Systematic monitoring is done for the above-ground pipeline support system and below-ground pipeline for movements which may jeopardize pipeline integrity. Above-ground pipeline is monitored by field crews who rebalance pipe loading on key supports and look for out-of-tolerance supports. Below-ground monitoring is done by field observations, surveys of monitoring rods attached to the pipe (Photo 4.2-2), and periodic inspections by inline inspection tools called "smart pigs" which travel through the pipe on the flow of the oil (Photo 4.2-3).

Integrity monitoring and repair consist of inline corrosion monitoring using "smart pigs" (which monitor corrosion and curvature/deformation), integrity assessment and investigation, and maintenance based on pigging information. A smart pig is an instrumented device that travels through the pipeline to detect corrosion, deformation, or wall thinning. When Alyeska began using smart pigs, a large number of digs were performed to investigate potential corrosion (see Figure 4.1-1). New smart pigs which

came into use in 1989 provide more accurate wall-thickness measurements. The number of corrosion pig "features" to be investigated has dropped as more and more sites are investigated (a feature is an anomaly in the pipeline wall that is reported by a smart pig and interpreted as a potential pipe-wall defect). Consequently, the inventory of potential pits and the number of digs have dropped. This drop also reflects more exact data analysis and improved cathodic protection.

Instrumented pigs provide data on corrosion, curvature, and dents and buckles (deformation) (Stevick et al., 1998). For the mainline, the corrosion pig is run one year, the curvature pig the next year, and the deformation pig the following year. Then the cycle repeats. For the fuel gas line, corrosion pigs currently run on a 5- to 10-year cycle.

Corrosion pigs detect pit dimensions, distinguish between corrosion defects and laminations, and determine whether the corrosion is external or internal wall loss. Pig data track many types of corrosion: at girth welds, under insulation, at transitions, and general corrosion of TAPS mainline pipe. Pigs record information about how well the other program aspects are working but do not treat the pipe in any way.

Corrosion has historical and active components. Historical corrosion, which can be stopped by remedial methods, is not a current concern. Active corrosion beyond minimal acceptable rates, if not mitigated, could threaten the safety and longevity of the pipeline. To identify areas of potential integrity threats, Alyeska uses tools such as database management programs to determine areas of statistically active corrosion changes from one pig run to the next.

The corrosion data management system is a database containing millions of data points — pipe-to-soil potential readings, coupon readings, geophysical data, pig data, and ultrasonic testing data (potentials are a measurement of the difference in electrical voltage between two materials). The system enables engineers to track pipe corrosion changes over time and thus aids them in making maintenance decisions.

In 2000, pipe curvature and dent data will be added to the records to integrate mechanical records with corrosion data. The scope of future programs will be broadened to include all integrity-related issues. Since startup, 56 corrosion and curvature/deformation pigs have been run through the pipeline (Hackney, 2000, pers. comm.).

Corrosion Control

Mainline pipeline corrosion is controlled based on Alyeska's *Corrosion Control Management Plan* (CCMP). The CCMP provides a five-part program of corrosion protection in accordance with Stipulation 3.10 (Cederquist, 1999).

- The corrosion data management system supports monitoring and maintenance decisions.
- Corrosion protection monitoring uses cathodic protection coupons, close interval survey, and conventional test-station monitoring to assess the level of corrosion protection on TAPS.
- Integrated monitoring methodology combines pig data, cathodic protection data, and mitigation history to guide decisions on remediation and pipe refurbishment.
- Enhanced or impressed-current cathodic protection is placed on TAPS to improve the corrosion protection coverage.
- The pipeline integrity component uses corrosion pig data to find and repair any corrosion defects that could potentially affect system integrity.

External pipeline corrosion is controlled through pipe coatings and cathodic protection. Coatings prevent water and/or soil from making direct contact with the pipe steel, thus eliminating the electrolytic path necessary for corrosion to occur. Where the coating is damaged, disbonded, or otherwise compromised, the pipeline can experience external corrosion. To mitigate this, cathodic protection is installed. Cathodic protection interferes with the electrical current that causes corrosion.

Alyeska's cathodic protection program consists of both galvanic and impressed-current systems. Twin zinc ribbon anodes were placed in the mainline pipeline ditch and connected to the pipe during construction on the 376 miles of conventionally buried pipeline. During operation, approximately 250 miles of supplemental impressed-current cathodic protection has been placed (Johnson and Bieri, 1998). Criteria used to assess the adequacy of cathodic protection are standard for the industry.

Supplemental cathodic protection has been placed on approximately 250 miles of TAPS as part of a five year, $23 million cooperative program between TAPS Owners and the State of Alaska. The program also includes research to address long-term performance issues. Upon program completion in late 2000, the results will establish future corrosion protection strategies for TAPS.

Impressed-current cathodic protection (ICCP) provides a low-level electrical current between remote anodes and the pipeline. This is now the corrosion-control remediation method of choice for TAPS. Alyeska has focused on this system because it can protect several miles of pipe per installation. Also, the level of electrical current can be easily adjusted if corrosion rates do not diminish. Such fine-tun-

ing is not possible with anodes.

ICCP is not optimum everywhere because it requires a reliable source of electric power. Pump stations have had ICCP systems since construction because they have power supplies. Providing power at more remote sites is difficult and expensive.

Another problem with ICCP in permafrost and bedrock foundations is high variability in soil resistivity. Highly resistive soils do not conduct current well. These soils limit the cathodic protection currents' effectiveness to a few miles.

Cathodic-protection monitoring of mainline pipeline takes place annually. Data are gathered from test stations, buried corrosion coupons, cased road crossings, the Atigun reroute, and the fuel gas pipeline (Stears et al., 1998). Cathodic-protection data gathering also occurs at buried propane tanks, pump stations, and the VMT. Rectifiers are checked six times a year.

Inhibitors are used to control corrosion in isolated and low-flow or seldom-flow piping in pump stations and in road-crossing casings. Internal coupons, which verify the effectiveness of the inhibitors, are removed and analyzed twice yearly. Pigs are used to monitor corrosion and curvature on the mainline pipeline. Data are collected, stored, evaluated, and trended.

Bridge Monitoring

Bridges for the pipeline, access roads, and workpads provide access for oil spill and maintenance personnel. The bridges are periodically evaluated for structural integrity and safety issues by engineering personnel.

Workpad and access-road vehicular bridges are maintained to state highway secondary road standards, and load limits for bridges are posted. Recently a program to evaluate all vehicular bridges required for oil spill response access was completed. Several bridges were reinforced for expected loads, and several bridges were raised to allow for increased flood flow.

Pipeline bridges were designed to accommodate static and dynamic loading combinations that included the weight of the pipe, fluid, insulation, snow and ice, wind, thermal expansion and contraction, and earthquakes. Pipeline bridges are located so that adequate clearance is provided between the bridge low chord and the pipeline design flood-level and to provide clearance for ice ride-up, aufeis buildup, and navigational traffic.

The relatively few modifications that have occurred on pipeline bridges have been engineered and documented. Alyeska monitors pipeline bridge performance through routine surveillance as well as third-party inspections. Currently, there are no known conditions that represent a concern or threat to the integrity of pipeline bridges.

Pipeline bridges are inspected annually in accordance with Alyeska bridge inspection manuals. To evaluate their integrity, pipeline bridges are inspected at intervals not exceeding five years by a professional engineer registered in the State of Alaska. The purpose of these inspections is to verify that each structure is performing as expected, to note needed maintenance, to notify appropriate personnel of improvement needs, and to serve as an independent monitor to verify the effect of maintenance, design, and construction procedures. Future annual and five-year inspections of pipeline bridges are expected to remain at current levels. Security surveillance is provided by remote video and motion sensor for the Yukon, Tanana, Gulkana, and Tazlina River bridges.

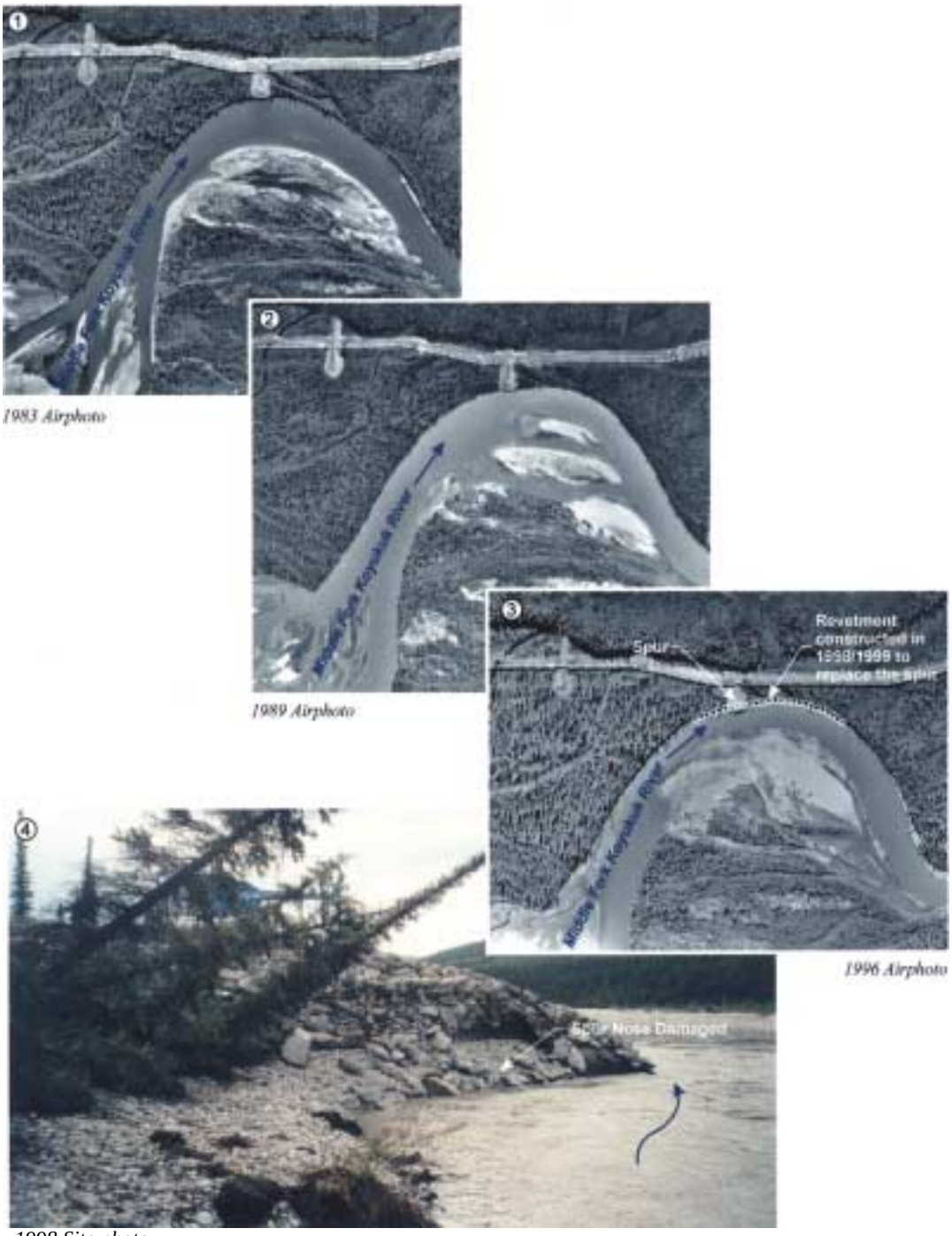
During 1997, inspections were performed on each plate-girder bridge and the Gulkana River Bridge. No significant discrepancies were noted. Due to lack of access at the Gulkana River Bridge during the 1997 professional engineer's inspection, a full reinspection was conducted in 1999. The Tazlina River suspension bridge was also inspected in 1999. The Tanana River Bridge is scheduled for inspection in 2001.

Rivers and Floodplains Monitoring

By W. Veldman

The rivers and floodplains along TAPS are monitored annually by engineering personnel using aerial photography and on-site evaluations, and are complemented by weekly surveillance flights by TAPS observers. These observations identify erosion areas and other anomalies or regime changes which may require continued observation or repair (Figures 4.2-11 through 4.2-13). Survey posts have been installed at a number of key locations so that aerial or ground reconnaissance can detect changes.

Monitoring occurs during and after floods, and annual river surveillance is conducted. In addition, comparative aerial photos are assessed. At some locations, survey stakes are used to accurately identify channel changes and the remaining river-to-pipeline buffer. River engineers use this information to assess the need for remedial measures. Detailed river-engineering assessments are undertaken to determine the need for and scope of remedial measures or new structures as a result of major floods. Examples of this are the detailed studies and designs done following high flows in 1992 on the Sagavanirktok, in 1994 and 1998 on the Middle Fork Koyukuk, and in 1999 at Miller Creek and in the Pump Station 4 area.

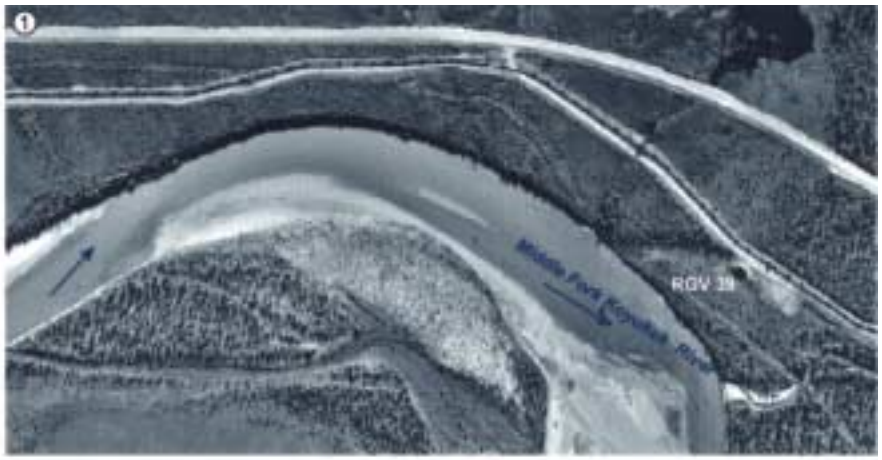


1998 Site photo

At this location, bank erosion towards the spur and elevated pipeline was minor until 1994. A major flood in 1994 necessitated repair of the spur, and high flows in 1998 necessitated construction of a new revetment in the winter of 1998/99. (Compare conditions in Photos 1, 2, and 3). Although the minimum pipeline-to-bank buffer was still about 80 feet in 1998 and the spur (Photo 4) was still partially effective in controlling the rate of and location of the erosion, delaying the work while more erosion occurred would have resulted in minimal pipeline-to-bank buffer and thus would have required "moving" the river (an extensive undertaking) rather than armoring the existing bank.

CONCLUSION: Routine, annual, and event-driven monitoring and follow-up engineering assessments are effective means to establish the need for additional structures and to ensure they are constructed in a timely manner.

Figure 4.2-11. *Middle Fork Koyukuk River, MP 218.5. Monitoring led to follow-up remedial action consisting of bank armoring.*



1996 Air photo

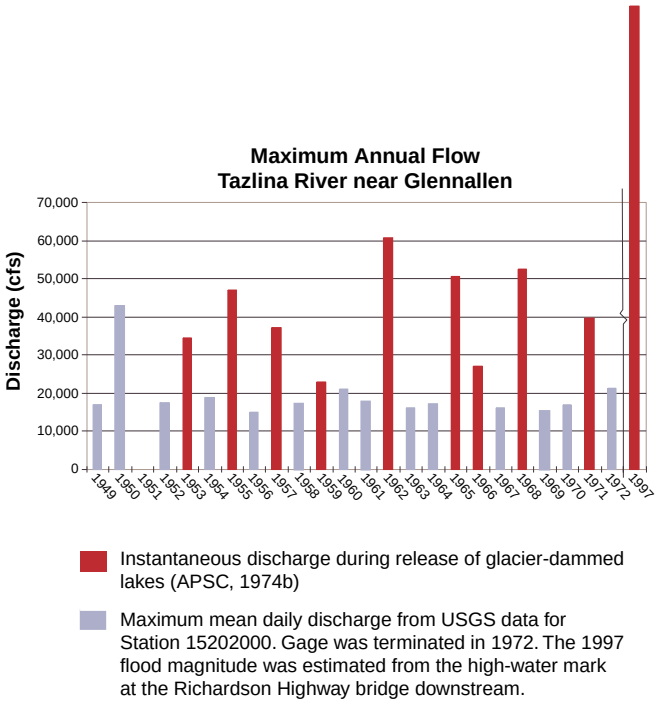
6/30/98 Site photos

The bank at this large bend is eroding towards the pipeline and RGV 39. The bank was 25 to 30 feet high with a minimum buffer of about 155 feet in 1998. The rate of erosion of the bank, even during major floods, compared to the remaining buffer, did not warrant armoring of the bank at the time of the assessment in 1998. Depending on the timing of the next major flood (the majority of bank erosion is caused during high-flow periods), a revetment may need to be constructed within 5 years, or nothing may be required for 10 to 20 years.

CONCLUSION: Monitoring and assessments can track long-term river changes which may not require immediate remedial measures, but warrant close attention on an ongoing basis.

Figure 4.2-12. *Middle Fork Koyukuk River, MP 217. Monitoring did not lead to immediate follow-up action.*

10/97 Site photo



Major river crossings such as the 650-foot-long Tazlina River bridge undergo extra monitoring — a video camera on site relays images to a nearby Security station. The flood magnitude and potential for river changes on the Tazlina River are related to the release of glacier-dammed lakes which typically produce flows two times as large as normal peak summer runoff. The flood of record, estimated to be about two times the size of the previous record in 1962, occurred in October 1997 as a result of heavy rains which triggered the release of all four lakes impounded by the Nelchina and Tazlina glaciers. At the centerline of the bridge, a buffer of about 150 feet remained on the north bank after the 1997 flood. Although this buffer would have been adequate for a considerable period of time and probably even the next major flood, and is considerably more than the total erosion experienced since startup, the potential consequences of another large flood on this major structure resulted in the decision to armor the bank in early 1999.

Figure 4.2-13. *Tazlina River Bridge, MP 686.7. Monitoring led to bank armoring to prevent any further erosion.*

In some instances during high flows, immediate protection measures are taken, such as reinforcing or adding to existing river training structures. More substantial and permanent works, such as new revetments or additional spurs, also may be built. Repairs are performed as necessary to protect the line within or near the major river systems as natural channel changes occur.

Seismic/Earthquake Monitoring

By D. Nyman

An earthquake monitoring system has been part of the pipeline control system since startup in 1977 (Stipulation 3.4.1.2). The monitoring system consists of 11 remote digital strong motion accelerograph (DSMA) stations located at Pump Stations 1, 4 through 12 (including the Pump Station 11 site), and the VMT. The system processes seismic data to evaluate the severity of earthquake ground shaking and to assess the potential for damage to TAPS. This assessment determines whether the pipeline should be shut down after an earthquake and delineates inspection requirements for the affected portion of the route.

The original earthquake-monitoring hardware and software were replaced in 1998 with a second-generation system. Each station consists of ground-motion-sensing instrumentation (accelerometers) and a computer that provides data acquisition, processing, recording, network communications, and output of alarms to the Operations Control Center (OCC) at Valdez. The pipeline controller determines the need for pipeline shutdown and field inspection through review of alarm displays from the earthquake monitoring system, as well as other control system information. Shutdown actions are initiated manually by the pipeline controller, but a shutdown sequence will occur automatically if seismic alarms are not acknowledged at the OCC within a preset period.

Stipulation 3.4.2.3 requires annual geodetic surveys of crustal deformation at active fault crossings. This requirement was based on the initial design assumption that the pipeline would cross faults in a buried mode and that relatively small movements could cause high stresses in the pipeline. However, at the three active faults along the pipeline route (Denali, McGinnis Glacier, and Donnelly Dome faults), the pipeline was built in an above-ground, unrestrained configuration.

In 1995, with the concurrence of the Joint Pipeline Office, annual fault monitoring by geodetic survey was discontinued (APSC, 1995d). Several factors led to this decision. First, survey measurements indicate no evidence of movement on any of the three faults during the monitoring period. Second, the above-ground pipeline was designed to withstand the maximum expected fault movements, such that the detection of small fault movements has no substantive benefit to pipeline integrity. Third, potential earthquake damage is not mitigated by fault monitoring, because fault movements occur over a matter of seconds during seismic events and generally are not preceded by periodic slip movements or creep. Survey benchmarks are maintained at each fault crossing to permit post-earthquake surveys of fault movements, if fault rupture occurs.

Slope Stability Monitoring

By R. Dugan

About 50 slopes along the ROW were identified during construction as having some potential for mass movements that could damage pipeline facilities. In accordance with Stipulation 3.5.1, these slopes are periodically monitored so that measures can be taken to prevent the occurrence of, or protect the pipeline against, the effects of such movements. The monitoring includes aerial observations and photography, site inspection, and direct measurements using a variety of instruments. The monitoring results are analyzed and documented, and additional monitoring, instrumentation, maintenance, or repair work is completed as needed.

Glacier Surge Monitoring

By R. Dugan

Glaciers near the pipeline are monitored by aerial photography for movement to ensure adequate notice is provided if a glacier approaches the pipeline or if outburst floods could occur from glacially dammed lakes (Stipulation 3.8). The pipeline would be shut down or major mitigation steps taken if glaciers jeopardized its integrity. Five glaciers are monitored on a 5-year schedule: Worthington, Canwell, Fels, Castner, and Black Rapids. The last monitoring work was completed in 1999. None of the glaciers has advanced since TAPS was built (APSC, 1999g).

Fuel Gas Line Monitoring

Monitoring is done to identify movement from frost heave, erosion, or ground disturbance. Maintenance or repair is conducted as necessary.

Buildings/Pump Station Structures

Survey monitoring is done on buildings and structures at the pump stations and at the VMT to identify movements

from permafrost thaw or ground subsidence. The information is used to develop maintenance programs and to arrest ground movement before foundation damage.

4.2.2.2 Surveillance and Maintenance Programs

Surveillance programs differ from monitoring programs on TAPS. Monitoring programs measure and report change from predetermined design limits such as survey elevation changes for VSMs or wall-thinning measurements from smart pigs. Surveillance programs are observations by trained observers of apparent changes that do not necessarily require direct measurements.

The Alyeska *Surveillance Manual* (MS-31) provides pipeline surveillance procedures for TAPS (Stipulation 1.18.1). Pipeline and civil surveillance activities are conducted to observe, identify, describe, quantify, and assess field conditions that may adversely affect the pipeline system, public safety, or the environment. Using ground vehicles, TAPS maintenance personnel conduct ROW surveillances in accordance with specific guidelines. Security and maintenance personnel also monitor the ROW by helicopter. Any observations or discrepancies are logged into a computer for future trending or preparation of a work order for maintenance or repair.

Alyeska's *Maintenance System Manual* (MP-167) provides maintenance procedures for critical TAPS systems (Stipulation 1.18.1). Planned maintenance programs ensure the reliability of critical equipment. These systematic programs use a work order process, which schedules and documents that the work was accomplished.

The TAPS maintenance strategy focuses on principles of reliability-based maintenance, which emphasizes developing an understanding of how equipment fails and identifying those failures before they have a negative impact. The maintenance system includes planning and scheduling work, condition monitoring, predictive maintenance tools, maintenance-performance measuring programs, and equipment-reliability analysis techniques.

4.2.2.3 Environmental Monitoring

The TAPS *Environmental Protection Manual* (EN-43) provides procedures and guidance for monitoring, testing, and working with TAPS systems to protect the environment. The Alyeska Environment Teams conduct environmental surveillances twice each year, using forms to record status of, and potential problems with, environmental issues. The surveillances are conducted by the Field Environmental Generalists (FEGs) at Alyeska facilities and along the pipeline ROW, and cover all of the subject areas included in EN-43. This program complies with Stipulation 1.18.1, Surveillance and Maintenance. The surveillances are followed by corrective actions that are tracked and confirmed when completed. The Alyeska Environment Team also uses an environmental management system based on American Petroleum Institute guidelines and on the International Organization for Standardization ISO 14001 standard for such systems.

Water Quality Monitoring

By B. Jokela

Water quality is monitored for compliance with state and federal laws and regulations. The monitoring provides a means of mitigating potential impacts to water resources by providing information on potential pollution to Alyeska and agencies. Monitoring is required for:

- Wastewater discharges to Port Valdez (EPA, 1997);
- Wastewater discharges along the pipeline (EPA, 1993a);
- Discharges from material sites covered under the EPA Multi-sector General Permit for Stormwater from Industrial Sites; and
- Drinking water quality.

State and federal agencies use permits, authorizations, and/or regulations to regulate wastewater discharges to land or to fresh or marine waters. In addition, Alyeska uses best management practices to minimize volumes of wastewater generated, as well as to ensure that the wastewater is handled and disposed of properly. Best management practices cover wastewater-generating activities along the pipeline and at the VMT.

Effluent monitoring is performed for the VMT BWTF and for all sanitary discharges. Tables 4.2-1 and 4.2-2 present permit-specific water quality monitoring requirements.

In response to stipulations of the 1989 re-issuance of the NPDES permit for the VMT and BWTF, a Technical Advisory Group was formed to: (a) allow technical experts and the public an opportunity to review and comment on draft monitoring reports prepared by Alyeska's consultants and (b) help agencies evaluate the operation of the BWTF and the reporting requirements of the NPDES permit. The original group included six members representing a broad range of expertise in environmental monitoring of marine systems. In 1993, ADEC established a broader work group to provide a forum for ADEC, EPA, the Technical Advisory

Table 4.2-1. *Requirements of the VMT NPDES permit.*

Discharge	Parameters	Frequency
Ballast Water Treatment Plant	Total Aqueous Hydrocarbons	Monthly
	BTEX	3/week
	Total Suspended Solids	3/week
	pH	Continuous
	Whole Effluent Toxicity	Quarterly
	Dissolved Inorganic Phosphorus	Monthly
	Ammonia	Monthly
	Flow	Continuous
	Density	Weekly
	Total Recoverable Zinc	Quarterly
Sanitary Waste	Biochemical Oxygen Demand	Monthly
	Total Suspended Solids	Monthly
	pH	Daily
	Fecal Coliform Bacteria	Quarterly
	Flow	Continuous

Table 4.2-2. *Requirements of linewide NPDES permit.*

Discharge	Parameters	Frequency
Excavation Dewatering	Turbidity	Daily (a)
	Settleable Solids	Daily (a)
	pH	Daily (a)
	Oil, Grease and Hydrocarbons	Monthly (b)
		As needed (c)
	Flow	Daily
	Visual (d)	Daily
Domestic Wastewater	Biochemical Oxygen Demand	Monthly
	Total Suspended Solids	Monthly
	Fecal Coliform	Monthly
	Total Residual Chlorine	Weekly
	pH	Weekly
	Flow	Daily
Hydrostatic Testing	Settleable Solids	Daily
	pH	Daily
	Visual	Daily
	Oil, Grease and Hydrocarbons	As needed (c)
	Flow	Daily

(a) Parameters monitored only if discharge reaches receiving water.
(b) Sampled only if excavation is within one-half mile of a pump station or other industrial facility.
(c) Sample collected if sheen is observed.
(d) Includes monitoring for sediment accumulation, impacts to vegetation, erosion, sheen and floating/other materials.

Group,[2] Alyeska, and the Prince William Sound Regional Citizens Advisory Council to build an understanding of BWTF issues and to make recommendations to oversight agencies. From 1990 to 1999, the work groups have met on 32 occasions and have initiated changes to plant operations and monitoring procedures, including institution of a pollution prevention framework and annual review process as part of the current NPDES permit (Kitigawa, 2000).

In addition, Alyeska monitors the receiving water environment in Port Valdez. This monitoring is focused on sediment chemistry, and benthic abundance and biological diversity and abundance (Section 4.3.1.2). The studies are designed to detect short- and long-term changes to the marine ecosystem and to understand any changes caused by natural variation and human influences (Feder and Shaw, 2000). Sediment hydrocarbon measurements are used to make comparative evaluations with nationally accepted standards. Biological studies provide a history of the types and abundance of organisms that inhabit the sediments.

Studies have generally shown that sediment concentrations of hydrocarbons are typically well below levels expected to cause environmental impact. However, recent sediment monitoring showed oiled sediments and alterations in the structure of the biological community (Shaw et al., 1999). The findings of the environmental monitoring assisted in developing refinements in the BWT operations in order to minimize future discharge of oily solids (Kitigawa, 2000, p. 16)

At material sites where earth disturbance could affect runoff water quality during rainfall, Alyeska performs the following stormwater monitoring and inspections in order to mitigate discharge of potentially polluted stormwater and to comply with the general stormwater permit:

- Evaluation of non-stormwater discharges at the site;
- Quarterly inspections of the site;
- Quarterly visual examinations of stormwater runoff (conducted during a storm event); and
- Analytical monitoring for total suspended solids (TSS), pH, and nitrate/nitrite as nitrogen (conducted quarterly during a storm).

In addition, comprehensive annual inspections are conducted of stormwater permitted sites to evaluate the effectiveness of the stormwater pollution prevention plan for the site. The plan outlines runoff management practices, sediment and erosion controls, and best management practices in place. Table 4.2-3 summarizes analytical monitoring requirements.

[2] The Technical Advisory Group was discontinued and was absorbed into the larger work group upon renewal of the permit in 1997.

With the exception of the VMT and Pump Station 1, water wells provide drinking water to Alyeska facilities outside of municipal and city boundaries. Under state regulations (18 AAC 80), all public drinking-water systems, including the VMT and Pump Station 1, must monitor the quality of water produced (Table 4.2-4).

Air Quality Monitoring

By E. Haas

All TAPS facilities are subject to both state and federal air quality regulations. ADEC issues air-quality construction and operating permits to each major facility. With the exception of Pump Station 5 — which is below the ADEC permitting threshold — all pump stations and the VMT have air-quality construction permits. Under Title V of the 1990 Clean Air Act Amendments, every major facility must obtain operating permits ("Title V" permits) from the state. Alyeska has applied for a Title V permit for all facilities including Pump Station 5. Until ADEC issues final Title V permits, each facility must operate in accordance with the conditions in the existing construction permits and in the Title V permit applications. The Title V permitting program requires that each facility periodically demonstrate compliance with all requirements in the existing permits and applicable regulations. Each Title V permit application contains a summary of all requirements the facility is subject to. The application also describes specific monitoring tasks pertaining to each permit requirement. Table 4.2-5 shows a summary of the key monitoring requirements. Extensive air quality impact data collected in the North Slope oil fields by the field operators and in Valdez by Alyeska show that both locations are in compliance with the state and federal ambient air quality standards and increments (see Table 4.3-7). Modeling results from Pump Stations 2 and 7 show that the stations are predicted to be in compliance with the ambient standards and increments under permitted conditions (see Section 4.3.1.3).

Table 4.2-3. *NPDES multi-sector permit requirements for operations material sites.*

Parameters	Frequency
Total Suspended Solids	Quarterly (a)
pH	Quarterly (a)
Nitrate/Nitrite as Nitrogen	Quarterly (b)
Visual Examination of Water Quality (includes color, odor, clarity, sheen, and other indicators of pollution)	Quarterly (a)

(a) Sampling performed during a storm event as defined by EPA.
(b) Storm event sampling, only in second and fourth year of multi-sector general permit (1997 and 1999).

Table 4.2-4. *State of Alaska drinking-water monitoring requirements.*

	Parameter	Frequency: Surface Water	Frequency: Groundwater
Class A Systems	Inorganic Chemicals	Yearly	Every 3 years
	Asbestos	One Sample (d)	One Sample (d)
	Nitrate	Quarterly	Yearly
	Nitrite	One Sample (d)	One Sample (d)
	Lead and Copper	Varies (a)	Varies (a)
	Pesticides	Waiver Obtained (b)	Waiver Obtained (b)
	Volatile Organics	Varies (c)	Varies (c)
	Radioactivity	Every 4 Years	Every 4 Years
	Coliform Bacteria	Monthly	Monthly
	Turbidity	Daily	Not Applicable
	Disinfectant Residual	Daily	Daily
Class B Systems	Nitrate	Yearly	Yearly
	Nitrite	One Sample (d)	One Sample (d)
	Coliform Bacteria	Monthly	Monthly
	Disinfectant Residual	Daily	Daily

(a) Monitoring performed in 6-month to 3-year intervals, depending on compliance status. All Alyeska systems fall under reduced monitoring requirements.
(b) Waiver obtained after initial sampling was performed.
(c) Alyeska systems on annual or triennial sampling scheduled based on previous analytical results.
(d) Monitor once during the first compliance period of each compliance cycle, depending on previous Alyeska analytical results.

Table 4.2-5. *Some key TAPS federal and state air-quality monitoring requirements.*

Parameters	Frequency
Fuel consumption (all stationary fuel burning equipment)	Continuous, daily, monthly
Operating hours (certain fuel burning equipment)	Continuous
Engine speed, combustion temperature (MLU gas turbines only)	Continuous
Fuel heating value	Monthly
Opacity, NO_x and SO_2 emission rates (certain fuel-burning equipment)	Continuous, monthly
Periods and amounts of excess emissions (all fuel-burning equipment)	Upon each occurrence
Fuel sulfur and H_2S content	Monthly
Amount and type of waste incinerated	Daily
COTU overhead gas H_2S content (PS 6, 8,10 only)	Every four hours
Sewage stack injection parameters, amounts injected (pump stations)	Every four hours, daily
Storage tank cleaning times	Continuous
VMT – tanker loading amounts per berth	Continuous
VMT – marine tankers opacity	Continuous
VMT – vapor recovery waste gas heat content	Continuous
VMT – crude tanks vapor pressure	Continuous
VMT – crude tank farm vapor recovery system venting minutes	Continuous
VMT – soil vapor extraction amounts	Monthly, annually
VMT – crude tank bottoms processing rates	Continuous
VMT – marine tanker bunker fuel sulfur content	Each vessel
VMT – vapor incinerator destruction efficiency	Continuous
Dates and amount of fuel burned and for fire fighting training	Daily
Demolition activities, amounts of asbestos removed	Continuous
Oil spill in-situ burning – times and amounts of materials burned	When applied
Use of dust suppressants – type and amount of materials used	When applied

Biological Considerations for Operations and Maintenance

By H. Whitlaw, S. Haskell, and R. Senner

The Federal Grant and State Lease stipulations hold Alyeska to a high standard of environmental protection and cover all pipeline-related construction, operation, and maintenance activities. The intent was to ensure that Alyeska would incorporate measures to avoid, minimize, or otherwise mitigate adverse impacts of the pipeline at the initial planning stages and maintain them throughout the construction, operation, maintenance, and eventual decommissioning of TAPS (Brna, 1999, pers. comm.). Crabtree and Roseberry (1981) reported that this approach is the most effective way to mitigate potentially harmful effects of pipelines on the environment.

In addition to the stipulations, TAPS operations and maintenance activities conducted by Alyeska must comply with all applicable federal and state laws, regulations, and permit conditions, as well as with borough and local jurisdictional codes. Furthermore, Alyeska applies its own best management practices and standard operating procedures based on environmental knowledge acquired during TAPS operation and maintenance. These measures include, but are not limited to:

- Improved solid-waste management (e.g., prompt and thorough incineration of garbage, complete enclosure of pump stations with fences, use of bear-proof garbage containers);
- Enforcement of company policy that prohibits the intentional or unintentional feeding of wildlife and activities that may attract wildlife to work areas;
- Procedures for safely and humanely dealing with wildlife that occasionally become involved with TAPS facilities or activities (e.g., hazing, translocations, live-capture boxes);
- Training of Security personnel in hazing nuisance animals;
- Requiring prior written permission from Alyeska for public access to the ROW;
- Prohibiting firearms at Alyeska facilities and on the ROW;

- Installing screens on air intakes at pump stations to protect birds and turbines;
- Working with ADF&G to deal with problem beavers. This may involve removal of beavers, dams, or in some cases retention of beaver dams that provide fish overwintering habitat;
- Revegetation research and monitoring; and
- Improvements in ballast water treatment at the VMT.

Terrestrial Mammals. Alyeska has identified seasonal and locational sensitivities relevant to the planning and execution of pipeline maintenance activities to avoid disturbing wildlife during critical periods (APSC, 1993). The following considerations relate to the Stipulations 2.2.1.1, 2.2.6.2, 2.5.4.1, and 2.8.1:

- **Bison:** Avoid bison as much as possible due to their potentially aggressive nature. Ground activity and low-level aircraft flights should be minimized around calving areas from early May through mid-July. Aircraft should not circle over any wildlife.
- **Black Bear:** Avoid activities in areas with sows and cubs, including any identified denning areas from just prior to denning until shortly after the bears emerge in the spring. Follow all fencing and waste disposal procedures to prevent the attraction of bears and hazardous situations for workers.
- **Brown (Grizzly) Bear:** Follow waste disposal procedures to avoid attracting bears. Aircraft flights should be at least 1,000 feet above a den site and at least 500 feet above bears. Brown bears react more to helicopters than fixed-wing aircraft. Even small blasting charges, such as those used in seismic work, can disturb a denning bear 1.5 miles away. Increasing levels of existing background noise within 0.5 miles can influence selection of a winter den site.
- **Caribou:** Minimize ground and low-level aircraft activity in the presence of caribou during calving season and active migration along the pipeline system. Also, long segments of open ditch and intensive maintenance work in these important habitats should be minimized when caribou are present.
- **Dall Sheep:** Some sheep react strongly to noise, human presence, and aircraft, while others can develop a tolerance for regular noise and traffic. Ground activities such as blasting and rock crushing should be minimized near lambing areas between May 15 and June 20. Natural mineral licks should be excluded from new material sites and access roads, and work around artificially created mineral licks should be avoided when ewes and lambs are present.
- **Moose:** Minimize activities that would reduce climax riparian vegetation, especially willows. Sensitive periods include late winter, and calving and post-calving seasons. Work during these sensitive periods where moose are present should be minimized because additional stress could be fatal to adults or newborn/unborn calves.
- **Muskox:** Do not attempt to get close to muskoxen. Minimize low-level aircraft activity near muskoxen, especially by helicopters.
- **Wolf:** Stay away from known den sites and minimize activities that would prevent wolves from using these sites. Follow waste disposal procedures to avoid attracting wolves.
- **Fox:** Stay away from known den sites and minimize activities that would prevent foxes from using these sites. Follow waste disposal procedures to avoid attracting foxes.
- **Beaver:** Distribution is not influenced by existing pipeline facilities and operations, but population growth and expansion could result in blocked culverts and modified drainages along TAPS.

Birds. Most bird species along TAPS are migratory and therefore protected by federal law. Stipulation 2.5.3.1 [Zones of Restricted Activities (ZRAs)] addresses potential disturbance of peregrine falcons: "(Contractor's) activities in connection with the Pipeline System in key fish and wildlife areas may be restricted by the Authorized Officer during periods of fish and wildlife breeding, nesting, spawning, lambing or calving activity and during major migrations of fish and wildlife…" The following considerations for particular bird groups relate to Stipulations 2.2.1.1, 2.5.3.1, and 2.8.1:

- **Waterfowl:** Minimize activities that may cause nest abandonment or stress during the flightless molting period. Some species of waterfowl such as the Canada Goose and many ducks can become habituated to human activity, but increased levels of disturbance such as heavy equipment or blasting should be minimized near waterfowl that are nesting, molting, brood-rearing, or migrating. During these times, low-level flights, especially by helicopters, should be minimized. Minimize activities that may result in changing water levels where nesting waterfowl are present.
- **Raptors:** An occupied Peregrine Falcon nest, as designated by the U.S. Fish and Wildlife Service (FWS) through the Authorized Officer, constitutes a ZRA. Between April 15 and August 31, all ground activity within 1 mile of an occupied nest is prohibited, and aircraft must remain at least 1,500 feet above the nest.

All activities within 2 miles of the nest that may produce high noise levels are prohibited. Traffic on the Dalton and Elliot Highways is exempt. Other exemptions must be authorized by FWS. For example, exemptions were made for nests near Pump Station 2 (Ritchie, 1999, pers. comm.). The Authorized Officer may apply additional restrictions within 15 miles of nest sites. ZRAs are subject to annual change according to actual nesting. Bald and Golden eagles are protected under special federal laws. In addition, FWS Section 7 permits are required for some activities that may affect threatened and endangered species (e.g., eiders and peregrines [even with their recent delisting]). Certain ground and aerial activities are restricted in proximity to active nests as determined by disturbance potential. Prior to June 1 of each year, all nests are considered to be potentially active and treated accordingly. After this date, only active nests require compliance.

- **Other Birds:** This category pertains mostly to ptarmigan and grouse species. It is recommended that disturbances near Sharp-tailed Grouse communal courtship displays (i.e., lek sites) be minimized.

Fish. Because the ROW includes approximately 800 stream or river crossings, the protection of fish habitats and maintenance of fish passage are high priorities (Stipulation 2.5.1). Grant and Lease stipulations and Alaska law require prior approval by the Alaska Department of Fish and Game (ADF&G) for activities that may disturb fish streams. In particular, any construction or maintenance activity along the ROW that could adversely affect anadromous or resident-fish-bearing waters must be permitted in advance by ADF&G under state law (AS 16.05). Sensitive periods for fish populations vary with species, life history, and habitat usage, and include migration and spawning activities occurring during open water. Streams with overwintering fish populations are considered sensitive year-round due to concentrations of fish in small areas stressed by winter, or because of incubation and rearing periods. Stipulation 2.5.3.1 identifies these areas as ZRAs.

Vegetation and Wetlands. All activities in wetland areas that require placement of gravel fill are subject to federal Section 404 permit regulations. Mitigation of impacts to vegetation is achieved by the following measures:

- Appropriate scheduling of maintenance activities to minimize stockpiling of soils that could impact underlying vegetation.
- Maintenance of natural drainage patterns in the landscape, to the greatest extent possible, to avoid erosion, sedimentation, dewatering of vegetation, and/or the formation of impoundments. This is achieved by proper placement and maintenance of culverts and by appropriate facility design and placement.
- Road maintenance and enforcement of appropriate driving speeds to reduce the dust load received by vegetation.
- Proper maintenance of facilities to ensure compliance with state and federal air quality regulations.
- Appropriate and timely response to all oil, fuel, or chemical spills.
- Revegetation, which along the TAPS ROW has been extensive and is the primary mitigation of impacts to vegetation in the ROW.

4.2.3 Spill Prevention and Response

By J. Lukin

Congress passed OPA 90 after the *Exxon Valdez* spill. Under OPA 90, tanker owners and operators are responsible for satisfying applicable federal response planning requirements in Prince William Sound. OPA 90 requires tanker owners and operators to provide and maintain the capability to conduct oil spill recovery up to 200 miles offshore in the Gulf of Alaska under federally stipulated weather conditions. To ensure personnel safety on the open sea in a response, tanker owners and operators have funded modifications to barges and purchased equipment to operate in the gulf, known for its severe storms. Among the provisions of OPA 90 are:

- Liability was increased for spills.
- Facility and tanker response plans were required.
- Regional Citizens' Advisory Councils were authorized in Prince William Sound and Cook Inlet.
- An oil spill recovery institute was established for Prince William Sound.
- Terminal and tanker oversight and monitoring were increased.
- A navigation light at Bligh Reef was mandated.
- Equipment and personnel requirements were specified under tanker and facility response plans.
- Prevention measures were implemented, including drug and alcohol abuse testing, licensing for mariners, vessel traffic systems, overfill monitoring devices, study of tanker navigation safety standards, tank vessel manning, pilotage, maritime pollution prevention training program study, and vessel communication equipment regulations.
- The act mandated a national planning and response system, including development of "Area Contingency

Plans" by the federal government.

- USCG vessel design standards were imposed requiring double-hulled tankers according to an established schedule and set of criteria.

In 1990, the Alaska Legislature passed House Bill 567 amending the state's oil-pollution-control statutes by significantly increasing standards for tankers, terminals, pipelines, and oil exploration and production facilities. ADEC subsequently issued major revisions to its oil spill regulations (18 AAC 75). Among the provisions of the new law were the following:

- Spill prevention requirements were added to spill contingency plan rules.
- Response planning standards were established for different types of facilities or vessels — i.e., volumes of oil a vessel or facility must plan to remove from the water within 72 hours of a spill. These are not cleanup standards that must be met by the holder of the contingency plan; they are planning standards that the planholder must use in the development of the contingency plan and identification of response equipment needs. For a discharge of crude oil from a tank vessel or oil barge, the plan holder must have the resources to contain or control, and clean up a response planning standard of a 50,000-bbl discharge within 72 hours (for a cargo volume less than 500,000 bbl) and a 300,000-bbl discharge within 72 hours (for a cargo volume greater than 500,000 bbl.
- Proof of financial responsibility was required ($300 per barrel of storage capacity of tank vessel or $100,000,000, whichever is greater).
- ADEC must review and approve oil discharge prevention and contingency plans every three years.

4.2.3.1 Pipeline

Operation of TAPS is governed by the *TAPS Oil Discharge Prevention and Contingency Plan* (CP-35-1) approved every three years by ADEC. The plan includes the following:

- Equipment and resources and field training for spill responders.
- Electronic leak-detection capabilities.
- Improved leak detection and leak prevention alarm systems for pump station tanks.
- More than 220 sites along the pipeline ROW designated as oil spill equipment staging and deployment areas, and dedicated oil spill contingency plan buildings and equipment at each pump station.
- Mutual aid agreements with villages near the pipeline to use residents and equipment in the event of a spill.
- Twelve spill scenarios covering a variety of terrain, oil products, spill volumes and seasonal conditions.
- Aerial photographs of the pipeline to aid in spill response planning.

Sections 4.2.1 and 4.2.2 above discusses the leak detection systems and the design features and operating procedures for reducing the likelihood of a spill and for minimizing its size should one occur. Table 4.2-6 summarizes the spill response equipment available along TAPS.

Prevention programs can be divided into two categories:

- **Equipment:**
  - Control system interlocks
  - Redundant system design
  - Secondary containment systems
  - Level gauges
  - Abnormal condition alarms
  - Valve system
- **Operational:**
  - Safe operating (including transfer) procedures
  - Operator training programs
  - Substance abuse program
  - Medical monitoring program
  - Security program
  - Corrosion monitoring and prevention programs
  - Preventative maintenance programs
  - Quality programs

Prevention programs involving equipment along the TAPS has been discussed in previous sections. However, operational systems are discussed in greater detail below.

Safe Operating and Transfer Procedures

Alyeska has a series of procedures to prevent spills from routine activities (Alyeska documents SA-38, SIM-215-3.5, PL-123, and PL-124). Among the activities that have received specific planning are: unloading propane, transferring gasoline to above-ground storage tanks, loading and unloading turbine fuels in remote locations, and fueling heavy equipment. Crude-oil breakout tanks at pump stations and above-ground storage tanks have additional operating procedures and protective measures.

Alyeska's Tank Preventative Maintenance Program includes the following protective measures that are described in more detail in the *Trans-Alaska Pipeline System Tank Manual* (TM-188). The procedures include inspection of tank-bottom thickness, tank-bottom structural repair, internal coating system, internal cathodic-protection system, external tank-bottom cathodic-protection system (as appropriate), and re-inspections at intervals designed to prevent the occurrence of tank-bottom penetration. Daily

Table 4.2-6. *TAPS oil spill contingency equipment.*

Category	Type/Description	Quantity
Vessels	Work barge w/trailer	2
	Riverboat w/trailer	13
	Airboat w/trailer	11
	Boat w/o trailer	1
	Inflatable rafts	13
	Anchors	30
	Personal flotation devices	>250
	½" line	42,000 ft
Boom	Fire-resistant boom	2,156 ft
	Protected-water boom	33,400 ft
	Palletized boom	32
Skimmers	Weir skimmers	22
	Manta Ray skimmers	12
	Skimpak skimmers	11
	Oleophilic skimmers	27
Storage	Tanks/Bladders	961,300 gal
	Drums (55-gal)	220
Miscellaneous	Mobile camp	1
	Communication modules	2
	Portable shelters	24
	Portable generators	24
	Helicopters	4
	Helitorch	1
	Vacuum trucks	11
	Space heaters	22
	Light tower/plant	22
	Pressure washers	11

inspections of tank farms are conducted and operations personnel record findings in facility data logs. Daily fuel accounting is performed at each location for all regulated tanks. If a discrepancy in volume greater than 0.05 percent is noted, an investigation is triggered. Alyeska's procedures meet or exceed industry standards recommended in API Standard 653.

Operational Prevention Programs

Training is a primary prevention program used to mitigate the risk of human error. Alyeska's training programs for operational-type activities involve qualification and certification standards, as well as licensing. Alyeska personnel receive training in safe operating procedures necessary to perform their duties. Contract workers involved in routine or project maintenance activities receive oil spill prevention training necessary to perform their duties. Contract maintenance and project work is controlled by a project work plan and work permit system.

In addition, Alyeska regularly holds safety meetings and communications meetings, and requires individuals to be proficient in safe operating procedures specific to their duties.

Substance Abuse Program

Alyeska employees and contractors who perform operations, maintenance, or emergency functions on oil handling or transfer facilities, or are operators of a commercial motor vehicle, are subject to a drug-testing program designed to meet federal requirements. Testing is conducted pre-employment, randomly, for cause, and post-accident.

Medical Monitoring Program

Medical monitoring programs are in place for Alyeska employees assigned to operations and maintenance or emergency response positions at field locations. The purpose of the program is to ensure that employees are medically and mentally capable of effectively performing the essential job functions to which they are assigned.

Security Program

Security for the pipeline system consists of required badges for employees and contract personnel that are pre-approved, facility ingress/egress points that are manned 24 hours a day, fences at all facilities, Security patrols, and lighting strategically located to provide critical vision points for Security. Above-ground pipeline crossings of major rivers are fenced, alarmed, monitored by closed-circuit television, and patrolled.

4.2.3.2 Valdez Marine Terminal

Oil storage and transportation facilities at the VMT are designed to prevent spills. The more likely sources of spills at the terminal derive from maintenance and system integrity problems, including pinhole corrosion leaks in pipes, improperly installed fittings, leaking gaskets, or valve packings. Potential spills could also occur from equipment failure or operator error. The procedures, requirements and equipment in place include, but are not limited to, the following:

- Secondary containment and drainage into tertiary systems.

- Visual inspections (hourly during loading) and camera surveillance of both grounds and equipment.
- Overfill alarms.
- Locking valves.
- Back-pressure automatic shutdown devices.
- Tanker booming during loading.
- Training, drills and exercises.
- Ultrasonic corrosion testing.
- Maintenance and inspection procedures.

The following prevention programs are in place and are explained in Alyeska's ADEC-approved *Valdez Marine Terminal Oil Discharge and Prevention Plan* (CP-35-2):

- Prevention training.
- Substance abuse prevention.
- Medical monitoring.
- Security.
- Transfer procedures, including hourly volume/quantity comparisons to verify amount loaded.
- Inspection and maintenance of storage tanks and secondary containment.
- Safety inspections by VMT personnel.
- Rockwall monitoring.
- Corrosion control program for steel piping.
- Leak detection program.
- Preventive maintenance.
- Surveillance and monitoring.
- Earthquake monitoring.
- Fire wires for rapid pickup by a tug to tow a tanker from the dock.
- Work permit system.
- Tanker size limitations for berths.
- Minimum mooring line requirements for tankers.

The VMT is also equipped with spill response equipment to handle potential spills, and a 10-person spill response team is always on duty at the terminal. Major equipment includes five self-propelled skimmers (listed in SERVS inventory), several workboats, and about 6 miles of oil boom available for immediate use.

4.2.3.3 Tanker Trade

Mitigation measures associated with tanker operations are presented here for consideration in the cumulative effects analysis in Section 4.5. Since the *Exxon Valdez* spill in 1989, significant improvements have been made in procedures to prevent a spill from a tanker and to respond to any spill which might occur. Table 4.2-7 summarizes the changes in spill prevention and response preparedness for tanker traffic in Prince William Sound, while Figure 4.2-14 illustrates these measures.

Alyeska's Ship Escort/Response Vessel System

SERVS was established on July 10, 1989, to help tankers navigate through Prince William Sound and to provide response services to the VMT and Alaska crude-oil shippers. Alyeska SERVS is certified by the USCG as an oil spill removal organization and registered by ADEC as an oil spill primary response action contractor for an oil discharge.

The Alyeska SERVS Base is located at the Valdez Emergency Response Base, built in 1994. The base is located at the Valdez small boat harbor and contains the Valdez Emergency Operations Center. The base also has equipment storage, a docking facility, and a helicopter landing area. Table 4.2-8 lists Alyeska SERVS equipment.

Procedures for Tanker Operations

The USCG has established tanker lanes and rules, and tracks all tankers on its Vessel Traffic Service (VTS). State-licensed marine pilots are required from and to Bligh Reef. In addition, precautions are taken during periods of high winds and low visibility, and when ice presents a potential hazard. Once tankers reach the VMT, the entire transfer operation is monitored, and response equipment and personnel are on standby. Before departure, the tanker and escort vessel masters, SERVS response coordinator, and the harbor pilot hold a conference to discuss the upcoming laden tanker transit. The VTS radar tracks each laden tanker through the sound until the tanker is 17 miles into the Gulf of Alaska.

Docking and Loading Procedures. As soon as a tanker is moored at the VMT, oil spill containment boom is placed around the tanker before it begins unloading its ballast water for treatment in the Ballast Water Treatment Facility and taking on crude oil. USCG regulations govern all transfers of liquids between the VMT and tanker. Before any transfer, a conference is held to discuss unique transfer procedures and safety measures. A berthed tanker is inspected hourly for any sign of a spill or leak.

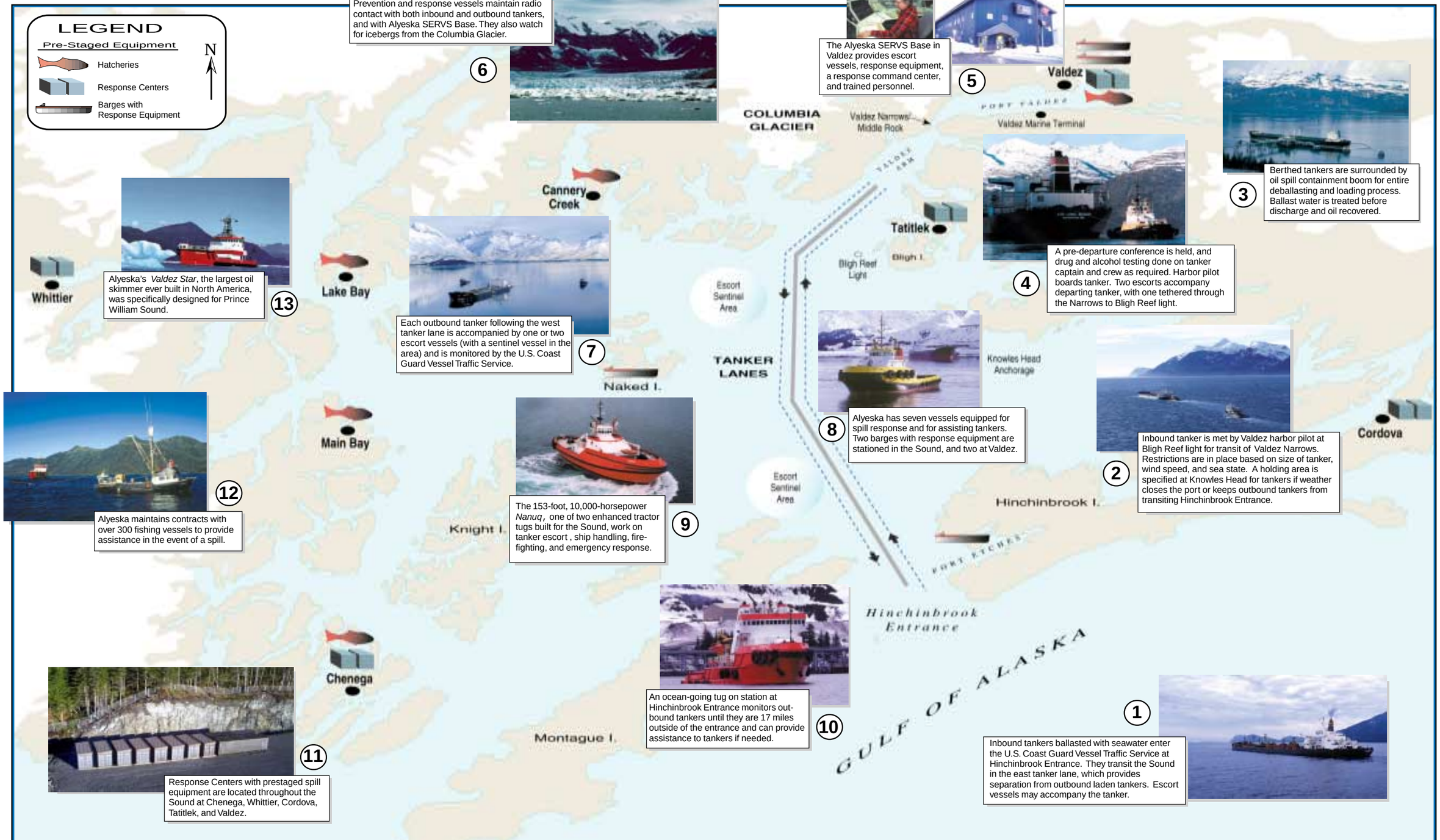
Escorts for Laden Tankers. Nine vessels are assigned to escorting, docking, and response duties, and at least two escort vessels are required for each laden tanker transiting the sound. Tethered escort is required through Valdez Narrows. In the northern sound, the escort vessels will be within one-quarter nautical mile of the tanker, when not tethered. In the central sound, a conventional tug or prevention and response tug (PRT) will maintain close escort, while the second escort vessel goes on sentinel duty to provide response coverage to a larger area. A vessel is on sentinel duty in the Hinchinbrook Entrance area. A third escort vessel may be added, depending on weather conditions.

Table 4.2-7. *Prince William Sound spill prevention and response.*

Category	Before March 1989*	Fall 2000*
Tanker, Escort, Tracking, and Operations	• Vessel escort only through Valdez Narrows • USCG radar tracking to pilot station (past Valdez Narrows) • No drug and alcohol testing for tanker crews	• 3 prevention and response tugs (PRTs), 2 enhanced tractor tugs (ETTs), and 4 conventional tugs • USCG Vessel Traffic Service; enhanced radar coverage; automated vessel tracking in Prince William Sound (PWS) • Tanker officer alcohol testing prior to sailing; weather restrictions on tanker operations; ice routing measures; tankers boomed during loading at Valdez Marine Terminal (VMT)
Oil Spill Recovery and Nonmechanical Response Systems	• 13 oil-skimming systems with recovery capability of 27,000 bbl of oil in 72 hours • 1 barge with 12,000 bbl storage for recovered oil • Approximately 5 miles of containment boom; no fire boom/igniter systems • Limited dispersant and application systems in place	• Major SERVS response equipment on 24-hour standby. • Over 70 skimming systems with recovery capability of 300,000 bbl of oil in 72 hours • 7 barges with 818,000 bbl storage for recovered oil • At least 35 miles of containment boom plus over 3,000 ft of fire-resistant boom with 2 helicopter igniter systems • Dispersant stockpile of over 60,000 gallons with fixed-wing, helicopter, and vessel-based application systems
Spill Planning, Management, and Training	• Contingency plan developed for “most likely” spill scenario of 4,000 bbl • Drills conducted every few years outside Port Valdez • Response team in place resembled a command system • Valdez Terminal employees provided response personnel; no SERVS organization	• State-approved comprehensive Oil Discharge Prevention and Contingency Plan developed by shippers and Alyeska for response planning standard of 300,000 bbl • Major tanker drill conducted annually with frequent smaller drills • Weekly drills and training exercises • Unified Incident Command System structure with USCG, Alyeska, shippers, and state for incident response • Alyeska SERVS is the dedicated, trained spill response organization with over 200 personnel and contractors
Community Involvement, Response, and Training	• No organized citizen involvement in plan development and oversight • No community response centers • No community training programs • Approximately 10 fishing vessels at Port Valdez under contract for spill response	• PWS Regional Citizens’ Advisory Council budget for 2000 is $2.5 million • 5 Community Response Centers in PWS • Community training programs in PWS and Kodiak • Program trains and integrates fishing vessels in oil spill response plans; over 300 fishing vessels under contract
Wildlife and Resource Protection	• No specific fish hatchery protection plans • No specific wildlife rescue programs	• Hatchery protection plans with pre-staged equipment for all hatcheries in PWS • Wildlife response plan with hazing, capture, and rehabilitation equipment on site and ready for rapid deployment
Communications	• Radio communications for spill response from scene to command center only	• Fixed radio repeater system with communications capability to cover PWS
Government Oversight	• State oversight at Valdez Terminal and tanker operations by 3 on-site state employees	• Comprehensive oversight of VMT and tanker operations by federal and state agencies, including the Joint Pipeline Office; 7 specially trained on-site state personnel
Spill Prevention and Response Budget	• Approximately $1 million annual for VMT and PWS	• Approximately $60 million annually

*Based on oil spill contingency plans reviewed and approved by the ADEC and USCG for 1999.
Note: ADEC (www.state.ak.us/dec/) offers a similar list (Feb. 1999) titled “Then and Now.”

Source: APSC (1999d) with slight modification.



Photos courtesy of Alyeska Pipeline Service Company

Figure 4.2-14.
Prince William Sound spill prevention and preparedness.

Table 4.2-8. *Summary of Alyeska SERVS spill response equipment.*

CATEGORY	TYPE	QUANTITY	SPECIFICATIONS
Vessels	Enhanced Tractor Tugs	2	153 ft long; 10,000 horsepower; 70,000-gallon storage for recovered oil.
	Prevention and Response Tugs	3	Enhance maneuverability, response equipment and towing equipment
	Other Tugs	4	Equipped with towing winches, and fire-fighting equipment
	Work Boats	10	
	Fishing Vessels on Contract:	50 (core group), 280 (support group)	
Storage (total capacity exceeds 835,000 bbl)	Response Barges	7	Including one dedicated nearshore barge and one lightering barge
	Mini Barges	48	Storage capacity of 249 bbl each
	Pollutank/Unitor Bags	6	Storage capacity of 629 bbl each
Skimmers (total maximum skimming capacity: 50,000 bbl per hour)	*Valdez Star* Oil Spill Recovery Vessel:	1	2,000 bbl per hour skimming capacity, 123 ft long
Self-Propelled	*Chenega Bay Star*	1	Recovery rate up to 571 bbl per hour
	Tatitlek Star	1	Recovery rate up to 571 bbl per hour
	Marco Class V	1	Recovery rate up to 571 bbl per hour
	Marco Class VII	1	Recovery rate up to 1,281 bbl per hour
Weir Skimmers	Boom/Weir System	2	Recovery rate up to 600 bbl per hour each
	High-Capacity Skimmers	12	Combined recovery rate up to 32,400 bbl per hour
	Moderate-Capacity Skimmers	13	Combined recovery rate up to 5,280 bbl per hour
	Skimmers	10	Recovery rate up to 171 bbl per hour each
Disc Skimmers	High-Sapacity Skimmers	12	Total recovery rate up to 4,620 bbl per hour
Miscellaneous	Skimmers	20	Various capacities and types
Containment Boom (at least 35 miles)	Open Water Boom:	Over 68,000 ft	
	Protected Water Boom:	Over 44,000 ft	
	Calm Water Boom:	Over 72,000 ft	
Non-Mechanical Equipment	Fire-Resistant Containment Boom:	Over 3,000 ft	
	Heli-Torch Ignition System	2	Plus contract helicopter
	Dispersant Application Systems: 3 vessel-based, 2 helicopter-based, and 2 C-130 based;		Over 60,000 gallons of dispersant in stock
Response Centers	Valdez, Cordova, Whittier, Chenega, Tatitlek		
Prestaged Hatchery Equipment	Lake Bay, Cannery Creek, Solomon Gulch, Main Bay, Sawmill Bay		
Other Prestaged Equipment	Naked Island, Port Etches		

Additional vessels are available if needed for a response or to fill in for scheduled and unscheduled maintenance.

- Currently, the three PRTs and two enhanced tractor tugs (ETTs) are designated to fill escort and response duties. These vessels carry response equipment such as boom and skimmers. The escort vessels accompanying each laden tanker monitor the vessel's actions, and will radio the escorted tanker to question or alert the tanker of atypical behavior. The tanker notifies the escort vessels upon recognition of a loss of steering and/or propulsion or suspected equipment malfunction.
- All laden tankers must have one tethered escort in the northern sound from Port Valdez to Bligh Reef light.
- One of the vessels is stationed in the Hinchinbrook area (including Port Etches) to provide sentinel assistance to tankers in Hinchinbrook Entrance. This vessel, which is also used as a close escort vessel for laden tankers, has open-ocean rescue capabilities.
- The two ETTs were built specifically for service in the sound and were both deployed in 1999.
- The three 140-foot, 10,000-horsepower PRTs were deployed in 2000. They have twice the horsepower and are more maneuverable than the escort/response vessels they replaced.

Vessel Traffic Management. The USCG Vessel Traffic Service (VTS) includes radar coverage in the upper sound and Automated Identification System (AIS) throughout the sound offshore to about 60 miles off Hinchinbrook Entrance. Tankers are required to notify the VTS before entering lanes and to maintain communication while transiting.

Vessel traffic is separated in to lanes. Traffic lane depths range from 600 to 1,000 feet, with a minimum of 350 feet in the Valdez Narrows. Traffic lane width is typically a mile.

- Vessel traffic is limited to one-way traffic in Valdez Narrows, with speed restrictions for laden tankers. The USCG grants permission for vessels to begin transiting the Narrows. Maneuvering zones have been established at each end of Valdez Narrows.
- The maximum speed for a laden tanker can not exceed 10 knots through Valdez Arm and 5 knots through the Narrows. Through the central sound, the maximum speed is 12 knots (pending state approval). The maximum speed for a tanker under ice-escort is 6 knots.
- Federal regulations require each tanker to have two licensed deck officers on watch on the bridge and one pilot between 60º 49' north latitude (south of Bligh Reef) and Port Valdez.

Inbound and outbound laden tankers maintain direct telecommunication with the SERVS Duty Officer, the USCG, and each other. The tanker escorts coordinate their position and course with the tanker's position and course. The tanker and the escort(s) also report their position to the SERVS Duty Officer as they reach designated way points.

Ice Navigation Procedures. Columbia Glacier is about 10 miles from the tanker lanes, and ice is sighted in the tanker lanes on average 10 to 15 times a month. When the USCG Captain of the Port determines hazardous ice conditions exist in Valdez Arm, the Valdez Narrows ice-routing measures will be placed into effect.

- Outbound tankers are required to use an ice-scout vessel if ice is within 1 mile of the traffic lanes.
- The USCG will route traffic around ice, as appropriate. These measures may include one-way zones. An ice-scout vessel may also be used and tanker speeds reduced.
- During low visibility, when ice is spotted or if no ice report has been received in 6 hours, SERVS dispatches an escort vessel to act as an ice scout for empty inbound tankers.
- Using searchlights, lookouts, and radar, the scout vessel keeps about one-half mile ahead of the tanker to assess ice hazards.
- The ice scout maintains a position between the tanker and Columbia Glacier on the trip to the VMT. When a laden tanker leaves, an escort vessel acts as a scout through the sound.
- The maximum speed for tankers under ice escort is 6 knots.
- If no safe routing exists, Port Valdez will be closed to tank vessel traffic.

Weather Restrictions. The primary weather concern in Prince William Sound is wind.

- If winds are below 30 knots, tankers may loiter in Port Valdez for up to 3 hours. If winds are above 30 knots, the USCG determines whether a tanker may loiter.
- Port Valdez and Valdez Narrows will be closed when the steady wind is above 40 knots.
- Outbound tanker transits through Hinchinbrook Entrance are restricted when the steady wind exceeds 45 knots or sea states exceed 15 feet.
- For tankers smaller than 150,000 deadweight tons, a third escort vessel participates in outbound transits when the steady wind exceeds 30 knots — the speed at which transits for larger tankers are prohibited.

Substance Abuse Prevention Program. Alyeska and the tanker owners and operators have programs for sub-

stance abuse prevention, as mandated by the USCG and the U.S. Department of Transportation:

- Each employee undergoes a pre-employment physical that includes substance abuse testing.
- Masters of tank vessels and any other officer who will be placed in command of the bridge during the transit of the sound are given a chemical breath test within 1 hour of scheduled departure.
- Employees performing designated work functions are subject to both annual and random substance-abuse testing.
- Personnel in operations or maintenance, emergency response workers, and any tanker, Alyeska, or contractor personnel seeking access to vessels via the VMT are subject to probable-cause testing.
- Anyone on a vessel (except stewage personnel), as well as anyone at the berth involved in an incident, is subject to post-incident substance testing.

Response Preparedness in Prince William Sound

The tanker owners and operators maintain the *Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan,* which serves as the basis for plans for each individual tanker. Alyeska acts as the implementing contractor for the tanker plan, which describes the equipment, methods, and procedures for preventing tanker spills and for responding to a variety of potential spills. According to State of Alaska rules, the plan must describe how it meets the state's "response planning standard" of 300,000 barrels within 72 hours. The plan also addresses the response to a catastrophic or worst-case discharge of 1.8 million barrels of oil over 8 days.

Each tanker operating in Prince William Sound maintains its own state- and USCG-approved discharge prevention and contingency plan, with Alyeska acting as the contractor for prevention and initial response.

The tanker owners and operators have contracted with Alyeska to provide initial response for a minimum of 72 hours, after which the response may transition to the responsible party. Transfer of the response occurs from Alyeska when the Federal and State On-Scene Coordinators allow the responsible party to assume management and control of response efforts. The approval process ensures that the responsible party's oil spill response personnel understand their responsibilities so that the transition from Alyeska to the responsible party may occur as effectively as possible. Guidelines are in place for the transfer of the response from Alyeska to the tanker owner/operator. Following transfer of response management, SERVS may continue to make response equipment and personnel available for the tanker owner/operator in its oil spill response.

Dispersants and In-Situ Burning. To supplement mechanical response equipment, Alyeska maintains three types of dispersant application systems. One such system mounts on tugs, while a second is used by a helicopter. In addition, Alyeska owns two Airborne Dispersant Delivery System Packages (ADDS Packs) stationed near Anchorage International Airport. ADDS Packs are available for large-volume aerial spraying from chartered or USCG aircraft. Helicopter dispersant systems are also available in Valdez.

Alyeska maintains a special fire-resistant oil spill containment boom that can be used to hold burning oil. Helicopter-based ignition systems are also part of Alyeska's inventory.

Approval would be obtained from the Unified Command for use of dispersants or burning, and Alaska Regional Response Team guidelines would be followed.

Wildlife Protection and Response. The *Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan* contains a wildlife response program based on requirements, guidance, pre-approval, oversight, wildlife protection efforts, and on-scene coordination of the wildlife trustee agencies (U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the Alaska Department of Fish and Game). The Alyeska SERVS oiled-wildlife treatment facility in Valdez is designed to stabilize, treat, and rehabilitate oiled sea otters. Oiled birds would be stabilized in the field and treated at the industry-sponsored Alaska Wildlife Response Center in Anchorage.

Lightering Operations. Alyeska maintains lightering equipment to assist a tanker with salvage operations as needed. Cargo may be moved internally on the vessel or removed to a barge or other vessel. Although it may be impossible to prevent an initial escape from a leaking tank, use of the lightering vessel in combination with internal transfer may significantly reduce the likelihood of further spillage. Lightering operations will be directed by the responsible party and the USCG.

Spill Response Scenarios. The tanker plan contains three oil spill response scenarios to show how the strategies and tactics in the plan would be applied in a spill. The three tanker spill scenarios evolve from a similar hypothetical grounding of a single-hull vessel of 265,000 deadweight tons with a loaded cargo capacity of 1,800,000 barrels of crude oil. All three scenarios focus on strategies and tactics for direct response to spilled oil as required in State of Alaska regulations.

Best Available Technology Analysis. Systems and procedures presented in the current *Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan*

were determined by the State of Alaska to be best available technology. The 1998 revision of the plan contains analyses of the following topics in accordance with recent revisions to ADEC regulations:

- Prompt detection of an oil spill.
- Escort vessel system.
- The Hinchinbrook tug.
- Towlines.
- Field communications system.
- Positive means of stopping a transfer in the shortest amount of time.
- Procedures to stop a discharge at its source and prevent spreading.
- Procedures for real-time surveillance and tracking of discharged oil.
- Wildlife hazing, capture, treatment and release.

Incident Management. Management of a spill under the Prince William Sound tanker plans follows the Incident Command System, which provides for a consistent approach by the various parties involved, including Alyeska, the tanker owner or operator, and state and federal agencies. The Incident Command System has been adopted and implemented by state and federal emergency response organizations and regulatory agencies in Alaska.

Communications System. Radio control stations, base radio stations, mobile radios, and fixed and portable repeaters are in place to provide for coverage of the entire sound.

- The radio telecommunications network comprises the following major components: radio control facilities, radio base stations, and mobile units aboard the vessels, vehicles, and aircraft employed in operations.
- All tankers loading at the VMT are outfitted, at a minimum, with two VHF marine radios, one single-sideband radio, and a satellite terminal with voice and telex. These stations enable the vessels to communicate not only with Alyeska facilities but with other vessels and coast stations operated by common carriers or governmental agencies. Each escort vessel is equipped with at least two VHF marine radios and one single-sideband radio.
- Alyeska uses radio sites at Reef Island and at Johnstone Point in Prince William Sound to provide VHF marine coverage supporting day-to-day escort of vessels into and out of the Port of Valdez and to provide dedicated, in-place, spill response channels available for immediate use.

Overall Training Program. The Alyeska SERVS training program includes courses in the Incident Command System, oil spill prevention and response, safety, simulation exercises, and both announced and unannounced drills. The program follows the guidelines outlined in the National Preparedness for Response Exercise Program.

- Qualified Individual Notification, Spill Management Team and Equipment Deployment Exercises are conducted annually.
- One internal unannounced exercise is conducted annually. Several government-initiated unannounced exercises may be conducted each year with Alyeska.
- The contingency plan is categorized into 15 elements. Each element of the plan is exercised on a rotating basis, at least once every 3 years.
- Each type of boom and skimming system must be exercised once per year in each operating environment (fully protected areas such as rivers, sheltered areas such as harbors, and open water).
- Tethered-tug exercises are conducted to familiarize vessel personnel with rescue techniques.

Fishing Vessel Fleet. Alyeska maintains over 300 contracts with fishing vessel owners from four regions (Seward, Kodiak, Cook Inlet and Prince William Sound). The contracted vessels are grouped in two tiers as the Initial Responders (50-vessel core fleet) and Secondary Responders, and a database is maintained of other vessels in the area that could assist if needed.

Equipment Staging at Communities and Hatcheries. Response equipment is staged at five Prince William Sound communities: Valdez, Cordova, Whittier, Chenega, and Tatitlek. Hatchery protection equipment is staged at the five operating hatcheries in Prince William Sound: Armin F. Koernig Hatchery (Chenega), Cannery Creek Hatchery (Unakwik Inlet), Wally Noerenberg Hatchery (Lake Bay), Main Bay Hatchery, and Solomon Gulch Hatchery (Port Valdez). In addition, response equipment is prestaged near the sensitive Valdez duck flats aquatic habitat.

Technical Response Tools. Alyeska maintains a computer model to predict the surface movement and weathering of oil spilled in the sound. The model also contains geographical information on resources at risk from a spill.

Regional Citizens' Advisory Council. OPA 90 established two "Oil Terminal and Oil Tanker Environmental Oversight and Monitoring Demonstration Programs" with Regional Citizens' Advisory Councils — one in Prince William Sound and one in Cook Inlet. The councils have the following duties:

- Advise on policies, permits, and site-specific regulations relating to the operation and maintenance of terminal facilities and crude oil tankers.
- Monitor environmental impacts of the terminals and tankers.
- Monitor operation and maintenance activities that

may affect the environment.

- Review the adequacy of oil spill prevention and contingency plans for tankers and terminals.
- Provide advice and recommendations on port operations, policies, and practices.
- Recommend standards and stipulations for permits and site-specific regulations intended to minimize the impact of terminal and tanker operations, modifications to tanker and terminal operation and maintenance, and modification to oil spill prevention and contingency plans.

4.2.3.4 North Slope Oil Fields

Spill mitigation measures associated with operation of the North Slope oil fields are presented here for consideration in the cumulative effects analysis in Section 4.5. Following are examples of the many spill prevention measures the operators have incorporated into their day-to-day operations:

- Preparation of spill prevention, control, and countermeasures (SPCC) plans and oil discharge prevention and contingency plans.
- Preparation of marine transfer operations manuals for facilities that receive fuel transfer from barges or other vessels.
- North Slope Fluid Transfer Guidelines: These guidelines provide a step-by-step procedure for transferring fluids, including checks before transfers, use of secondary containment, and checks after the transfer is complete. In addition, the guidelines call for the avoidance of transfers near water bodies, tundra, and wildlife habitat.
- North Slope Unified Operating Procedure for Surface Liner/Drip Pan Use: This procedure requires the use of portable under-equipment liners wherever there is a chance of spills from equipment during maintenance work or fluid transfers. The purpose is to provide secondary containment, maintain contaminant-free work sites, and to encourage proper spill prevention techniques during normal field operations.
- Tanks, vessels, and piping are subject to both visual inspection and non-destructive integrity testing to detect corrosion so that remediation measures can be taken before system integrity is compromised.

North Slope operators maintain oil spill contingency plans for all their operations on the North Slope, in accordance with state and federal laws and regulations. The State of Alaska law requiring such plans is contained in AS 46.04.030, while the federal Oil Pollution Act of 1990 dictates plans for facilities that handle oil. The following agencies require plans:

- Alaska Department of Environmental Conservation
- U.S. Coast Guard
- U.S. Environmental Protection Agency
- U.S. Minerals Management Service
- U.S Department of Transportation

The plans provide detailed descriptions of the facilities, spill prevention programs, and response plans to handle spills of varying sizes.

Central to industry's spill response plans on the North Slope is the use of the Incident Command System (ICS), a crisis management system adopted by state and federal agencies, as well as the oil industry in Alaska. This system uses standardized organization charts and position descriptions, as well as forms for completing essential work. Use of ICS by all parties involved in an oil spill helps to ensure efficient management of the incident.

North Slope spill response plans are based on the operators' membership in Alaska Clean Seas (ACS), the oil spill response cooperative for the North Slope. ACS was founded in 1980 as the Alaskan Beaufort Sea Oilspill Response Body (ABSORB) and has the capability to respond to major onshore and offshore spills.

4.2.4 Social Mitigation Measures

By L.D. Maxim

Because social direct, indirect, and cumulative effects are closely intertwined, mitigation measures for all such effects are considered here. At the outset, it is appropriate to note that physical, biological, and social impacts are closely linked. Indeed, nearly all of the mitigating measures identified in Sections 4.2.1 through 4.2.3 above also help to reduce potential social impacts. Thus, for example, measures designed to reduce the likelihood or consequences of oil spills also reduce the likelihood and/or severity of impacts on subsistence harvests, one of the social impacts considered in this analysis. Adverse effects on subsistence resources have significant sociocultural implications because of the central importance of subsistence to Alaska Native culture. Therefore, measures that reduce subsistence impacts also lessen social impacts.

As a second example, the pipeline has been designed with features (e.g., height constraints on elevated sections, buried animal crossings, and designated big-game crossings) to mitigate possible constraints on the free passage of terrestrial mammals. Though designed to minimize impacts on animal populations, these measures also limit adverse

impacts on subsistence harvests.

Because of such linkages among physical, biological and social impacts, the focus of this section is on mitigating measures that are either targeted specifically on social issues and those (regardless of motivation) that are likely to have significant applicability to social impacts.

Mitigating measures are identified in, reflected by, or pursuant to one or more of the following:

- Stipulations in the 1974 Federal Grant and State Lease for TAPS;
- Stipulations in lease agreements for onshore and offshore ANS development (see, e.g., BLM and MMS, 1998);
- Specific commitments made by the TAPS Owners or Alyeska (e.g., as a component of oil spill contingency plans, in consent agreements);
- Economic/demographic factors; and
- Applicable federal and state laws and implementing regulations.

Examples from each of these general categories are presented below.

4.2.4.1 Original ROW Stipulations

Both the Federal Grant and State Lease contain numerous provisions that identify mitigating measures and duties to abate/rehabilitate damages relevant to possible social impacts. For example, several sections of the Federal Grant require measures that limit, mitigate, or require rehabilitation of potentially adverse TAPS impacts. These include:

- Section 9, Construction Plans and Quality Assurance Program.
- Section 10, Compliance With Notices To Proceed.
- Section 13, Damage to United States Property; Repair, Replacement or Claim for Damages (including requirements to rehabilitate any natural resource that shall be seriously damaged or destroyed).
- Section 16, Laws and Regulations.
- Section 23, Port Valdez Terminal Facility (including provisions to minimize environmental impacts).
- Section 24, Duty of Permittees To Abate.
- Section 29, Training of Alaska Natives.
- Section 30, Native and Other Subsistence.

As another example, most stipulations are designed to prevent, mitigate, or rehabilitate potential impacts. Three categories of stipulations are included in the Federal Grant: *general*, *environmental*, and *technical*. Stipulations in each category are applicable to social impacts. In the general category, for example, Stipulation 1.9 (Antiquities and Historical Sites) requires that an archaeologist provide surveillance and inspection of TAPS and its archaeological values, including an assessment of the protection measures to be undertaken by the Permittees. In the environmental category nearly all stipulations serve to mitigate social impacts. For example, Stipulation 2.10 (Aesthetics) instructs the permittees to consider aesthetic values in planning, construction, and operation of TAPS. This stipulation includes specific provisions (e.g., limitations on the straight length of pipeline segments visible from highways) to limit aesthetic impacts. As another example, Stipulation 2.5 (Fish and Wildlife Protection), referred to above, identifies measures that protect wildlife. Lastly, in the technical category, many stipulations mitigate possible social impacts. For example, Stipulation 3.6 (Stream and Flood Plain Crossings and Erosion) contains provisions to minimize the effects of scour, channel migration, undercutting, ice forces and degradation of permafrost.

4.2.4.2 Stipulations Contained in Other Lease Agreements

A routine feature contained in EISs regarding federal and state leasing activities for ANS fields is the identification and analysis of mitigation measures, which minimize cumulative impacts. Mitigation measures are ultimately reflected in lease stipulations. For example:

- The EIS for the Beaufort Sea Planning Area Oil and Gas Lease Sale 170 (MMS, 1998) contains numerous measures for protection of biological resources, conflict avoidance mechanisms to protect subsistence whaling and other subsistence activities, limitations on facility siting in the vicinity of Cross Island (to minimize subsistence conflicts), use of pipelines for transport of crude, and measures to minimize adverse effects on polar bears.
- The EIS for the National Petroleum Reserve-Alaska (NPR-A) (BLM and MMS, 1998) incorporates mitigation measures both implicitly and explicitly. For example, numerous explicit constraints on exploration and production and facility siting are identified for the entire planning area and for certain parts of this area, termed *land use emphasis areas*, because of their surface resource values. For each of the alternatives, there are both generic and specific stipulations that mitigate social impacts. Proposed stipulations for this planning area are detailed and include subsistence-related stipulations such as developing a monitoring plan for effects of exploration, development, and production on subsistence, and consulting with the North Slope Borough and the Subsistence Advi-

sory Panel about siting, timing, methods of operation, and mitigation that could be implemented to assure that exploration, development, and production activities do not conflict with subsistence practices.

- The EIS for the Northstar Project (USACE, 1999) identifies numerous mitigation measures designed to reduce impacts on subsistence species. Examples include requiring the use of acoustic scaring devices to disperse sea ducks and other migratory birds from an oil spill area, establishing flight corridors for helicopter traffic to minimize noise impacts on various bird and mammal populations, establishing vessel corridors and seasonal operating restrictions to maximize separation between vessels and migrating whales, prohibition of certain drilling operations during periods of broken ice to reduce the chance of an oil spill occurring when oil spill cleanup efficiencies are likely to be low, and the imposition of various constraints on construction activities to minimize environmental impacts.

These measures mitigate indirect and cumulative impacts of the proposed action.

4.2.4.3 Specific Commitments by TAPS Owners or Alyeska

Mitigation measures are also identified in specific commitments made by TAPS Owners and/or Alyeska. These measures are contained in numerous documents, such as various oil spill contingency plans and consent agreements. For example, Section 29 of the Federal Grant requires permittees to enter into an agreement for recruitment, testing, training, placement, employment, and job counseling of Alaska Natives. The purpose of this section was to ensure that Alaska Natives received certain economic benefits from TAPS operations and to help alleviate chronic unemployment on the North Slope. The consent agreement ultimately developed employment goals (expressed as the percentage of positions to be filled by Alaska Natives) by labor category by year.

From time to time, companies institute or modify internal policies that mitigate possible social impacts. For example, access to oil field lands is one of the subsistence issues on the North Slope. Traditionally, all access for subsistence hunting has been restricted in the oil fields for security and safety reasons. Recently, ARCO agreed to permit access at its Alpine and Tarn developments for subsistence hunting and fishing purposes with certain security/safety-related exceptions. This policy change serves as a mitigation measure for subsistence-related cumulative impacts.

4.2.4.4 Economic/Demographic Factors

Economic and demographic factors sometimes act in concert to align economically efficient choices with those that mitigate social impacts associated with oil field development. For example, the remote location of the ANS fields relative to population centers, the lack of infrastructure, and the difficult climatic conditions make it necessary to provide accommodations and meals for ANS workers and those who work at several pump stations along TAPS. This economically efficient solution also limits contact between Alaska Natives and non-Natives.

Concerns for the potential adverse consequences of increased interaction between oil-industry workers and local residents of North Slope villages are often addressed in EIS analyses of ANS developments (e.g., BLM and MMS, 1998). Specific impacts noted include the growth of racial tension between oil workers and residents, introduction of new values and ideas, and an increased availability of drugs and alcohol (BLM and MMS, 1998). Analysts (e.g., BLM and MMS, 1998) claim that these effects could cause "some disruption to sociocultural systems," but concede that these impacts "would not displace existing institutions." Presumably, such contact could also have benefits (cultural exchange, new ideas), although these are not typically addressed in project analyses.

The alignment of economic and other factors — which provides an impetus for enclave development — also creates a de facto mitigation measure. Potential social benefits of enclave development are acknowledged implicitly in the NPR-A EIS (BLM and MMS, 1998).

4.2.4.5 Federal and State Laws and Implementing Regulations

TAPS operations are governed by numerous laws and implementing regulations. For example, environmental laws and regulations limit environmental impacts, which generally also serve to limit social impacts (e.g., subsistence, sociocultural). One broad subset of environmental laws with particular relevance to social impacts is that collection of laws and regulations dealing with oil pollution. Measures taken to ensure compliance with these laws (see Sections 4.1 and 4.2) reduce the likelihood and consequences of oil spills and, therefore, social impacts.

Another group of laws with specific applicability to impacts on cultural resources is that concerned with preservation of cultural resources, including portions (Section 106) of the National Historic Preservation Act of 1966 (as amended), NHPA, and the companion Alaska Historic Pres-

ervation Act. NHPA and implementing regulations (e.g., those in 36 CFR 800) provide for the identification of cultural resources (sites, districts, structures, buildings, and objects) in the TAPS project area and consultation with various groups to ensure that cultural values are considered. Section 106 of NHPA requires federal agencies to "take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation ('Council') a reasonable opportunity to comment on such undertakings." Key objectives of the Section 106 process are the identification of historic properties potentially affected by an undertaking, assessment of potential effects, and search for ways to avoid, minimize, or mitigate any adverse effects on historic properties (36 CFR 800.1). This and similar laws have spurred considerable archaeological research in the TAPS project area prior to, during, and subsequent to construction to identify and characterize historic sites in the area.

In practical terms, Alyeska refers to the State Historic Preservation Office to obtain site clearance prior to engaging in activities that have the potential to cause adverse impacts on cultural sites.

4.3 Impacts of Proposed Action

Section 4.3 discusses the impacts of the proposed action, i.e., renewal of the TAPS ROW for the period 2004-2034. This section is divided into three main subsections:

- Physical Characteristics
- Biological Resources
- Social Systems

The impacts in this section are the direct and indirect ones associated with continued operation of TAPS. Cumulative effects of the proposed action are addressed in Section 4.5, while Section 4.4 covers direct and indirect impacts of the no-action alternative.

These analyses follow as closely as possible the definitions provided by the Council on Environmental Quality (CEQ):

- **Direct effects** are "caused by the action and occur at the same time and place" (40 CFR 1508.7).
- **Indirect effects** are "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.7).
- **Cumulative impact** is "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7).

In general, Section 4.3 discusses direct and indirect effects. ANS and PWS effects are treated as cumulative effects in Section 4.5 because these regions are not directly affected by TAPS as defined in Stipulation 1.1.1.22 of the Federal Grant. (However, the economic analysis in Section 4.3.3 treats them because of the model used for the analysis. See the introduction to Section 4 for an explanation of how these various effects are treated.

4.3.1 Physical Characteristics

4.3.1.1 Terrestrial Environment

By R. Dugan and Golder Associates

Continued operation of TAPS will impact some parts of the terrestrial environment because of maintenance activities, corrosion digs, construction projects for pipeline-related facilities, and the continued presence of a buried warm-oil pipeline in permafrost terrain. Maintenance since startup has caused localized temporary land disturbance but has generally stabilized the ground on and adjacent to the ROW. Since nearly all maintenance activities occur on or along existing stabilized embankments, new major long-term changes to the terrestrial environment are not expected.

Geology and Physiography

Impacts on the geology and physiography along TAPS are expected to be localized to the workpad, access roads, and their immediate margins and will generally include temporary soil erosion and accelerated riverbank erosion. Modification to the permafrost regime is discussed below. There will be essentially no direct impact to the underlying bedrock or topography except for possible new material-site developments. Maintenance work could cause minor local changes to terrain similar to those during original construction but on a much smaller scale. The pipeline will not affect seismicity, although seismic activity may impact the pipeline.

Paleontological Resources

Large portions of the pipeline overlie rocks containing plant and animal fossils, particularly marine plant and invertebrate species. Damage to these resources could result from excavation or spills. However, these fossils are so widespread and numerous that potential impacts from the pipeline are minor. Vertebrate fossils are much less common but are more likely to be affected by pipeline maintenance activities. Vertebrate fossils would likely be encountered during gravel mining or erosion of river banks.

Other activities that could lead to the disturbance of near-surface remains are reroutes of the pipeline, cleanup of spills, and changing the pipeline mode from below-ground to above-ground or vice versa. Since the location and type of the vertebrate remains are unknown until these activities occur, the severity of the potential impacts is difficult to assess. There have been no significant discoveries of fossil remains on the TAPS ROW during operation (Kunz, 2000, pers. comm.).

Soils and Permafrost

With respect to soils and permafrost, the impacts of continued TAPS operation are minimal. Most of the thermal impacts have already occurred or are significantly slowing. Continued monitoring and maintenance will identify and repair any areas where settlement or heave may exceed operational standards.

The pipeline was designed and built to maximize pipeline stability and minimize environmental impact. It was typically buried conventionally where the soils were unfrozen or thaw-stable and was elevated in zones of thaw-unstable permafrost. Since construction, the soils in permafrost zones have been affected by thawing. The thaw bulb that has developed around the buried pipe has reached equilibrium and is unlikely to continue to grow because the pipeline temperature is decreasing with decreased throughput. The thaw bulb could eventually shrink in the cold continuous permafrost north of the Brooks Range. Shrinkage of the thaw bulb could contribute to frost heave in some areas.

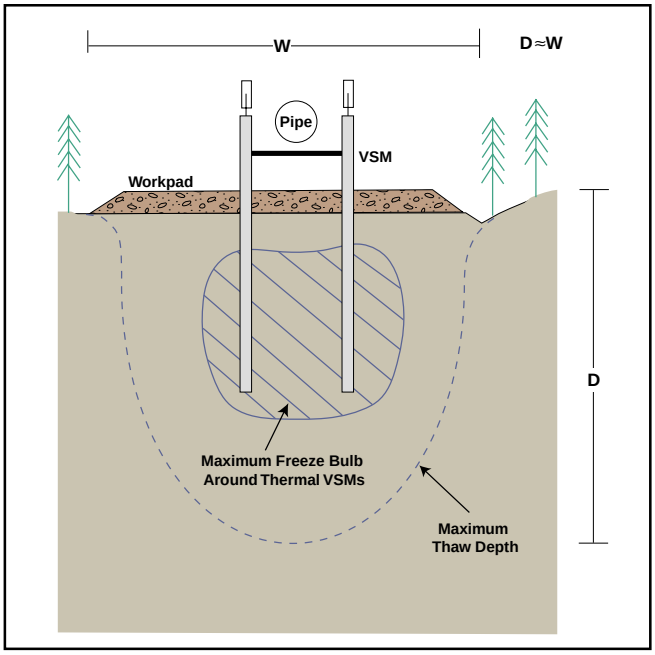


Figure 4.3-1. *Conceptual maximum thaw-bulb development for above-ground pipe.*

However, the impact of continued pipeline operation in areas of permafrost is likely to be minimal and well within operational limits.

Workpad and access-road embankments built over the relatively warm permafrost south of the Brooks Range have compressed or disturbed the vegetative cover that formerly protected the permafrost. This has caused the ground to absorb more radiant heat and has resulted in the thawing of near-surface permafrost under the embankments. Because the impact of the workpad controls the gross thermal state around the VSMs, the maximum thaw-bulb development for above-ground pipe could locally approach the configuration shown in Figure 4.3-1. During the life of the pipeline, this thaw-bulb configuration would likely be an unusual case in most above-ground sections and would be limited to a few areas of discontinuous permafrost. Lowering of the permafrost table has caused settlement where the near-surface soils contained excess ice before thawing. The settlement has caused localized disruption of drainage and formation of ponds in the depressions. The ponds rarely extend more than a few yards from the edge of the embankments. Where the underlying soils were particularly ice-rich, ponds have locally extended onto the workpad (Figure 4.3-2).

Figure 4.3-2. *Example of localized workpad impact on ice-rich permafrost.*

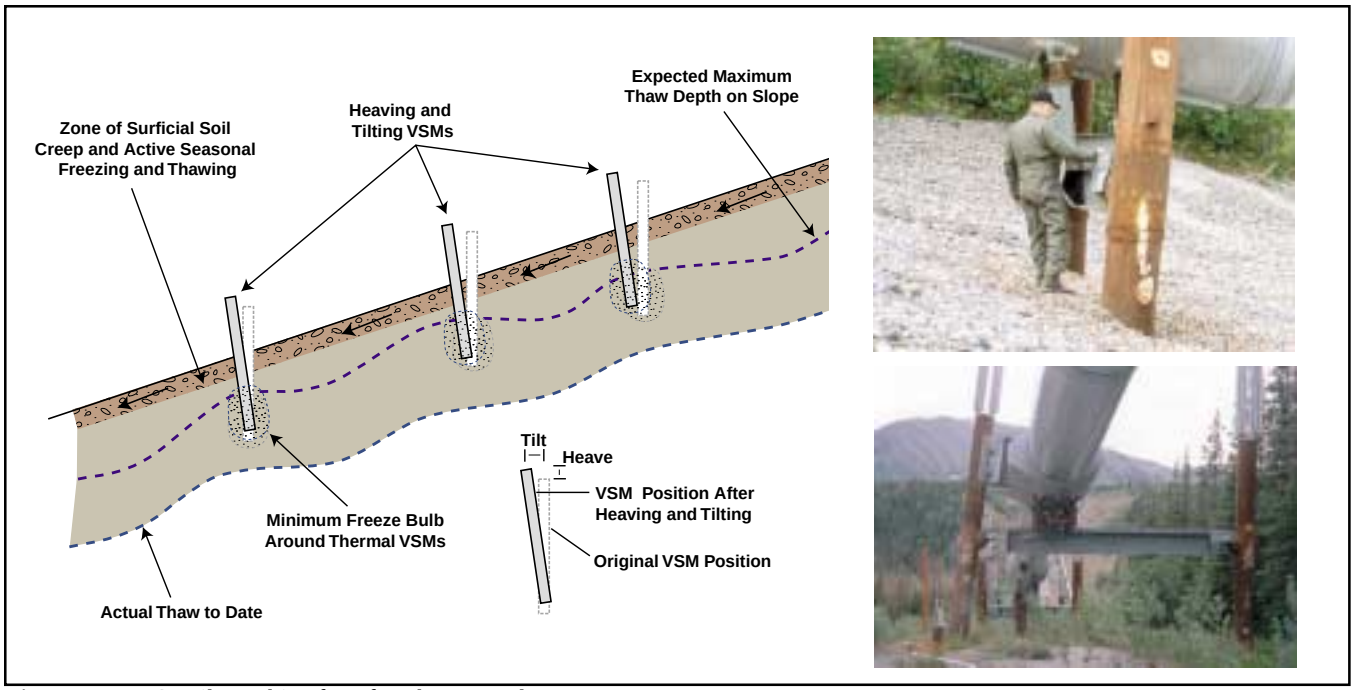


Figure 4.3-3. *VSM tilt resulting from frost heave on slopes.*

As the top of the permafrost continues downward, the rate of thaw generally decreases. Continued operation of the pipeline is not likely to further affect this process significantly because the effect of the above-ground pipeline is minimal compared to the effect of the workpad that is already in place. In addition, the thaw depths under the workpad are already approaching the anticipated maximum in some locations, and the VSMs have settled in only a few areas.

In addition to the effects on drainage, the continued downward migration of the permafrost table may locally affect VSM stability. Where permafrost thaws below the VSMs, settling or seasonal frost-jacking of VSMs may occur. Figure 4.3-3 shows the process of VSM heaving and tilting. A saturated thawed zone provides water for winter ice lenses that grow along the VSM freeze bulbs and at the active-layer freeze front. These growing ice lenses push the VSM and its freeze bulb up and downslope. In the future, localized repairs will likely be necessary, particularly on slopes where VSM movements aggravated by surficial soil creep may cause the support shoes to lose contact with the cross-beam. VSM movements have generally been mitigated by adjusting the height of the cross-beam, adding free-standing heat pipes, and using other techniques such as applying wood chips to insulate the workpad.

Monitoring programs report that about 300 of approximately 78,000 VSMs installed on TAPS show signs of movement (up, down, leaning) that exceeds maintenance standards and may require intervention. None of these affect the structural integrity of the associated above-ground pipeline support system. Most of these VSMs are on slopes in marginal permafrost areas and may have to be replaced with longer VSMs installed to a greater depth (Sorenson, 2000, pers. comm.). All of these impacts have been, and will continue to be, mitigated through Alyeska's routine monitoring and maintenance program.

Future maintenance activities such as corrosion digs and VSM repairs will typically take place on existing embankments, and the vegetative cover outside the embankments is unlikely to be disturbed. Therefore, soils outside the immediate limits of the embankment are unlikely to be affected during routine operation. In the case of oil spills, cleanup plans are designed to minimize the effect of the spill on the environment, including permafrost. However, oil spill cleanup conducted off the workpad could damage the vegetative cover, and this damage could lead to localized thawing of permafrost, causing settlement and ponding.

Loss of pipeline support due to thawing permafrost has occurred since construction in a few areas. Notable examples include:

- Pipe deformation resulting from thaw settlement that resulted in a leak on the north side of Atigun Pass (MP 166) in 1979. The permafrost at this location was not identified during TAPS construction.
- Several feet of vertical settlement for a segment of buried pipeline due to thawing of ice-rich soils in the Dietrich River floodplain at MP 200 in 1985. The

permafrost at this location was not discovered during TAPS construction.

- Minor movement of VSMs on slopes at Pump 11 Hill (MP 687) and Squirrel Creek (MP 717) due to thaw settlement and frost-jacking of VSMs.
- Pipe settlement and deformation at MP 734.

The leak in Atigun Pass reached the Atigun River and caused some impact. The Dietrich River settlement resulted in a realignment, causing temporary disturbance to the ground surface over a limited area. Maintenance and repairs associated with the movement of VSMs on the slopes have not affected areas off the workpad.

Short segments of the pipeline are buried in ice-rich soils. These segments are refrigerated and closely monitored to ensure that the soils under the pipeline remain frozen to prevent pipe settlement. Figure 4.3-4 shows the anticipated maximum thaw-bulb development for the refrigerated-burial segments.

Sand, Gravel and Rock

Continued operation and maintenance of TAPS will require sand, gravel, and quarry rock; workpad repairs; road bedding and surface materials; and flood damage control and revetment projects. Removal of gravel and related construction materials from non-permitted locations is not allowed, although materials can be obtained from privately owned pits. From 1995 to 1999, Alyeska's annual usage ranged from approximately 30,000 to 97,000 cubic yards (Nagel, 2000, pers. comm.). It is thus conservatively estimated that Alyeska will need approximately 100,000 cubic yards of these materials per year. Most of these materials will likely be obtained from the 69 material sites on public lands for which Alyeska currently has mining permits.

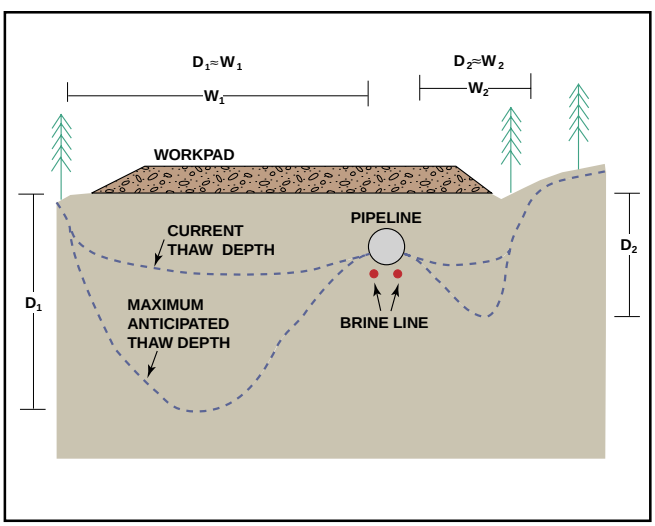


Figure 4.3-4. *Conceptual thaw-bulb development for refrigerated burial.*

Many of these sites have existing stockpiles (Globig, 1999, pers. comm.).

Additional mineral extraction will result in development of previously undeveloped portions of some existing material sites. Development of new material sites or reopening of previously closed material sites may also be required where existing mineral resources have been depleted. Within the footprint of the newly developed areas and access roads, this activity will result in modifications to the topography, loss of existing vegetation, landscape scars, and alteration of natural drainage patterns. The extent of surface disturbance from future material-site development is unknown but is likely to be limited to a few acres at existing material sites. The size of possible new material sites will likely be significantly less than the typical 20- to 40-acre sites opened during construction. The construction-era material sites were used to construct extensive sections of workpad, access roads, pump station pads, and the Haul Road. This required approximately 41 million cubic yards of mineral materials. Future earthwork materials will be primarily for maintenance and will be minimal by comparison.

Soil erosion and siltation may occur temporarily during mining and before stabilization of the disturbed surfaces. Material sites for production of riprap will likely require blasting of rock faces, leaving an enduring visible scar over a small area.

Hazardous Materials

Hazardous materials used in conjunction with the operation of TAPS are procured, handled, used, stored, and disposed of in accordance with regulatory requirements and strict procedures. These materials are not disposed of on the right-of-way. Hazardous materials could impact the terrestrial environment if they are leaked or spilled. Where this occurs, cleanups will be conducted to mitigate damage to the environment.

To minimize the shipping and handling of hazardous materials, crude oil, used oil, and other hydrocarbon-based compounds that meet certain criteria are injected into the pipeline according to specific guidelines and procedures (APSC, 2000b). Strict work-site guidelines and updated secondary containment systems installed at fueling stations and storage facilities have reduced the potential for releases of hazardous materials.

At present, there are 58 contaminated sites on the TAPS ROW. Approximately 90 percent of these sites are contaminated by diesel fuel, and the remaining sites are contaminated by other types of petroleum hydrocarbons. Half of these sites are either closed, requiring no further action, or are pending closure.

Rivers and Floodplains

By W. Veldman

Impact of Existing Facilities. The impact of the pipeline on the behavior of rivers and floodplains depends on whether river training structures are used, the type of structure, and whether the pipeline, particularly when parallel to the river, is located in the active or main channel area or in vegetated floodplain fringe areas.

Buried river crossings with no river training structures have little or no impact on the behavior of rivers. As part of construction, riverbeds were restored to the original grade. Typically, some settlement occurred in backfilled ditches during the first year due to the loose nature of the backfill and/or frozen material or ice in the ditches if constructed in the winter. With the first moderate to high flow during spring runoff or rainfall, the natural bedload transported into the ditches filled in the settled areas. The banks were typically restored to their natural conditions or, for erosion control purposes, cobbles or rock placed on them. After a single year of operation, there was little or no evidence of construction except for loss of vegetation at the banks.

Most of the bridged river crossings have some type of river training structure to guide flow. The structures are necessary to reduce scour and bank erosion and thus protect the integrity of the bridge piers and abutments. The Yukon River bridge and the Atigun River bridge north of Pump Station 4 are examples of crossings with no river training structures. These bridged crossings have little or no impact, except for the local impact of the piers on flow. The piers result in a local deepening of the river immediately in front of and alongside the piers.

Figure 4.3-5 shows bridged crossings and associated river training structures at the Tanana, Middle Fork Koyukuk, and Hammond river crossings. Some additional riprap was placed along the north bank of the Tanana River in 1996; this placement may have not been consistent along the length of the bank. Minor work was also done along the south bank. Neither the north or south bank maintenance work protruded significantly into the river and consequently had little or no impact on the river. The large guidebanks at the Middle Fork Koyukuk River and Hammond River bridges are parallel to the flow and have little impact on the behavior of the rivers except for locally limiting their movement.

Many elevated stream crossings are on VSMs (Figure 4.3-6). Where bank erosion or channel scour could result in significant “stick-up” height on the VSMs, riprap islands are typically placed around the piles, as shown on the photographs. This riprap has only a local effect on flow. The effect of more significant riprapping around VSMs on wide fans such as Snowden Creek is still minimal.

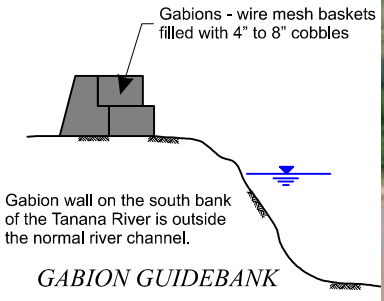
Revetments are armored structures parallel to the flow to prevent further movement of the river towards the pipeline or to protect the pipeline or facilities during operation (Figure 4.3-7). On the Middle Fork Koyukuk and Delta rivers, the impact of the structures on flow patterns and overall river behavior is minimal because the structures are constructed on the edge of wide rivers or following the bank. At the alluvial fan at Trims Creek, the revetment prevents spillage of the creek into Pump Station 10.

Spurs are structures built perpendicular to river flow (Figure 4.3-8) to deflect main-channel high-velocity flow away from the pipeline by limiting the formation of major channels between the structures and thus over the pipeline. The length of the spurs, and therefore their impact on flow patterns, depends on the width of the river, the presence of vegetation, and ice conditions.

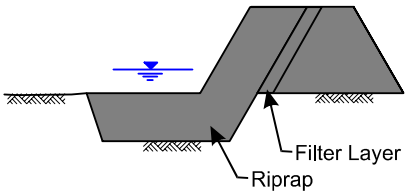
When initially constructed, spurs can have a significant impact on the flow patterns of rivers as the main channel flow is deflected beyond the ends of the spurs. In highly mobile rivers like the Delta (Photo 1 in Figure 4.3-8), the spurs presently have little or no impact on flow as natural features in the river — primarily the noses of alluvial fans upstream — influence overall flow patterns. In the future, the natural flow patterns could change again, resulting in main channel attack into the spurs. When new spurs are built in river systems such as the Sagavanirktok River (Photo 2), the flow deflection created by the spurs will form new channels through bars or even vegetated islands or deepen existing channels. (In the 1993 work at MP 22, a channel was excavated across a high vegetated gravel bar area to ensure the flow could bypass the new spurs). Where spurs are constructed adjacent to subchannels in a vegetated floodplain, like the Middle Fork Koyukuk (Photo 3), the spurs are sized and positioned to ensure the subchannels are not blocked.

Various types of structures are used to protect valve sites and/or the access to the valves (Figure 4.3-9). The armoring required to protect Check Valve (CKV) 29A and CKV 30 in the Atigun River (Photos 1, 2, and 3) is very local in nature and has little effect on the overall behavior of the river. At RGV 34 in the Dietrich River (Photos 4 and 5), more extensive armoring is required. Because this armoring was placed on the eroding bank, the structure has had little impact on the behavior of the Dietrich River. The armoring will prevent further movement of the river but will not restrict the behavior of the river compared to the preconstruction, natural width of the river.

Revetments are also used to protect transitions to shal-



3. North bank before placement of additional riprap, 1996



4. After repair

Guidebanks are armored structures built parallel to the river flow to guide the flow into bridge openings and/or to protect the bridge foundations. In the case of the Tanana River bridge near Big Delta (MP 531.0), a vertical gabion wall was constructed on the south bank to protect the main pier and wind anchors (Photo 1). No repairs of the gabion protection have been necessary to date. (Riprap on the bank, a more typical design, was not used due to a prime fish spawning area along this bank.) The north bank was also armored and required a minor repair of the riprap in the mid-nineties (Photos 2-4). The structures at the Tanana River have had little or no impact on the behavior of the river. In the case of the Middle Fork Koyukuk River bridge (Photo 5) and the adjacent Hammond River crossing (Photo 6), extensive guidebanks were required to align the flow, minimize scour at the bridge, and protect the abutments of the bridges. Photo 5 shows the bank erosion upstream of the Middle Fork Koyukuk guidebank compared to the alignment of the river past the structures at the bridge. The structures have been effective and, other than locally limiting the movement of the banks of the river, have had little impact on the overall behavior of the rivers at these locations.

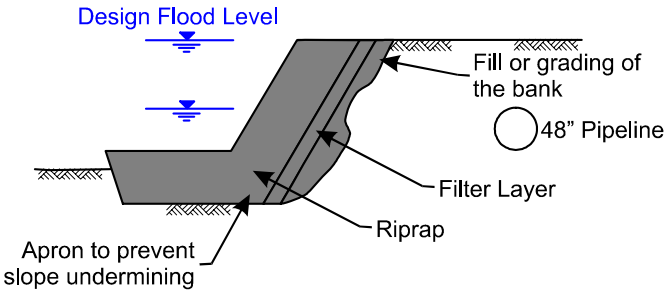
CONCLUSION: Where guidebanks protect the bridge structures from future erosion, they have had little impact to date. In mobile rivers like the Hammond, they are key to controlling the flow through the bridges.

Figure 4.3-5. *Guidebanks to align flow at major bridges.*

Variations of the standard VSM span and pile design were effectively used for minor to moderate-sized crossings to accommodate a wide range of flow, bank, and potential erosion conditions. At a crossing of the Jim River subchannel (MP 271.6, Photo 1), 4-pile bents were used on both banks to accommodate potential additional "stick-up," or unsupported length, resulting from bank erosion and scour. (Note that to date there has been little bank erosion.) At the larger crossing of Prospect Creek (MP 248.0, Photo 2), a 4-pile bent with riprap to limit scour was used. The effect of these crossings on the behavior of the creek has been minimal to nil. At Snowden Creek (MP 198.0, Photos 3-4), riprap is used to limit scour at the VSMs in the event of a channel change into the abandoned flood-plain material site on the downstream side. At Minnie Creek (MP 225.7, Photo 5), the flow is parallel to the pipeline. If the flow crosses the line, riprap around the VSMs will limit erosion with little impact on the overall behavior of the creek. As the pipeline profile here is relatively low, scour or loss of fill around the VSM's would not result in significant stick-up and thus would not be a structural concern. The versatility of a VSM-type crossing, as well as the pipeline itself, is clearly illustrated at Linda Creek (MP 215.3, Photo 6) where the clear-span and transition from elevated to buried resulted in no disturbance of the narrow, deep creek valley.

CONCLUSION: VSM-type crossings have minor to no impact on the behavior of creeks.

Figure 4.3-6. *Elevated crossings on vertical support members.*



Revetments are composed of armor, usually riprap, placed on a natural bank or on a dike to stop erosion and limit the movement of the river. The 1994 flood in the Middle Fork Koyukuk River, in excess of the 100-year event, resulted in significant bank erosion at a sharp bend at MP 231.5 (Photos 1-3). To prevent further encroachment of the river into the right-of-way, the natural bank was graded and armored with large rock (Photo 3). Work was done during the 1994-1995 winter season with nominal in-stream activity required — the equipment worked on the riprapped apron at the toe of the slope. The structure has minimal impact on the behavior of the river as it follows the natural bank. At the wide braided stream of the Delta River near Pump Station 10 (MP 585, Photo 4), a revetment guides the flow to protect the shallow-buried line behind it. The revetment's impact on the river behavior is local — only a minor narrowing of the river is apparent. At Trims Creek immediately south of Pump Station 10 (MP 586, Photo 5), a revetment has been very effective in preventing spillage of the creek into the pump station. Both the Delta River and the Trims Creek structures were built as part of the original construction and have required little or no maintenance. In fact, vegetation is present along the Trims Creek dike.

CONCLUSION: Revetments limit the movement of rivers and are key to protecting the pipeline. They typically "hold" the river at a specific location rather than diverting the river.

***Figure 4.3-7**. Revetments to limit riverbank erosion or movements.*

Spurs are gravel and riprap armored structures that, by projecting out perpendicular from the bank, reduce velocities and scour over the pipeline which is buried or elevated parallel to the floodplain. Long structures were used on the Delta River north of Pump Station 10 (Photo 1), and the effectiveness of the spurs is clearly visible. Subchannels form between the spurs, but the spacing of the spurs prevents significant flow and thus scour over the pipeline, as evidenced by the vegetation. In the Sagavanirktok River, the 1992 flood of record caused significant bank erosion at MP 47.0. Spurs were constructed in the winter of 1992-1993 to deflect the flow away from the buried pipeline (Photo 2). In the Middle Fork Koyukuk River (MP 243.0, Photo 3), spurs were used to prevent the enlargement and movement of subchannels to and over the buried pipeline. High flows in 1994 required the addition of a short spur to prevent the further movement of the river. A close-up of the riprapped end of a spur is provided in Photo 4. (Note the extent of riprap versus the length of the spur).

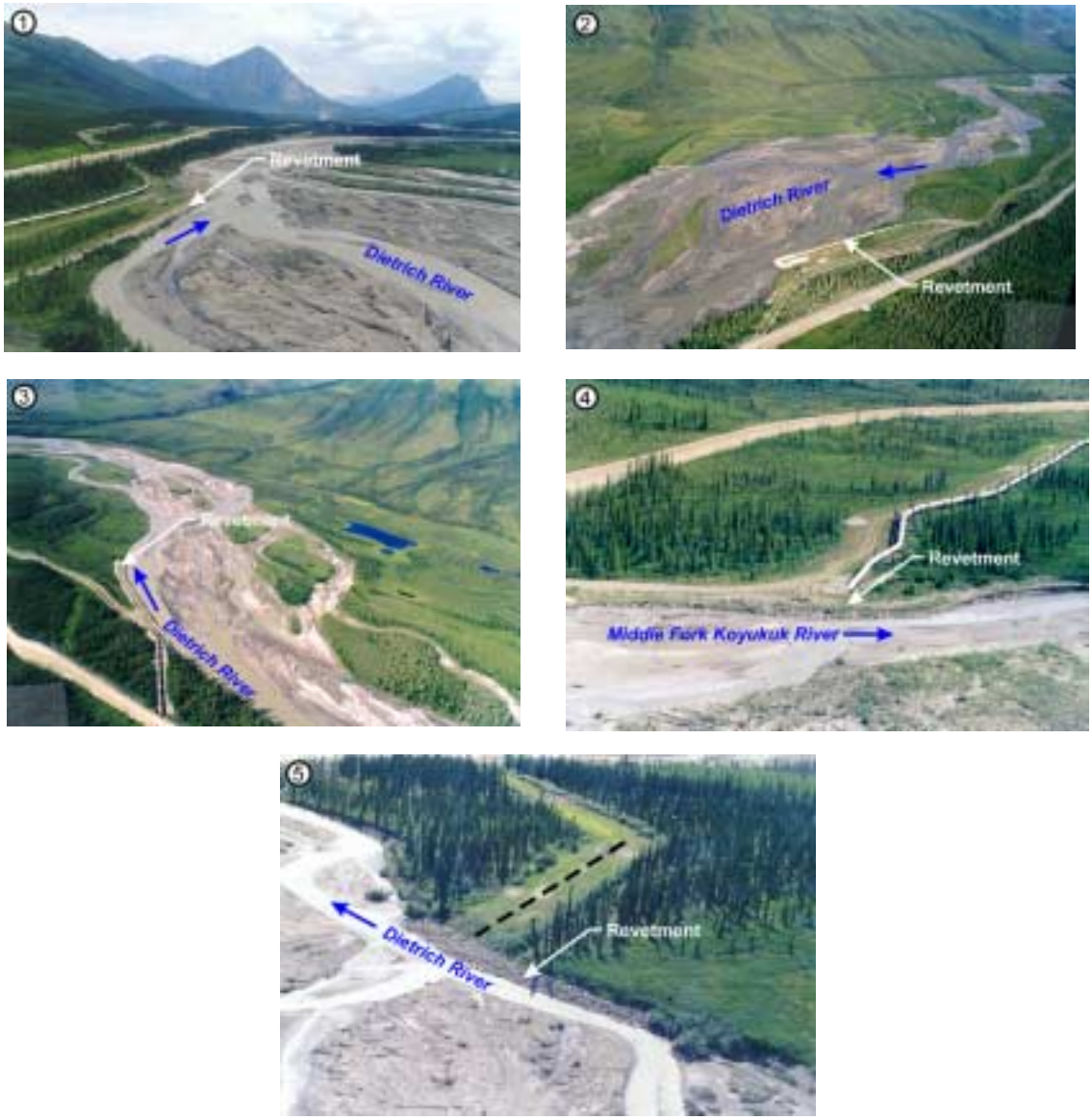
CONCLUSION: Spurs are effective means to deflect the main channel flow away from the pipeline or to minimize the formation of new channels. As they are only used on wide braided rivers, they have little effect on the overall behavior of the rivers.

Figure 4.3-8. *Spurs to deflect main channel flow from the pipeline.*

Armoring around valve sites and along the workpad is required at times. Protection of valve pads is key to their safe operation, but the need for and timing of access via a workpad depends on the valve type and the operational mode of the pipeline. Check valves with a manual actuator need little or no vehicle access or maintenance — the valves need to be open with the present throughput rate to allow the passage of pigs without damage. The nitrogen needed to operate powered actuators is delivered by vehicles, thus necessitating a workpad or other route that is passable by truck. Remote gate valves also rely on periodic vehicular access. Photos 1 and 2 show CKV 29A in the Atigun River floodplain. The valve site is well protected from the river; however, the workpad requires periodic maintenance. Just to the south of this location, CKV 30 (Photo 3) is located in the narrower part of the Atigun River as it emanates from the north face of Atigun Pass. The valve site, replaced in 1991 as part of the Atigun River mainline replacement project, is well protected from the river. At RGV 34 (MP 185.8, Photos 4 and 5), adjacent to the Dietrich River, high flows in June 1998 and resultant bank erosion required immediate riprap placement (Photo 5), which was then upgraded during the 1998-1999 winter.

CONCLUSION: Valve sites are key components of the pipeline and need to be well protected from rivers. Surface access to the valve sites, and thus the need to protect the workpad from the river, may be more or less critical depending on the type of valve and the operational state of the pipeline.

Figure 4.3-9. *Armoring at valve sites.*



Various types of river training structures are used to protect mode transitions and elevated lines. At MP 200.0 (the section rerouted and remoded out of the river), a riprapped revetment is used to protect the elevated line prior to it leaving the Dietrich River floodplain area (Photos 1 and 2). At the downstream end of the realignment, the bank is armored to protect the elevated line where is re-enters the floodplain and is close to the main channel (Photo 3). At the Middle Fork Koyukuk River crossing (MP 208.5, Photo 4), a revetment is used to protect the transition to the elevated mode. In locations such as this, proximate to the river where ground conditions dictated the elevated mode, a structure was essential because setback of the buried line into the thaw unstable bank was not feasible. In the Dietrich River (MP 180.6, Photo 5), armoring of the bank was used to protect the transition to a shallow-buried line section. All the structures illustrated have a minimal impact on the behavior of the rivers because they follow the natural bank.

CONCLUSION: Structures are key to protecting elevated lines and transitions proximate to the rivers where, from a geotechnical viewpoint, deep-burial into the riverbank is not feasible.

Figure 4.3-10. *Structures that protect transitions and elevated lines.*

low buried or elevated line sections (Figure 4.3-10). The impact of revetments on flow patterns and river behavior is minor because they are constructed on, or parallel to, the existing banks.

Impact of Maintenance or Construction of New Structures. The maintenance or extension of structures or the construction of new structures is done in accordance with construction plans approved by regulatory agencies. The nature of the plans, with a focus to protecting the water quality of the adjacent rivers, varies from site to site. At the Middle Fork Koyukuk River (Figure 4.3-7), the riprap at the toe of the revetment was placed first and then a gravel driving surface was placed on top of the riprap, thus enabling the machinery to work essentially out of the flow area. Winter scheduling minimizes in-stream work on waterways such as the Dietrich and Sagavanirktok rivers, which have little or no flow in winter.

In the design and layout of all structures and maintenance works, the impact on adjacent structures or on natural vegetation and flow patterns is considered to ensure that the impact is minimal and well within the kinds of changes induced by natural river processes. The new structures will usually have a local impact. For example, the new revetment on the Middle Fork Koyukuk River (Figure 4.3-7) is expected to cause some local bank erosion at its upstream end. On the other hand, the new spurs constructed on the Sagavanirktok River at MP 47 had a more significant impact on flow patterns as the main channel shifted away from the eroding bank next to the pipeline.

Quantifying the impact of future maintenance and new works on the behavior of streams is not possible on a TAPS-wide scale. It varies from location to location depending on river characteristics and the type of remedial measures required. However, it is worth noting that:

- Spurs such as the one at MP 47 can have a significant local impact on flow, but even at this location, their impact is nominal compared to natural changes that can occur in the wide, braided Sagavanirktok River,
- The revetments along the Dietrich River and Middle Fork Koyukuk River since the major 1994 flood, and along the north bank of the Tazlina River bridge in response to the 1997 flood, were built along the post-flood bank alignments and thus had little impact on overall flow patterns.
- Along the Middle Fork Koyukuk River in the MP 243 area, the length of additional spurs, required due to channel changes induced by the 1994 flood, were significantly reduced compared to the original spurs in order to minimize their effect on vegetated islands.
- At small creeks, such as Vanish at MP 145, where high flows in 1999 resulted in significant VSM "stick-ups", it was necessary to deflect the flow into its original location. By careful layout and construction of the transitions from the armored areas back to the original banks, the impact of the works on creek behavior and flow patterns is very limited.

The scope of future maintenance needs depends primarily on the timing, location, and magnitude of high-flow events. The record, widely distributed floods on the Sagavanirktok River and Middle Fork Koyukuk River systems in 1992 and 1994, respectively, and the required response/maintenance plans, are probably representative of the scope of major maintenance initiatives that could be required in the future if record to near-record floods occurred. Work will likely be required at a number of locations along the Middle Fork Koyukuk River in the future where pronounced, well developed channel bends are moving towards the pipeline. (The movement of these bends is being closely monitored in order to be able to implement remedial measures, if and when necessary, in a timely and sound manner.) Future channel changes and possible additional works that might be required along the Sagavanirktok River are more difficult to estimate as the multi-channeled braided nature of this river causes predictions to be largely speculative in nature. Dramatic and rare events such as the simultaneous release of the glacier dammed lakes in the Tazlina River watershed, which required armoring of the north bank in 1998-99 after no maintenance needs at all for more than 20 years, are difficult to predict with accuracy.

4.3.1.2 Water Resources

By B. Jokela, V. Gates, D. Gryder-Boutet

Water Use in Pipeline Operations

Pipeline operations require fresh water for potable water for manned facilities, equipment washing, dust abatement on roadways and pads, and hydrostatic testing.

The Alaska Department of Natural Resources regulates use of Alaska's water resources and issues permits for temporary or long-term water appropriations. Alyeska has certificates of appropriation for water use at permanent facilities, including each pump station except Pump Stations 1 and 6. Water used at Pump Station 1 is purchased from the North Slope Borough's Service Area 10 water utility. A well at 5-Mile Camp is used as a water source for Pump Station 6, for which water is trucked across the Yukon River Bridge. Each active pump station typically consumes between 4,500 and 7,500 gallons a day, mostly for domestic uses. Volumes of camp water use at various facilities is illustrated in Figure 4.3-11.

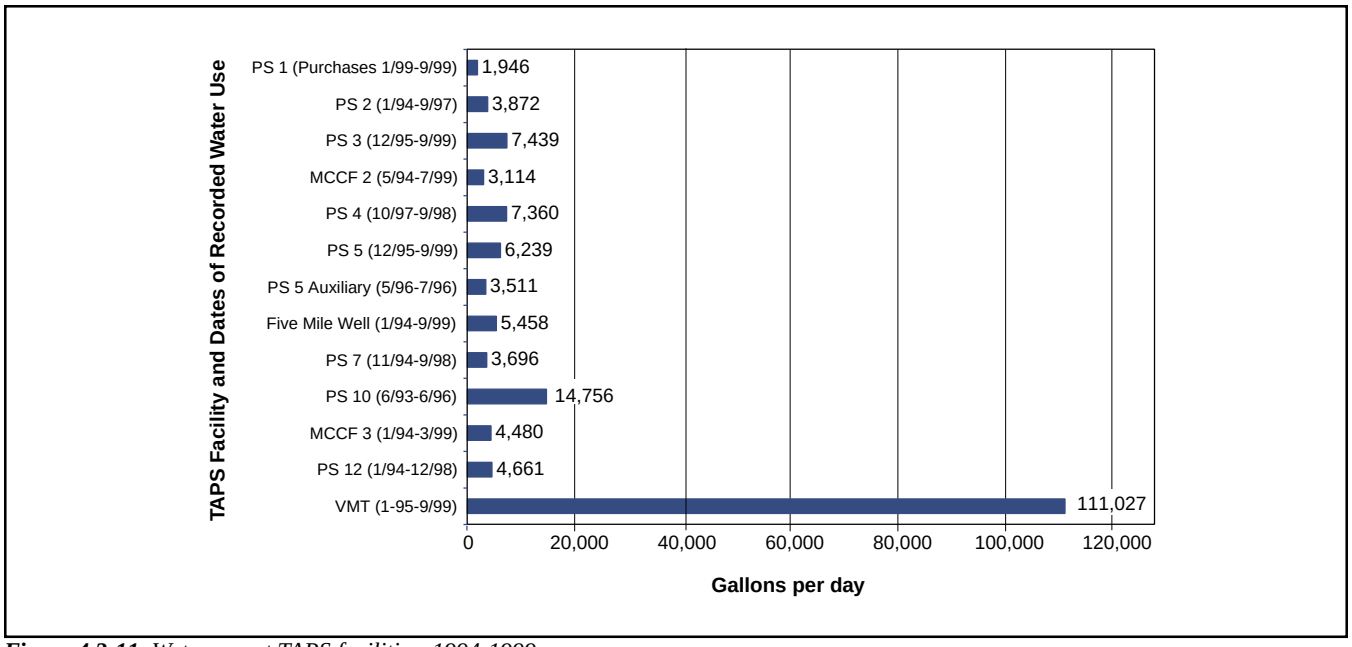


Figure 4.3-11. *Water use at TAPS facilities, 1994-1999.*

The VMT, which uses significantly more water than other facilities, has a certificate of appropriation for withdrawals from Allison Creek. Since October, 1995, average water withdrawals under this appropriation have amounted to over 111,000 gallons per day. Industrial water uses at VMT include power-plant boiler-water, stack-scrubber systems, steam-cleaning of equipment racks, and other washdown processes.

Alyeska maintains additional temporary water-use permits for facilities such as mobile construction contingency facilities (MCCFs) and for special projects. Volumes of water for temporary use vary significantly. The largest single project for which temporary-water-use permitting was necessary occurred in 1997, when 7.4 million gallons were withdrawn from East Lake, near MP 0), for tank cleaning and testing at Pump Station 1.

Potable Water Use

Where living quarters are provided, personnel on duty typically consume and discharge up to 100 gallons of water per person per day for potable water use (i.e., drinking water, food preparation, and personal hygiene). At the pump stations and camps, potable water is generally supplied by local wells built and maintained by Alyeska for that purpose. Pump Stations 1, 8, and 9 do not maintain living quarters for workers, due to their proximity to local communities or other facilities, and potable water use is much less there. Currently, only Pump Stations 1, 3, 4, 5, 7, 9, and 12 are in use, further diminishing total water use. As additional pump stations are ramped down, water use will be diminished or discontinued at those stations as well.

The Valdez Marine Terminal operates continually with a staff of up to 550 people. No living quarters are provided for the staff at the terminal. Most reside in Valdez and use municipal water supplies as a principal source of potable water. As a result, potable water use at the terminal is generally less than 25 gallons per person per day.

Industrial Water Use

Water use for industrial cooling or process needs at the active pump stations is insignificant. Water is used occasionally for washdown of equipment, such as vehicles, turbine fans, and other equipment which is exposed to the environment. Some washwater is routinely contained and collected for co-processing with sanitary wastewater. Other waters are discharged onto the workpad, in accordance with the line-wide NPDES permit (No. AK-005056-3) and best management practices (BMPs). Due to the occasional nature and small volumes of wastewaters, no adverse effects on receiving water quality are apparent or have been reported for permitted discharges.

Sanitary Discharges from Pump Stations and MCCFs

Discharges of sanitary wastewater take place in accordance with state and federal permits, including U.S. EPA (NPDES) permits. Table 4.3-1 summarizes typical sanitary discharges from pump stations and MCCFs. These are treated by various means.

In permafrost areas, discharge to groundwater is imprac-

ticable, and long-term discharge of wastewaters across tundra is viewed as increasing potential for thermal erosion. Only Pump Station 5 has ongoing discharge of sanitary wastewater to tundra wetlands. For years, this facility was served by a lagoon system. Wastewater was contained and treated via facultative biological decomposition, with discharge to tundra wetlands. In 1999, the lagoon system was upgraded to conventional aerobic secondary treatment using a small mechanically activated sludge plant. Discharge from this process is distributed through a diffuse outfall across tundra wetlands.

At Pump Stations 1, 3, and 4, sanitary wastewater is screened using a fine-mesh rotary strainer. The screened wastewater is stored in a holding tank and then pumped to the exhaust stacks of the engines powering the crude oil pumps. High-pressure nozzles inject the wastewater into the hot exhaust flow, where it is atomized and evaporated. Any remaining organic material dissolved in the liquid stream is volatilized and disinfected in the hot exhaust. The exhaust-gas flow disperses the relatively small volume of sterilized water vapor into the atmosphere. In order to ensure that full dispersal takes place, Alyeska has established operating procedures in conjunction with ADEC (APSC, 1997d). Sewage injection can commence only when reaction turbines are running at least 2,350 revolutions per minutes (rpm) and exhaust gas temperatures exceed 750ºF. Air is injected in conjunction with the wastewater flow at a minimum pressure of 70 pounds per square inch gauge (psig), and liquid pressure is continuously monitored to ensure appropriate atomization. Nozzles are inspected regu-

Table 4.3-1. *Summary of wastewater discharges from pump stations and MCCFs.*

Pump Station or Camp	Status	Dates of Operation	Permanent Living Quarters	Current Population (a)	Historic Maximum Population	Typical Flow (gpd) (b)	Design Capacity (gpd) (b)	Current Wastewater Disposal	Previous Treatment
1	Open	1977-present	No	50 day-use	60	2,000 (d)	10,000 (c)	Stack injection	—
2	Ramped down 1996	1979-97	Yes	0	40	4,00 (d)	10,000 (c)	Not in use	Stack injection
3	Open	1977-present	Yes	45	45	7,500 (d)	10,000 (c)	Stack injection	—
MCCF #2	Inactive	Various	N/A	0	Up to 80	2,900 (d)	14,000	Secondary biological	—
4	Open	1977-present	Yes	40	45	4,700 (b)	10,000 (c)	Stack injection	—
5	Relief only - no pumps	1977-present	Yes	60	80	6,300 (e)	8,000	Secondary Biological	Lagoon
6	Ramped down 1997	1977-97	Yes	0	100	6,500 (b)	6,000 (b)	Not in use	Stack injection
Fly Camp at PS 6	Open	1998-present	Yes	16	16	950 (d)	850	Septic	—
7	Open	1980-present	Yes	30	30	3,800 (b)	3,400 (b)	Septic	—
8	Ramped down 1997	1977- 97	No	0	20 day-use	600	1,000	Septic	—
9	Open	1977-present	No	25 day-use	30 day-use	780 (b)	1,000 (b)	Septic	—
10	Ramped down 1997	1977-97	Yes	0	38	4,200 (b)	12,000 (b)	Septic	—
MCCF#3	Inactive	Various	N/A	0	Up to 80	3,500(e)	14,000	Secondary biological	—
11	Never constructed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	—
12	Open	1977-present	Yes	35	90	4,200 (b)	9,100 (b)	Septic	—

(a) Gryder-Boutet (1999).
(b) Mikkelsen (1997).
(c) Based on twin-nozzle injection into 850°F exhaust-gas temperature
(d) Estimated from water-use records and water-purchase records
(e) Based on NPDES discharge monitoring reports

gpd = gallons per day
N/A = Not applicable

larly and replaced as needed. Screenings are incinerated at each pump station. Periodically, holding tank sludge is trucked away for disposal to a private wastewater utilities off the pipeline corridor, thereby eliminating local sanitary discharges to surface or groundwater at these facilities. If injection is impractical because of maintenance or inadequate exhaust gas temperatures, wastewater would be trucked to a remote permitted disposal facility.

Sanitary wastewater at Pump Stations 7 through 12 is treated through conventional septic treatment systems. These systems are serviced regularly to maintain appropriate septage levels for waste treatment.

Each MCCF has a self-contained sanitary wastewater secondary treatment system that uses rotating biological contactor technology and a holding tank. Treated wastewater from each site is discharged locally in accordance with the line-wide NPDES permit.

Disposal of Other Wastewater Discharges

Direct discharge of sanitary wastewater, washwaters, hydrotest waters, or stormwater and snowmelt to surface water is uncommon. The linewide NPDES discharge permit specifies rules for discharge of sanitary wastewater, hydrotest waters, and excavation dewatering. In applying for a renewal of that permit in 1998, Alyeska inventoried all kinds of wastewater discharges from normal operation (Table 4.3-2). Wherever possible, discharge to dry channels, tundra, or upland areas is preferred to discharge to surface waters.

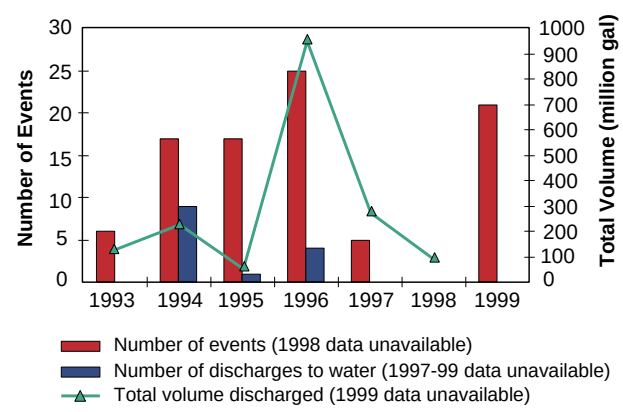
Hydrotesting. Hydrostatic testing is performed on segments of pipe or on tankage brought into service following installation or repair to ensure that construction is soundproof and leakproof. Hydrostatic testing occurs infrequently. The maximum annual volume of water for hydrostatic testing was 3.8 million gallons in 1991 when over 8 miles of pipeline were reconstructed to improve the stability of the pipeline in the Atigun River valley. Water from hydrostatic testing is discharged in accordance with the line-wide NPDES permit, which mandates laboratory characterization, documentation, and erosion protection requirements for the discharge.

Excavation Dewatering. From time to time, excavation of buried pipeline segments is required to confirm pipeline pig findings or other test data. Where groundwater is encountered during maintenance digs, the water must be removed and discharged away from the trench. Dewatering is performed in a manner that permits safe working conditions within the trench, allows for unhindered examination of the portion of the pipeline in question, and poses no significant environmental concerns.

Dewatering discharge has been regulated through various permits, beginning with a State of Alaska wastewater discharge permit since 1983. The current NPDES permit requires notification, volume estimates, and descriptions of procedures employed to minimize erosion and discharge of pollutants from excavation dewatering. Dewatering data for discharges greater than 500,000 gallons has been collected since 1993 (Figure 4.3-12).

Draining of Secondary Containment Dikes. Secondary containment structures at pump stations and the VMT may trap snowmelt and rainwater. The structures must be drained periodically to ensure that the full capacity of the secondary containment systems is maintained. Snowmelt and rainwater removed from the containment systems is typically unaffected by contact with the tanks and containment structures. Dewatering of secondary containment of waters is allowed by State of Alaska Wastewater General Permit 9640-DB004, which established monitoring requirements and effluent limitations. To guard against discharge of pollutants, the discharge is visually inspected for sheen. No discharge of waters bearing hydrocarbon sheen is allowed by the general permit.

In 1997, over 60 different secondary containment structures along the pipeline were drained. There were 297 occasions for dewatering, including over a dozen repeat visits to a few stations. Total water drained was 15,678,000 gallons. Over two-thirds of the volume came from early summer dewatering of the tank farm at Pump Station 1, where the secondary containment volume is highest. At the VMT, discharge from secondary containment structures is di-



Compiled from APSC (various years): dewatering records and discharge monitoring reports, 1993-1999.

Figure 4.3-12. *Discharges from excavation dewatering.*

Table 4.3-2. *Discharges addressed in 1998 line-wide NPDES permit application.*

Out-fall	Category	Sources	Discharge Volumes	Discharge to	Active Dates	Treatment
001	Excavation Dewatering	Maintenance of buried pipeline	380 gpd to 21 MMgpd	Varies; upland discharge preferred	Varies — <1 day to 120 days	BMP, erosion control, infiltration
002	Hydrostatic Testing	Leak testing of new or repaired pipelines and tankage	Varies — 1996/7: 7,800,000 gal/yr	Dry channel, snow	Varies — 3 days per event typical	BMP, erosion control, infiltration
003	Sanitary Wastewater	Pump Stations 5, 6	6,000 gpd	Tundra wetland	varies	Secondary biological
		MCCFs	14,000 gpd ea			
004	Secondary Containment Dewatering	Tank farms	4,000,000 gal/yr	PS workpad	Seasonal, site-dependent, intermittent	BMP, sorbent used if sheen noted
		Valve vaults	500,000 gal/yr			
		Basements	50,000 gal/yr			
		Leading edge flow meters	30,000,000 gal/yr			
		Fuel loading areas	10,000 gal/yr			
005	Potentially Containing Oil	Petroleum product spill	500,000 gal/yr	Facility workpad	Seasonal, site-dependent, intermittent	BMP
		PS air filter cleaning	20,000 gal/yr			
		Monitoring well purging	100 gal/event			
		Pump test water	300-900 gal/event			
		PS mop water	50,000 gal/yr			
		PS meltwater	10,000 gal/yr			
		PS equip. shop meltwater	10,000 gal/yr			
		PS accumulated rain water	1-500 gal/event			
		Vacuum truck hydrotest	25,000 gal/yr			
006	Containing Particulates	Outdoor vehicle washing	10,000 gal/yr	PS workpad	Seasonal, site-dependent, intermittent	BMP
		Indoor vehicle washing	10,000 gal/yr			
		Equip./structure washing	100-3,000 gal/event			
007	Containing Chlorine	Water truck disinfection	2,000-4,000 gal/event	Facility workpad	Seasonal, site-dependent, intermittent	BMP
		Drinking water facility disinfection	1-500 gal/event			
008	Containing Residual Aqueous Film-Forming Foam	Fire line flushing	100,000 gal/yr	PS workpad	Seasonal, site-dependent, intermittent	BMP
		Fire truck flushing	3,000 gal/event	Airport taxiway		
		Fire training	2,000 gal/yr			

BMP = Best management practice

rected to the Ballast Water Treatment Facility.

Stormwater Runoff. Currently, only 11 facilities meet the applicability criteria of the EPA Storm Water Multi-Sector General NPDES Permit for Industrial Activities (MSGP) and have the potential to affect waters. Alyeska operates the sites in conformance with the MSGP standards. The affected sites are all material sites which may discharge rainwater or snowmelt from mined areas to surface waters. No monitoring data are yet available, as sites have not been accessible by Alyeska personnel during runoff events since commencement of coverage under the MSGP.

Construction activities that disturb more than 5 acres, do not involve excavation dewatering, and have the potential to impact waters of the U.S. are covered under the NPDES Permit for Storm Water Discharge from Construction Activities Associated with Industrial Activity (Permit No. AK-R-10-0000). For TAPS projects that meet criteria for coverage under this permit, specific notices of intent are submitted to EPA and regulations are adhered to.

Discharges from Valdez Marine Terminal

Two outfalls at the VMT are covered by NPDES permit No. AK-002324-8. The VMT sewage treatment plant is

authorized to treat 10,000 gallons per day of sanitary wastewater from the Western Operations Area of the VMT. Treated wastewater is discharged into Port Valdez. Additional sanitary wastes from the Eastern Operations Area are processed through a septic treatment system.

The other outfall addressed in the NPDES permit is from the Ballast Water Treatment Facility, which processes ballast water offloaded from incoming tankers and a variety of waste streams collected in the VMT industrial wastewater sewer system (IWSS). Process wastewater, potentially contaminated stormwaters, oily washdown water, filter backwash, bilge waters, and oil spill wastewaters contribute to IWSS flows. Sewers and containment systems have been designed to collect surface runoff from rainfall of 5.1 inches in a 24-hour period. Areas served by IWSS include the following:

- Tank farms.
- Power generation/vapor recovery.
- Fuel storage and loading area.
- Emergency response building/administration area (including laboratory).
- Fire training grounds.
- Sludge tank area.
- Transformer dike areas.
- Tanker berths.
- Fire pump buildings.
- West metering facilities.
- Maintenance/warehouse area.
- SERVS and SERVS contract vessels.

A detailed description of the IWSS is found in the *Oily Water Sewer Manual, Alyeska Marine Terminal* (OW-44). Approximately 93 percent of the wastewater processed by the BWTF is tanker ballast and bilge water.

Tanker Ballast Water. Tankers use seawater for ballast to maintain stability when not carrying cargo. Ballast water carried in clean tanks (segregated ballast) is discharged without treatment. The primary concern with the segregated ballast discharge is the introduction of non-indigenous species (see Section 4.12). Significant quantities of ballast water are carried in the "dirty" cargo tanks. This ballast water contains contaminants and is offloaded at the VMT and treated in the BWTF. The treated water is then discharged to the marine waters of Port Valdez through an outfall pipe to a 63-meter-long diffuser which ranges from 62 to 82 meters in depth.

The BWTF is designed to treat up to 30 million gallons/day of oily ballast water and small amounts of industrial wastewater from VMT maintenance activities. Treatment occurs through three processes:

1. Gravity separation,
2. Dissolved-air flotation (DAF), and
3. Biological treatment.

Figure 4.3-13 provides a simplified schematic of the BWTF. The entire BWTF is controlled by a computerized supervisory control and data acquisition (SCADA) system located in a centralized control room.

Ballast water and other influent wastewaters are pumped from their sources to one of the three 18-million-gallon ballast-water storage tanks, known as the *90's Tanks*. In addition to influent storage, the 90's Tanks provide calm conditions for gravity separation. The tanks are 250 feet in diameter and fill height is 49.5 feet. Pressure from the fluid level in the tanks provides energy to drive wastewater flow through the remainder of the treatment system.

Settling in the 90's Tanks typically occurs for a minimum of four hours, during which the tank is closed to further influent that may disturb the separation process. Oils and emulsions that migrate to the top of the liquid are skimmed and directed to the smaller 100-foot-diameter oil recovery tanks — known as the *80's Tanks* — for further processing by gravity separation. Oil skimmed from the 80's Tanks is returned to the crude oil stream.

Metering pumps are used to inject a polymer into the discharge line from the 90's Tanks to assist in accumulation of oil and other contaminant particles through an electrochemical association called *flocculation*. Groups of aggregated particles called *flocs* are more amenable to separation from the water in the DAF cells due to enhanced buoyancy and reduced surface tension.

Six DAF cells form the second level of treatment for oily wastewater in the BWTF. Each DAF cell is a concrete channel 24 feet wide, 112 feet long, and 12 feet deep. A recycled stream of process water is exposed to high-pressure air in pressure-retention tanks packed with a plastic material that provides a very large surface area to expose the flowing water to the air. As a result, the high-pressure air is forced into solution with the flowing wastewater. Upon mixing with the main flow of wastewater, the water is released to normal pressure. Air comes out of solution in tiny bubbles which attach to oil and floc particles in the wastewater stream and rise to the surface, where they are skimmed and directed to the 80's Tanks for oil recovery. Water is pumped from the DAF outlet channel to the pressure-retention tanks for recycling through the DAF process.

When originally built in 1976, the BWTF employed only gravity separation and DAF processes to remove oil before discharging the saline ballast water to Port Valdez. While this system achieved its original purpose, the waste discharge limitations imposed on the BWTF in the NPDES permit were later revised to include a limit on BTEX.

Alyeska responded to this revision by adding biological oxidation as a third tier of the treatment train in 1989.

Currently, wastewater discharged from the DAF cells is enriched with nutrients (phosphate and ammonia-nitrogen) which promote the growth of organisms that consume any remaining dissolved oils and aromatic hydrocarbons. The process is further enhanced by jet aeration and mixing in two parallel biological treatment tanks (BTTs). Water pumped through a header is aerated by a jet from a parallel air header at a pressure near atmospheric.

Microbial floc materials generated in the BTT are skimmed and redirected to the 80's Tanks. Underflow from the skimming systems is discharged through a baffle and weir system to a submarine outfall in Port Valdez. Temperature, BTEX, and oxygen are continuously monitored to ensure complete treatment. To provide supplemental removal of BTEX when biological upsets occur, a polishing air stripper was installed downstream of the BTTs to remove occasional elevated levels of BTEX before they reach the effluent.

Sludges accumulate in the bottom of the BWTF — mostly in the 90's Tanks, the DAF cells, and the BTTs. Sludges of similar composition also accumulate in sumps and portions of the industrial wastewater sewer system. Normal maintenance requires periodic cleaning of the BWTF tanks, and a separate sludge tank is maintained at the BWTF for such residues. Recovered oil from the sludge tank may be trucked directly to the 80's Tanks or via the

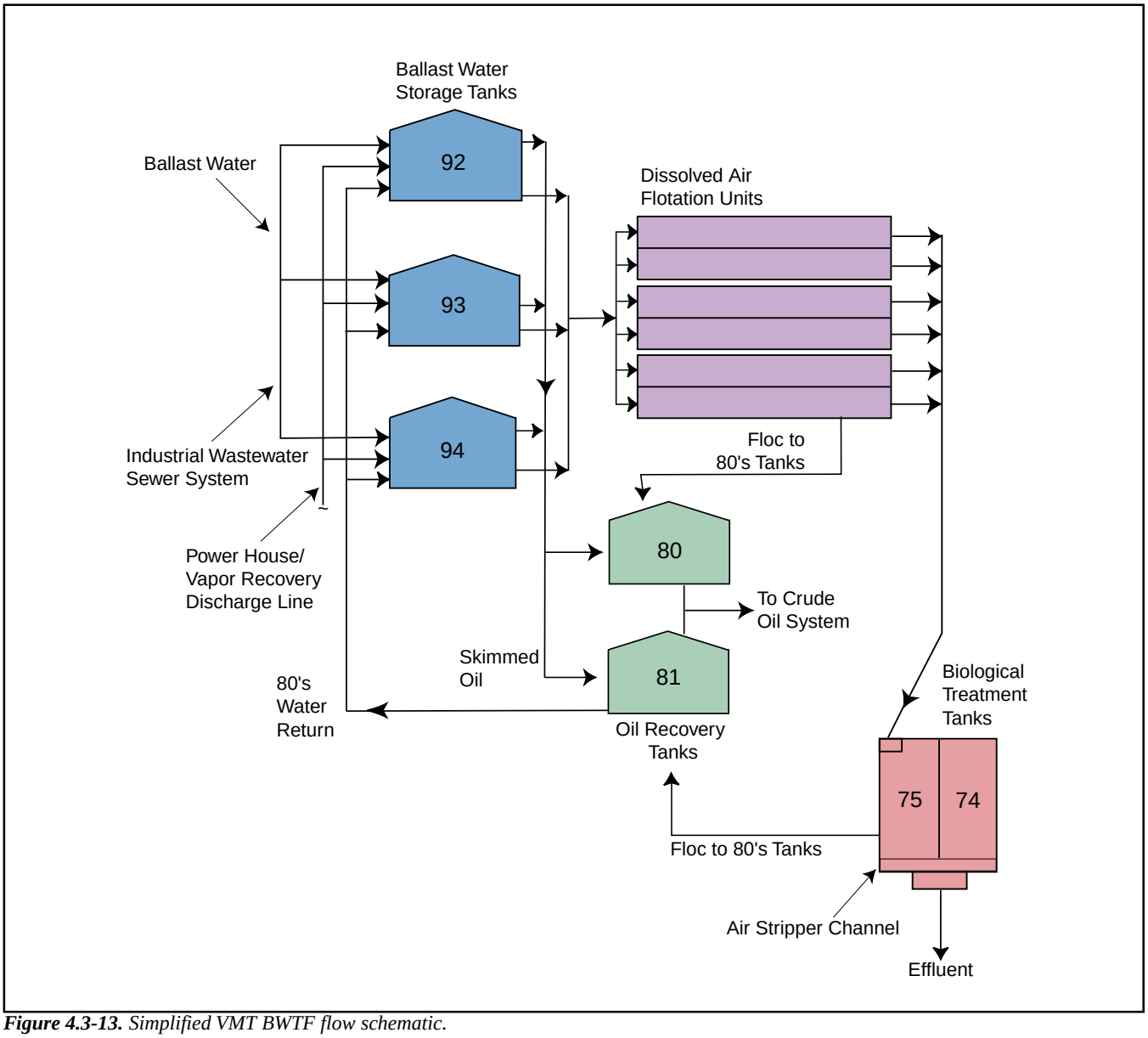


Figure 4.3-13. *Simplified VMT BWTF flow schematic.*

DAF sumps. Process solids from the sludge tank are transported in accordance with state and federal regulations for disposal off site. The BWTF operates under a NPDES permit issued by EPA and certified by ADEC. The original permit was issued in 1974 and has been renewed three times (1980, 1989 and 1997). Significant improvements have been made to the original BWTF to continue to meet effluent limits that have become increasingly stringent over the years.

In addition to certifying the NPDES permit, the ADEC has authorized a mixing zone for the BWTF effluent discharge (APSC, 1995c). The approved mixing zone is in accordance with the water quality standards and was reviewed and concurred with by all relevant state agencies before it was granted. It actually consists of two zones, a small acute zone near the diffuser and a larger chronic zone. Chronic criteria concentrations of target pollutants (derived from tests of the response of marine biota to various concentrations of pollutants) may be exceeded inside the mixing zone. Criteria maximum concentrations (acute exposure criteria) may be exceeded within the acute mixing zone provided that passing organisms will not encounter lethal exposure levels. A human-health risk assessment was part of the referenced mixing zone application.

The BWTF is permitted to treat up to 30 million gallons per day (MMgd) of oily ballast water and industrial wastewater derived from terminal maintenance activities. Typically, the BWTF discharges about 14.5 MMgd of treated water.

Effluent and Environmental Monitoring. Extensive monitoring is required by the VMT NPDES permit to document pollutants discharged through the diffuser and their effects on Port Valdez. Figure 4.3-14 depicts average annual BWTF discharges, as well as concentrations of total suspended solids (TSS) and total aromatic hydrocarbons (BTEX). Figure 4.3-14 also shows the addition of more stringent TSS and BTEX effluent limitations over time, with each re-issuance of the NPDES permit. A more complete summary of the effluent monitoring (including effluent toxicity testing) is included in the mixing zone application (APSC, 1995c).

The effect of treatment improvements is evident from the time series of BTEX. Monitoring of BTEX began in the early 1980s. Biological treatment was added to the process for BTEX removal. A major upgrade of process units was completed in March, 1991. Today, due to continuous process refinements, discharged BTEX is typically less than 0.02 milligrams per liter (mg/l).

Near-field (mixing zone) and far-field monitoring is performed to demonstrate effects of the discharge on marine sediments and benthos. These studies have been conducted by the University of Alaska, Institute of Marine Sciences and are reported to the EPA and the ADEC (see Shaw et al., 1999). Additionally, numerous special studies have been conducted to document the impact of BWTF discharge on the marine environment of Port Valdez.

Since the mid-1990s, the Ballast Water Treatment Working Group has reviewed these annual reports as well as other issues regarding the BWTF. This group is composed of representatives of the ADEC, EPA, Prince William Sound Regional Citizens Advisory Council, National Marine Fisheries Service, and Alyeska.

Impacts of Continued Operations

Continued operation of TAPS for the proposed renewal period will require continued use of water resources to support operations and maintenance activities. Wastewaters will continue to be treated, discharged, and assimilated by upland and freshwater receiving environments along the pipeline. Marine waters of Port Valdez will continue to be used to assimilate treated discharges from the VMT, including sanitary wastewater and ballast water.

Water Use and Sanitary Discharge at Pump Stations and MCCFs. As throughput of oil declines, ramping down of additional pump stations will mean reductions in staff at pump stations that are placed on standby. Furthermore, automation of certain operations will allow reduction of field crews at other sites.

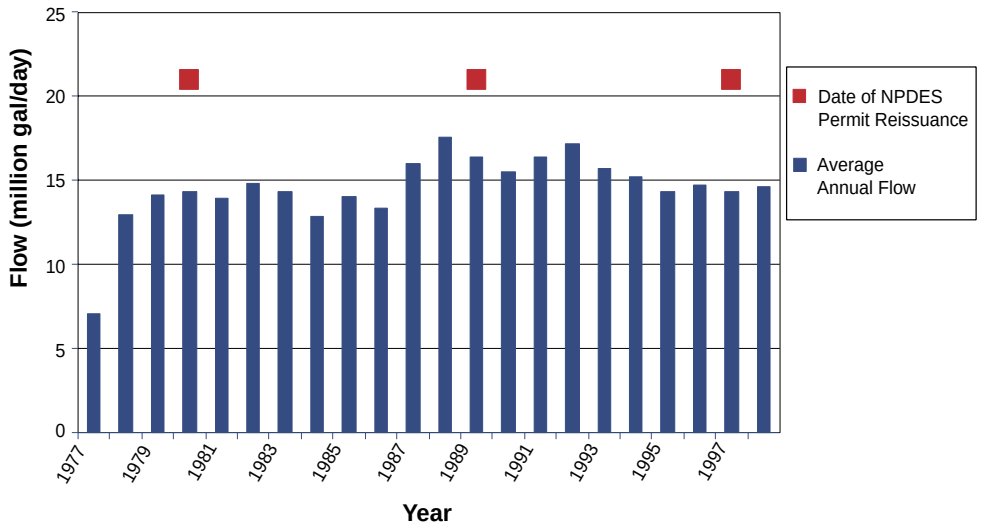
Reductions in staffing at the pump stations and camp facilities will result in a parallel drop in domestic water use for drinking water and sanitation at each facility.

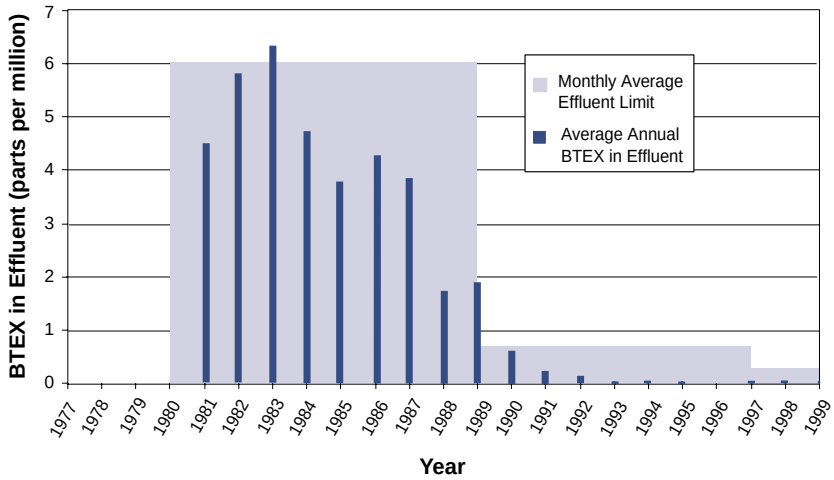
Wastewater injection into stacks at Pump Stations 1, 3, and 4 requires sufficient stack temperatures to ensure vaporization, volatilization, and disinfection of the wastewater plant effluents. Reduced throughput may affect the temperatures of pump engine exhaust, necessitating use of alternative means for wastewater disposal, such as package treatment plants.

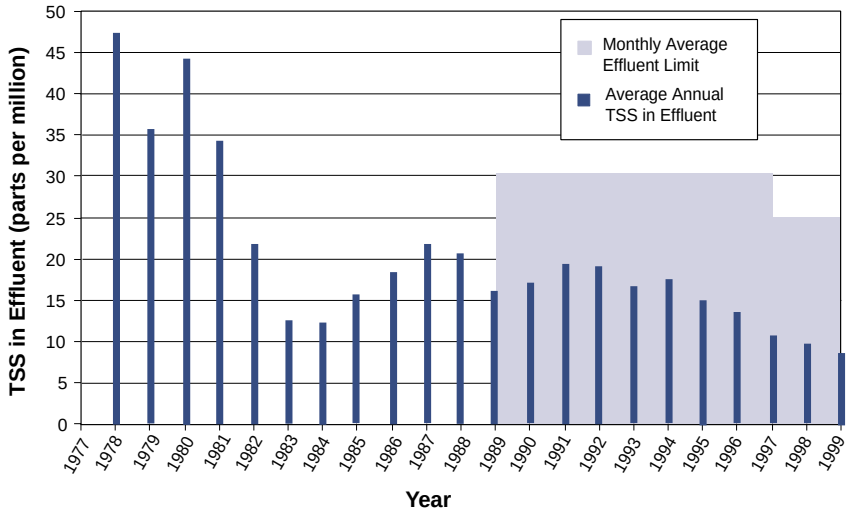
Secondary biological sewage treatment and effluent disposal to wetlands are expected to continue for the MCCFs and Pump Stations 5 and 6 (when the permanent living quarters are active) in accordance with discharge limitations imposed by state and federal permits. Permitted discharges are expected to be assimilated by local water resources with no significant effect on productivity or viability of aquatic ecosystems.

The septic systems leachfields at Pump Stations 7, 9, and 12 will be nearing their typical useful life in the next decade and will be replaced if necessary.

Industrial Water Use and Discharges. In addition to







Source: NPDES permit discharge monitoring reports (APSC, 1977-present)

Figure 4.3-14. *Annual flow and levels of BTEX and TSS for VMT treated ballast water discharges.*

the pump station and camp domestic-water needs, water will continue to be used for a variety of industrial activities. Industrial water needs are usually associated with intermittent and temporary activities, and are likely to have a wide variance from the average projected use. Table 4.3-2 illustrates projected discharges from various industrial uses, as described in the linewide NPDES permit renewal application (APSC, 1998a). The permit reflecting these discharges is yet to be re-issued; the previous permit is being enforced by administrative extension.

Discharges will continue to be generated from dewatering of excavations. Maintenance digs may occur for:

- Follow-up investigations from corrosion pig data analysis,
- Mainline valve inspections,
- Mainline cathodic-protection monitoring and remediation,
- Maintenance of existing river-training structures and the addition of new structures, or
- Maintenance and repair of the fuel gas line.

Estimates of the number of excavations, the extent of each, and the prospects for encountering groundwater are uncertain. Based on the history of dewatering to date, Alyeska estimates that approximately two sites per year will need dewatering in excess of the NPDES reporting requirement of 500,000 gallons (see Section 4.1.1.1).

Excavations typically take place in winter to minimize the potential for groundwater handling. The effects of dewatering can be minimized by discharging to vegetated areas or dry channel beds to avoid impacts to surface water. The effects of discharge on nearby surface waters depend on the rate and temperature of the discharge; on the slope, roughness, permeability, temperature, and moisture content of the receiving surface; and on the presence or absence of ice and snow. Water discharged onto a snowy surface in winter will freeze readily if atomized (as in a snow-making operation) or if allowed to spread out over a broad area. Assuming that water is allowed to freeze as a one-inch-thick sheet of ice over existing frozen ground, one million gallons of water will cover approximately 40 acres.

Currently, only 11 of the material sites identified along TAPS are subject to coverage under the MSGP for industrial stormwater discharge. New sites or expansions of existing sites may be located and/or developed in response to particular future project needs. Design of a mining or quarrying plan for each site will require submittal of a stormwater pollution prevention plan to ADEC and will entail development only in conjunction with implementation of BMPs for stormwater pollution prevention. Effects of stormwater runoff into waters along the pipeline route are not significant, because such runoff carries no introduced pollutants and results only in transient increases in sediment load.

Discharges to Port Valdez. Treated ballast water will continue to be discharged from the VMT into Port Valdez throughout the renewal period. Although OPA 90 requires phasing out of single-hull tankers by January 1, 2015, use of double-hulled tankers will not eliminate the need to carry ballast in tanks previously containing crude oil. Clean seawater ballast will continue to be discharged directly to Port Valdez, and the BWTF will continue to treat large volumes of ballast water from the tankers.

Other oily wastewaters derived from VMT operations, as well as liquids cleaned up from spills at the VMT, will continue to be routed through the BWTF. Discharges from VMT operations currently account for approximately 1.36 MMgd of the wastewater treated and discharged by the BWTF (APSC, 1998c). These discharges will continue throughout the renewal period at approximately the same rate.

Reduced throughput of oil will reduce the number of tanker visits, and segregation of ballast water in double-hulled tankers will reduce the average volume of ballast water treated on a per tanker basis. Figure 4.3-15 compares historical and projected annual average throughput of oil to historical and projected ballast water discharge. Projected BWTF flows are based on analysis of the range of ballast water offloaded from each tanker in the existing fleet and expected changes over time as throughput declines and as double-hulled tankers gradually replace the existing fleet. Average annual BWTF discharge is expected to eventually stabilize between one-quarter and two-thirds of the current long-term historical average flow from the BWTF. Additionally, the total loading of pollutants in Port Valdez has significantly decreased due to improvements in BWTF processes that have taken place over the years, such as the installation of the biological treatment tanks, air strippers, and monitoring instrumentation, such as the on-line BTEX analyzers. The pollutant loading is expected to continue to decrease with reduced TAPS throughput.

Reduced hydraulic loadings will affect the dynamics of treatment at the BWTF by increasing the hydraulic retention time in the process units during normal operations. Longer detention times could lead to slightly higher levels of contaminant removal prior to the biological treatment processes. The reduced contaminant load going to the biological tanks, coupled with longer detention times, may require adjustments to keep the biological process viable. BWTF operators currently make adjustments for longer detention times whenever winter storms prevent tankers

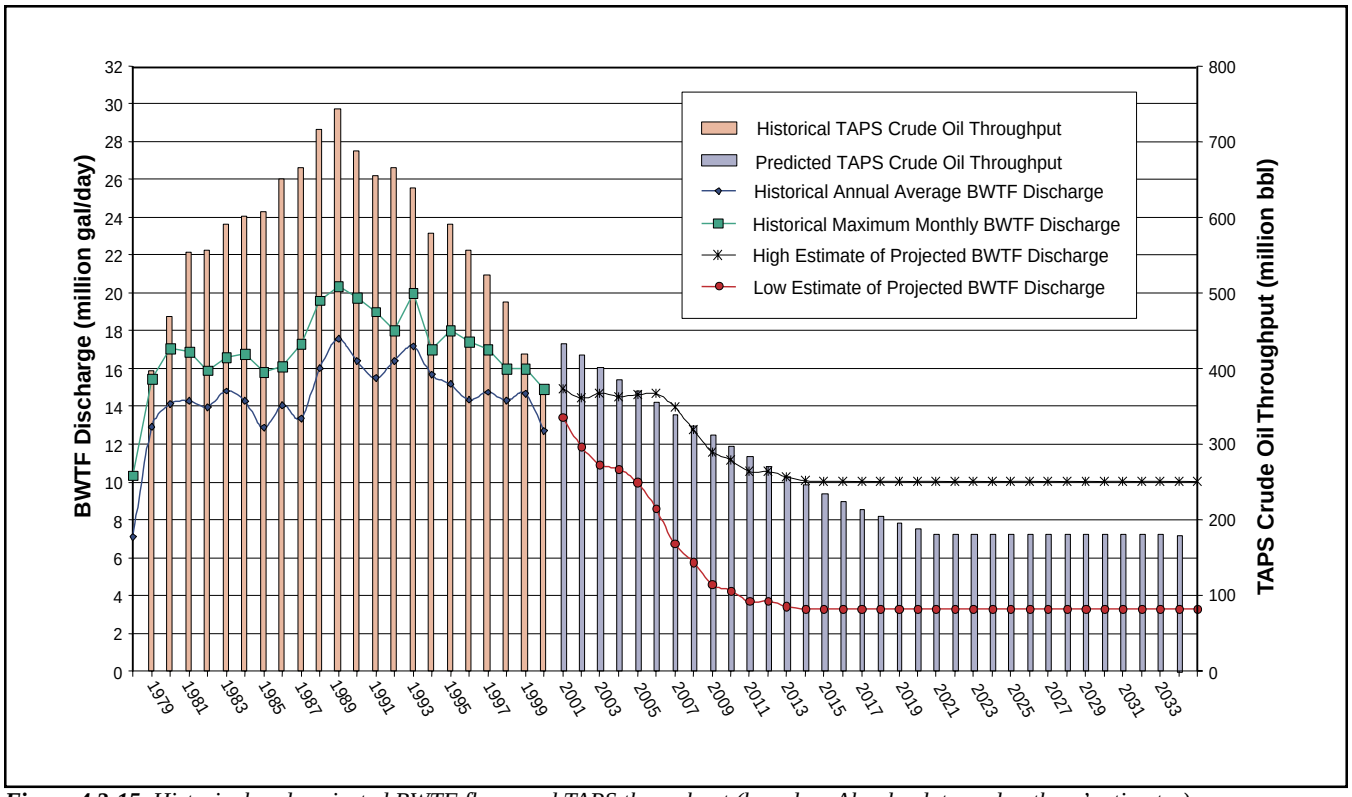


Figure 4.3-15. *Historical and projected BWTF flows and TAPS throughput (based on Alyeska data and authors' estimates).*

from entering Port Valdez. After a storm, queuing of tankers at the VMT is expected. Design maximum rates of ballast-water offloading and treatment will continue to be required, regardless of any overall reduction in flows. Alyeska has sponsored and continues to sponsor research on the response of BWTF processes on variable flows, in conjunction with the engineering faculty of the University of Alaska Anchorage (Woolard and Luetters, 1997).

The existing NPDES permit for the BWT is due for renewal in 2002. The renewed permit (and subsequent renewals) will contain the necessary limitations to ensure the BWTF effluent is in compliance with the water quality standards throughout the ROW renewal period.

No changes are envisioned for the domestic waste discharge from the VMT. The NPDES permit for its effluent will be renewed throughout the ROW renewal period.

4.3.1.3 Atmospheric Environment

By E. Haas

As TAPS throughput has steadily declined since 1989, there has been a corresponding TAPS-wide net decrease in emissions because of the reduced demand on pumping capacity (and the reduced burning of fuel). Consequently, it can be assumed that the ambient air quality impacts associated with the TAPS pump stations are no higher now and are likely lower than they were during the peak throughput years of 1988-89. Major improvements were made to the control of hydrocarbon emissions at the VMT, and no emission increases are expected beyond the 1998 post-startup levels of the tanker vapor-recovery system. The following sections discuss the impacts of TAPS emission sources on various aspects of air quality.

TAPS Emission Sources

TAPS sources emit a number of air pollutants subject to federal and state air-quality regulations. Each pump station is regulated individually as a facility with an air quality permit issued by the State of Alaska. Currently, there are ten active air-quality permits for the pump stations. Pump Station 5 has not required an air permit because the existing emission sources are below the size threshold for a permit under state regulations. No permit was issued for Pump Station 11 because the station was never built. Air quality permits are being maintained for stations in rampdown mode. The VMT has one facility air quality permit that covers all operations (APSC, 1999e). Under the state Title V permitting program, new operating permits will be issued for all existing pump stations (including Pump Station 5) and the VMT.

The equipment at Pump Stations 2 and 7 and the VMT is also subject to various Prevention of Significant Deterioration (PSD) limits under the Clean Air Act. The VMT is currently the only TAPS facility subject to air toxics requirements. Emission limits for the tanker vapor-recovery system are set by 40 CFR 63, Subpart Y.

Emission sources associated with TAPS can be categorized as stationary, mobile, or fugitive. Stationary sources include fuel-burning equipment such as the mainline turbine/pump units, booster pumps, power generation turbines, Therminol process heaters, personnel-living-quarters space heaters, diesel-fired water pumps, and solid-waste incinerators. In addition, the VMT has power boilers and vapor-recovery-system incinerators. Mobile sources include on-road equipment such as Alyeska's fleet of light trucks, as well as heavy construction equipment. In addition to these emission sources, air contaminants are also emitted from open burning at pump stations, the VMT, and along the pipeline. Fugitive-dust emissions occur from heavy equipment and vehicle traffic. Finally, emission sources also have minor fugitive emissions associated with them from equipment leaks (e.g., from valves and fittings).

TAPS stationary, mobile, and fugitive sources emit pollutants listed by federal and state air quality regulations as criteria and non-criteria pollutants. The main criteria pollutants emitted are nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), inhalable particulate matter (PM-10), and volatile organic compounds (VOCs). There are also minor amounts of lead, hydrogen sulfide (H_2S), and other reduced sulfur compounds from combustion sources. NO_x, CO, and SO_2 are the main pollutants emitted by stationary fuel-combustion equipment, as well as by mobile sources. VOCs are the primary pollutants emitted by sources such as the crude-oil breakout tanks and the BWTF. Table 4.3-3 summarizes estimated annual criteria-pollutant emissions for each pump station and the VMT.

Section 112 of the 1990 Clean Air Act Amendments published a list of non-criteria pollutants, or "air toxics." Of the listed air toxics, the following pollutants are the most prevalent in crude vapors (APSC, 1997d): xylenes, toluene, benzenes, naphthalene, hexane, and ethyl benzene.

Pump Stations. Fuel-burning equipment associated with the pump stations is listed in Tables 4.3-4 and 4.3-5, along with the other types of emission sources. The pump stations are limited by permit to burning fuel oil with a sulfur content of 0.24 percent or less. These fuel-sulfur limits are designed to limit the emissions of sulfur dioxide to the atmosphere, and emissions are reported to the agencies. Natural gas from the North Slope production facilities is provided to Pump Stations 1, 2, 3, and 4 via the fuel gas pipeline. All major fuel-burning sources at these stations use natural gas as their primary fuel. Natural gas is one of the cleanest fuels available and provides substantially lower criteria and non-criteria emissions for most pollutants than other types of fossil fuels. Fuel oil is stored at Pump Stations 2, 3, and 4 as a backup fuel in case of interruptions of the gas supply. All stations south of Pump Station 4 use No. 1 or 2 fuel oil for all combustion sources. Other fuel and emission limits apply on a source-by-source basis.

Each pump station (except Pump Station 5) has either two or three mainline turbine packages that drive either a full- or a half-head pump. Each mainline turbine unit produces up to 24,600 exhaust-gas horsepower and can run on either natural gas or oil. Units fired with natural gas at a gas generator speed of 7,900 rpm produce a 640,800 lb/hr exhaust stream (consisting primarily of carbon dioxide and water vapor) with an NO_x concentration of 74 parts per million (ppm) (corrected to 15 percent O_2). NO_x is formed primarily at high combustion temperatures. The TAPS turbines are operated at lower temperatures than newer, more

Table 4.3-3. *Potential annual air emission rates for TAPS facilities (a).*

Pollutant	PS 1	PS 2 (b)	PS 3	PS 4	PS 5 (c)	PS6 (b)	PS 7	PS 8 (b)	PS 9	PS 10 (b)	PS 12	VMT (d)	Total
Particulates	120	33	105	97	0	65	71	89	91	106	95	270	1,142
NO_x	775	608	677	626	175	487	913	1,115	1,207	1,393	1,196	1,740	10,912
CO	587	748	427	400	50	253	389	126	451	298	458	76	4,263
SO_2	39	12	44	45	65	243	373	618	581	1,765	577	1,324	5,686
VOC	28	64	12	8	n/a	18	28	41	37	46	39	3,631	3,952
TOTAL	1,549	1,465	1,265	1,176	290	1,066	1,774	1,989	2,367	3,608	2,365	7,041	25,955

(a) Calculated annual potential emission rates (tons/year) based on maximal allowable annual fuel use rates and source-test emission rates or U.S. EPA AP-42 Emission Factors.
(b) Pump stations are currently in rampdown mode.
(c) PM emission rate assumed as insignificant. VOC emission rate not available.
(d) VOC emission rate does not include loading emissions from uncontrolled berths.

***Table 4.3-4**. Permitted stationary emission sources at TAPS pump stations.*

Equipment Unit	PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	PS 7	PS 8	PS 9	PS 10	PS 12
Avon Gas Generator (Mainline Unit)	3	2*	3	3		3	2*	3	3*	3	3*
Solar Turbine Booster Pump	3										
Solar Turbine Injection Pump					2						
Solar Turbine Electric Generator	2	3	2	1	1	2	2		1	1	1
Garret Turbine Electric Generator	3		3	3	3	6		2	1	5	1
Solar Turbine Gas Compressor	2										
Detroit Diesel Electric Generators		1	3			3	1			5	
Eclipse Therminol Heater	3		2	2	2	2		2	2	2	2
Broach Compressor Module Heater	1										
Carotek Heater		2					2				
Weils McClain/Burnham Boiler			2								
PLQ Heater	2			1	2						
Topping Unit Crude (Born) Heater						1		1		1	
Topping Unit Flare Stack						1		1		1	
Therm-Tec Solid Waste Incinerator	1	1	1	1	1	1	1			1	1
Cummins/Detroit Firewater Pump	1	1		1		1	1		1	1	
Vapor Recovery Flare	1										
Crude Breakout Tank	2	1	1	1	1	1	1	1	1	1	1
Turbine Fuel Tank — Diesel/JP-4		6	1	1		2	2	2	2	2	2
Topping Unit Residuum Tank						1		1		1	

*Equipped with rim cooling

efficient units. Thus, the turbine exhaust from the TAPS mainline turbine units contains fairly low NO_x concentrations even without emission controls.

Several of the mainline turbine units are equipped with rim cooling, which increases the power output of the turbine package without significant equipment replacement or modification. With increased power output and fuel consumption due to rim cooling, both criteria and non-criteria pollutants increase proportionately. However, the use of rim cooling does not necessarily increase emissions stationwide. Rim cooling is useful in situations where one or two non-rim-cooled turbines are not sufficient to meet the station's load demand. The use of rim cooling can avoid the need to add or bring online additional turbines. This option is particularly important for load balancing during pipeline rampup or rampdown phases (APSC, 1990). When a pump station is put on rampdown, the remaining stations have to carry the additional load.

One crude oil topping unit (COTU) each is located at Pump Stations 6, 8 and 10. None of the COTUs are currently in operation; however, the equipment is kept in an active permitting status (The COTUs were ramped-down with the pump stations). Each COTU can process up to 14,000 bbl per day of crude and can produce up to approximately 3,000 bbl per day of turbine and diesel fuel. Each COTU includes a crude heater unit with a firing rate of 35 million Btu/hr, a crude distillation unit, an overhead-gas accumulation system, and an overhead-gas vapor relief system with a flare stack. Overhead gas from the crude distillation unit is burned as fuel gas in the crude heater along with supplemental fuel oil. During COTU system upsets, the overhead gas is routed to the COTU flare stack. An emission control system was installed in 1994 to reduce SO_2 emissions from the crude heater. The system includes two gas-adsorption vessels to remove H_2S from the fuel gas before the gas is fired in the crude heaters. The gas-adsorption process can reduce H_2S from the overhead gas stream to single digit parts per million (ppm) levels. A system is in place that monitors H_2S levels in the fuel gas several times each operating day.

Each pump station has either one or two crude breakout tanks with an individual holding capacity ranging from 55,000 to 210,000 bbl. The majority of crude vapor emissions are generated when liquid crude is transferred into the tanks and vapor is vented to the atmosphere. The two tanks at Pump Station 1 are equipped with a vapor recovery system to control VOC emissions. The tanks at Pump Station 1 also function as crude-breakout or pressure-relief tanks when crude has to be diverted during pipeline upsets or slowdowns. All other tanks along the pipeline are consid-

Table 4.3-5. *Permitted Valdez Marine Terminal emission sources.*

Stationary Equipment	No. Units
Stationary Combustion Engines	
Power Boilers	3
Waste Gas Incinerators	3
Solid Waste Incinerator	1
Emergency Generator	1
Lifeline Generator	1
Firewater Diesel Engine	7
Tanks	
Crude Tanks in East Tank Farm	14
Crude Tanks in West Tank Farm	4
Fuel Tanks	16
Used Oil Storage Tank	1
Fire Training Site	
Fire Training Fuel Tanks	3
Fire Training Pit	1
Ballast Water Treatment System	
Recovered Crude Tanks	2
Ballast Water Separation Tanks	3
Dissolved Air Tanks	6
Dissolved Air Effluent Channel	1
Biological Treatment Tanks	2
Air Strippers	4
Marine Vapor Collection System	
Tanker Loading Berth Vapor Collection	2 (berths)
Tanker Loading Berth w/o Vapor Collection	2 (berths)

Mobile Equipment	No. Units
Marine Sources	
Crude Tankers	N/A
Barges	N/A
Tug Boats	N/A
Onshore Sources	
Gasoline-fueled vehicles	
Automobiles	N/A
Snowmobiles	N/A
Bombardiers	N/A
Diesel-fueled vehicles	
Light-duty trucks	N/A
Buses	N/A
Backhoes	N/A
Front-end loaders	N/A
Cranes	N/A
Other diesel-fueled equipment	
Oil-fired heaters	N/A
Welders	N/A
Generators	N/A
Light towers	N/A
Pumps	N/A
Pressure washers	N/A
Snow blowers	N/A

ered breakout tanks. They are not considered storage tanks and are not equipped with vapor emission controls.

Most stations have an incinerator for on-site disposal of solid waste. The majority of the units have design charge rates from 200 to 300 pounds per hour of solid trash and oily materials. Each unit has an auxiliary fired temperature-controlled afterburner in the exhaust stack for emissions control. The afterburners are fired with either natural gas or fuel oil.

Vapors from crude transfer and storage at Pump Station 1 are collected in a common vapor header and routed to the tank-vapor incineration flare. In 1994-95, a new flare tip and a gas-assist combustion system were installed to improve the smokeless combustion of the flare at high vapor-flow rates. The flare's smokeless capacity was also increased in 2000, and an additional increase in capacity is planned for 2001.

Pump Stations 2, 6, 8, and 10 are currently ramped-down. Overall station air emissions are therefore at a minimum and are only from sources that provide life support, such as electric power and space heat for facility maintenance.

Pump Station 5 operates an extensive equipment maintenance facility including a variety of small combustion sources. Pump Station 3 operates a maintenance facility for heavy equipment and consequently has a higher rate of mobile source movement and emissions.

Valdez Marine Terminal. Large stationary and mobile emission sources at the VMT are listed in Table 4.3-5. The larger VMT air emission sources are described below.

All crude storage tanks at the VMT have fixed roofs. The tank emissions are controlled with a vapor return line from each tank, and for each tank farm this line is manifolded into a common low-pressure vapor header which is part of the onshore vapor-recovery system. When a tank is emptied, the resulting additional vapor volume has to be filled with blanket gas (a mix of inert exhaust gas and crude vapors) to prevent air (oxygen) from entering the system and causing an explosive atmosphere inside the tank. Blanket gas is provided via a high-pressure vapor header at each tank farm with an individual supply pipe to each tank. A series of pressure/vacuum vents are located on top of each of the storage tanks to avoid over- or under-pressuring the tanks. These vents are designed to operate to protect tank

integrity. All tank vents were extensively upgraded in 2000.

During the 1990s, a number of operational upgrades were made to the power/vapor control system including the installation of an automatic operations control and data recording system, as well as the implementation of improved operational procedures. All of the above measures resulted in a significant reduction of tank vapor losses.

As tanker cargo tanks are emptied of ballast water, they are filled with flue gas from the ship's boilers for pressure equalization and to provide an inert atmosphere in the tank. When the ships are loaded with crude oil, the inert gas is displaced and hydrocarbon vapors are generated through partial evaporation of warm crude. In March 1998 a marine vapor-collection system commenced operation to recover tank displacement vapors at Berths 4 and 5 and to route the vapors to the onshore vapor-recovery system. The collected vapors are available for pressure equalization in the onshore crude storage tanks as crude is withdrawn for loading (vapor balancing). The displacement vapors include the crude loading vapors as well as the tanker inert gases. With the control of two berths and a hydrocarbon destruction efficiency of 98 percent, a reduction of about 27,500 tons per year in VOC emission from the tankers was estimated in the 1995 Tanker Vapor Recovery PSD permit application (APSC, 1997d) .

Berths 1 and 3 are not equipped with vapor control systems but are regulated by 40 CFR 63, which limits the volume loaded from the uncontrolled berths and thus limits the amount of VOC emissions. Section 63.562 (d) requires a reduction in the amount of crude oil loaded at the uncontrolled berths. In 2002, no more uncontrolled loading will be permitted, with the exception of a small loading allowance for berth maintenance purposes.

The vapor recovery system was originally installed to control VOC emissions from the onshore storage tanks. The tanker vapor-recovery system was tied in with the storage-tank vapor-recovery system in 1998. The installation of the vapor recovery system resulted in a slight increase in combustion emissions related to generating additional electricity needed to transport collected ship vapors within the vapor recovery system.

In the present configuration, three vapor compressors are available to move waste gas into and out of the crude storage tanks, while the other two units draw the vapors from the berth vapor lines. The vapors generated in the crude oil storage tanks and those captured from tanker loading are used as blanket gas to maintain tank pressure. Flue gas generated by the facility's power boilers is also used as make-up gas when not enough blanket gas is available from the vapor recovery system.

The flue gas that is used as make-up blanket gas is scrubbed to remove sulfur compounds and compressed in the vapor compressors before it is recirculated into the high-pressure vapor header and returned as blanket gas. Excess gas from the vapor recovery system is compressed and used as fuel in the power boilers or destroyed in the waste-gas incinerators. When there are sufficient quantities of high-heating-value gas, it is preferentially used as fuel in the power boilers. This practice not only results in cost savings by offsetting, on a Btu-per-Btu basis, the amount of distillate fuel required to maintain boiler load but also reduces emissions since gas is cleaner-burning than liquid fuel and the gas does not end up being burned in the waste-gas incinerators.

After berthing, tankers containing ballast water in their cargo tanks discharge their ballast to the onshore BWTF, which consists of three 430,000-bbl ballast-water separation tanks where initial gravity separation of the oil from the ballast water occurs. The ballast water is further treated in six dissolved-air flotation tanks, followed by two biological treatment tanks including a series of air strippers to remove the remaining volatile hydrocarbons during rare biological system upsets. The entire system is permitted to process up to 30 million gallons of ballast water per day. (Current throughput is less than one-half of that capacity.) Criteria air pollutants are emitted in the form of VOCs and include non-criteria pollutants (BTEX).

Tankers at berth operate their boilers and/or generators to run ballast-water transfer pumps (deballasting) and to provide onboard utility power (hoteling). The length of the deballasting operation depends on the size of the tanker but typically takes 6 hours, and since the operation requires increased power loads from the ship's engines, it thus produces more emissions. Following deballasting, the tankers go into hoteling-only mode for loading, and the ship's boilers operate at a reduced load with lower emissions. Loading may take 24 hours or more. Under worst-case emission conditions, up to three tankers may be simultaneously deballasting or hoteling at berth.

Existing Emission Impacts

Section 4.3.1.3 discusses TAPS throughput decline and the likelihood of a TAPS-wide net decrease in emissions and emission impacts. This assumption is supported by the results of several air-quality permit applications and modeling studies and the fact that a number of improvements were made at the pump stations and the VMT. The following sections describe the existing impacts of TAPS in view of seven standard air-quality criteria:

- **Ambient air quality standards:** North Slope moni-

toring data and TAPS modeling data showed a fair margin in meeting ambient standards during years of higher pipeline throughput and worst-case emission rates. Under current throughput, it is expected that ambient standards will be met.

- **Non-attainment areas:** The Fairbanks/North Pole area is the only non-attainment area potentially affected by TAPS operations. With Pump Station 8 in rampdown mode, no pump stations contribute significant amounts of carbon monoxide to the non-attainment area. The small trucks operated by Alyeska in the area are powered by low-CO-emitting diesel engines. Plug-ins are provided to reduce cold-start and idling emissions.
- **Visibility:** Visibility impact analyses on Class I area were performed for Pump Stations 2 and 7 and for the VMT. None of the studies predicted any significant degradations of the vistas for Denali and Tuxedni National Parks and other sensitive Class II areas.
- **Acid rain:** The deposition of acidic air pollutants on sensitive ecosystems in remote regions of the state is predominantly a result of long-range transport from sources outside Alaska. Furthermore, the remote regions of Alaska receive the lowest levels of acidity in the U.S. TAPS emissions do not contribute any significant amounts to acidic depositions within the state.
- **Noise:** No adverse effects are known due to noise from stationary TAPS sources beyond the facility boundary lines. Some disturbances have been observed from air traffic, particularly helicopters, during pipeline overflights (see Section 3.2.4-5).
- **Ice fog:** Pump Stations 1 and 8 are potential contributors to local ice-fog episodes. However, Pump Station 1 is a small source compared to others in the North Slope oil fields, and Pump Station 8 is in rampdown mode. Thus, the overall contribution of TAPS facilities to local ice fog is small.
- **In-situ burning:** In-situ burning may be used for oil spill response, and Alyeska participated in a multi-agency/stakeholder working group developing guidelines for such burning, which can only be used if approved by state and federal authorities after consideration of emission impacts.

Under the Clean Air Act, the EPA is responsible for setting National Ambient Air Quality Standards (NAAQS). Based on the NAAQS, the State of Alaska sets standards (AAAQS) that must be at least as or more stringent than the NAAQS. For most pollutants, the NAAQS and the AAAQS are identical. An area where the monitored level for a specific pollutant exceeds the AAAQS is called a non-attainment area. No pump station or the VMT is located in a non-attainment area. Fairbanks is an non-attainment area for carbon monoxide, but both Pump Stations 7 and 8 are well outside the non-attainment area.

Impacts on Ambient Air Quality. On the North Slope, ambient air quality and meteorological monitoring has been carried out since 1986 near BP's Central Compressor Plant (CCP) and Pad A, and since 1991 near Gathering Center 1 (GC 1) (SECOR, 1995). Pump Station 1 is located at equal distances from the CCP, GC 1, and Pad A (Figure 4.3-16). The emission impacts from Pump Station 1 are included in the monitoring data collected at the monitoring sites and did not contribute to any exceedances of the standards (SECOR, 1995). Table 4.3-6 lists the highest monitoring values observed from 1986 to September 30, 1999, and compares these values to the applicable AAAQS and increments. The ambient impacts from gaseous pollutants emitted by stationary sources like gas turbines, heaters, and diesel generators from Pump Station 1, CCP, or GC 1 are quite low and well within the AAAQS and the increments. The monitored impacts of PM-10 are relatively low, as expected for these types of sources. With the use of natural gas as fuel, the contribution of PM-10 from stationary sources is quite low and cannot be expected to have a significant contribution to the ambient level. The contributions (percentages) of the individual measured air pollutants for the Prudhoe Bay Unit between 1986 and 1992 were statistically determined as follows (SECOR, 1995):

- NO_x: 80 percent
- CO: 16 percent
- SO_2: 1 percent
- PM-10: 2 percent

However, some of the short-term (24-hour) PM-10 monitoring data show excursions above normal during 1990-92 at GC 1. These excursions can be attributed to high winds causing re-entrained fugitive dust from roads and wind erosion from disturbed land. Table 4.3-7 and Figure 4.3-17 show the monitored ambient impacts at Prudhoe Bay from 1989 to 1998. The data lead to the conclusion that there has not been any measurable degradation of the existing air quality since the start of monitoring at Prudhoe Bay.

Actual ambient monitoring data have not been collected for the pipeline region between Pump Station 1 and the VMT; however, a number of ambient modeling studies were performed between 1990 and 1997, evaluating the impacts of a number of air pollutants on the existing air quality, native vegetation, wildlife, and vistas.

Ambient-impact modeling studies were carried out for

Table 4.3-6. *Monitoring and modeling data for TAPS air-quality impacts.*

	AMBIENT VALUES [micrograms per cubic meter (µg/m³)]									CLASS II VALUES (µg/m³)			
	Ozone	SO_2			NO_x	CO		PM-10		NO_x	SO_2		
Averaging Period	1 hr	3 hr	24 hr	Annual	Annual	1 hr	8 hr	24 hr	Annual	Annual	3 hr	24 hr	Annual
Standard	235	1,300	365	80	100	40,000	10,000	150	50	25	512	91	20
CCP (a)	116	34	24	3	26	—	—	29	6	—	—	—	—
GC 1 (a)	20	131	39	3	20	—	—	155	12	—	—	—	—
A PAD (a)	—	—	—	—	9.4	—	—	—	—	—	—	—	—
CPF 1 (a)	116	44	26	5	16	>1,300	>950	108	11	—	—	—	—
DS-1F (a)	100	55	10	3	4.9	>1,300	>950	57	7	—	—	—	—
PS 2 (b)	—	—	—	—	55	—	—	—	—	2	—	—	—
PS 7 (b)	—	171	76	19	64	—	—	—	—	5	6	2	1
PS 7 (c)	—	211	84	21	—	—	—	—	—	—	—	—	—
PS 8 (c)	—	427	264	66	—	—	—	—	—	—	—	—	—
PS 9 (c)	—	181	80	20	—	—	—	—	—	—	—	—	—
PS 10 (c)	—	244	109	27	—	—	—	—	—	—	—	—	—
PS 12 (c)	—	422	188	48	—	—	—	—	—	—	—	—	—
Generic PS (d)	—	225	187	15	87	4	2	110	15	—	24	26	1
VMT-TVR (e)	112	222	65	10	17	2,100	1,100	87	15	—	—	—	—
VMT-TVR (f)	—	117	34	7	—	—	—	8	0.5	4	—	—	—
VMT-TVR (g)	—	1,187	280	23	33	—	—	—	—	—	—	—	—
VMT-TVR (h)	—	1,155	280	23	—	—	—	65	10	33	—	—	—

(a) Monitored impacts: Highest recorded value between 1986 and September 30, 1999.
(b) Modeled impacts: 1990 PSD application for addition of rim cooling to mainline turbine units.
(c) Modeled impacts: 1991 application for increase in turbine fuel sulfur content.
(d) Modeled impacts: 1997 modeling report for generic pump station; 0.24% fuel sulfur including background concentration; increment consumption based on fuel-sulfur difference of 0.2% to 0.24%.
(e) Monitored impacts: 1990-1993 Valdez Marine Terminal ambient monitoring network.
(f) Modeled impacts: 1995 VMT PSD application for tanker vapor recovery system (maximal impacts from system).
(g) Modeled impacts: 1995 VMT PSD application for tanker vapor recovery system (incremental impacts from system).
(h) Modeled impacts: 1995 VMT PSD application for tanker vapor recovery system (total post-construction facility impacts).

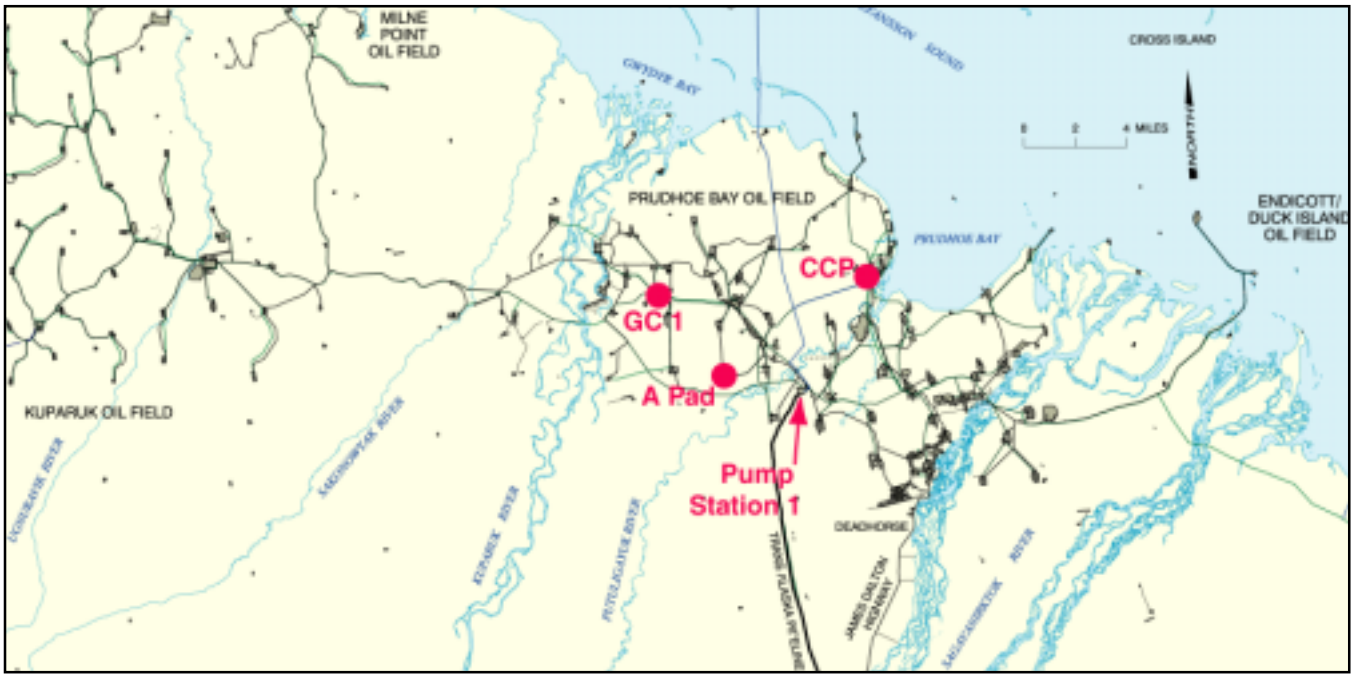


Figure 4.3-16. *Ambient air monitoring stations (shown by red dots) in the Prudhoe Bay oil field in the vicinity of Pump Station 1.*

PSD analyses for Pump Stations 2 and 7 for the addition of turbine rim cooling in 1990 (APSC, 1990). Pump Stations 7, 8, 9, 10, and 12 were modeled in 1991-92 for increases in sulfur dioxide emissions with the use of turbine fuel with a higher sulfur content (TAPS Permit Correspondence Files, 1990/91). A generic modeling study with a typical source arrangement was performed in 1996-97 to evaluate the impacts from any TAPS pump station in lieu of modeling each individual station (APSC, 1997c). Table 4.3-8 summarizes the predicted ambient impacts for the modeling studies carried out for the pipeline route and for the VMT compared with the AAAQS and increments. All studies predicted that the impacts from the operating pump stations would be in compliance with the ambient standards and increments.

Background ozone and PM-10 ambient-impact monitoring data are available from a monitoring program carried out by the National Park Service Gaseous Air Pollutant Monitoring Network in Denali National Park and Preserve (NPS, 1997). An analysis of the daily maximum concentrations monitored during the summer months between 1988 and 1997 did not show significant improvements or degradation of the air quality trends. The annual average concentration of total suspended particulates (TSP) was 1.8 µg/m^3 between March 1997 and February 1998, which was the lowest measured concentration among all national park monitoring sites. The above data indicate that it is likely that no deterioration of the natural background values has occurred in the remote areas of Interior Alaska.

From October 1990 through March 1993, Alyeska operated an extensive ambient-air-quality network at the VMT. Five air-quality monitoring and meteorological sites were online throughout the Valdez basin. Three of the sites were decommissioned in November 1991, and two sites (East Gate and West Terminal) adjacent to the VMT continued operating through March 1993 (APSC, 1997d). As shown in Table 4.3-6, the monitored concentrations collected up to March 1992 were well below the corresponding NAAQS. (The table does not include PM-10 measurements for the period October 17-19, 1992. During this time, elevated concentrations of PM-10 were measured as a result of high winds, dry conditions, and the presence of volcanic ash in

Table 4.3-7. *Prudhoe Bay Unit, 10-year ambient-air-impact trend (micrograms per cubic meter).*

Station/ Pollutant	Averaging Period	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	NAAQS
CCP													
NO_X	Annual	13.2	16.9	18.8	18.6	16.2	17.7	26.3	15	16.9	26.3	20.7	100
Ozone (O_3)	1 hr	105.8	98	92.1	94.1	111.7	82.3	115.8	111.7	102.1	96	94.1	235
SO_2	3 hr	15.7	13.1	13.1	13.1	10.5	13.1	13.1	13.1	18.3	23.6	28.8	1,300
	24 hr	13.1	10.5	7.9	10.5	7.9	10.5	10.5	10.5	13.1	18.3	18.3	365
	Annual	7.9	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	5.2	5.2	80
PM-10	24 hr	24.1	15.9	20.8	16.5	29.3	28.4	53.5	12.8	47.1	69.9	28.0	150
	Annual	5.7	5.2	4.6	6.1	6.2	6.6	11.6	3.2	4.6	7.7	3.7	50
A PAD													
NO_X	Annual	9.4	9.4	9.9	9.4	11.9	8.1	9.4	7.8	7.5	7.5	7.5	100
O_3	1 hr	119.6	105.8	147	152.9	180.3	103.9	106	98	110	109.8	96.0	235
SO_2	3 hr	—	—	—	—	—	—	—	—	—	—	—	1,300
	24 hr	—	—	—	—	—	—	—	—	—	—	—	365
	Annual	—	—	—	—	—	—	—	—	—	—	—	80
PM-10	24 hr	—	—	—	—	—	—	—	—	—	—	—	150
	Annual	—	—	—	—	—	—	—	—	—	—	—	50
GC 1													
NO_X	Annual	—	—	20.7	15.5	20.2	16	18.8	11.3	11.3	11.3	9.4	100
O_3	1 hr	—	—	76.4	98	105.8	80.4	94.2	111.7	100.1	90.2	96.0	235
SO_2	3 hr	—	—	131	34.1	101.4	21	44.5	99.6	73.3	15.7	21.0	1,300
	24 hr	—	—	52.4	13.1	39	7.9	15.7	31.4	23.6	7.9	13.1	365
	Annual	—	—	3.5	3.5	2.6	2.6	2.6	2.6	5.2	2.6	2.6	80
PM-10	24 hr	—	—	19.1	155	54.7	64.3	—	—	—	—	—	150
	Annual	—	—	8	16.2	11.2	9.8	—	—	—	0	—	50

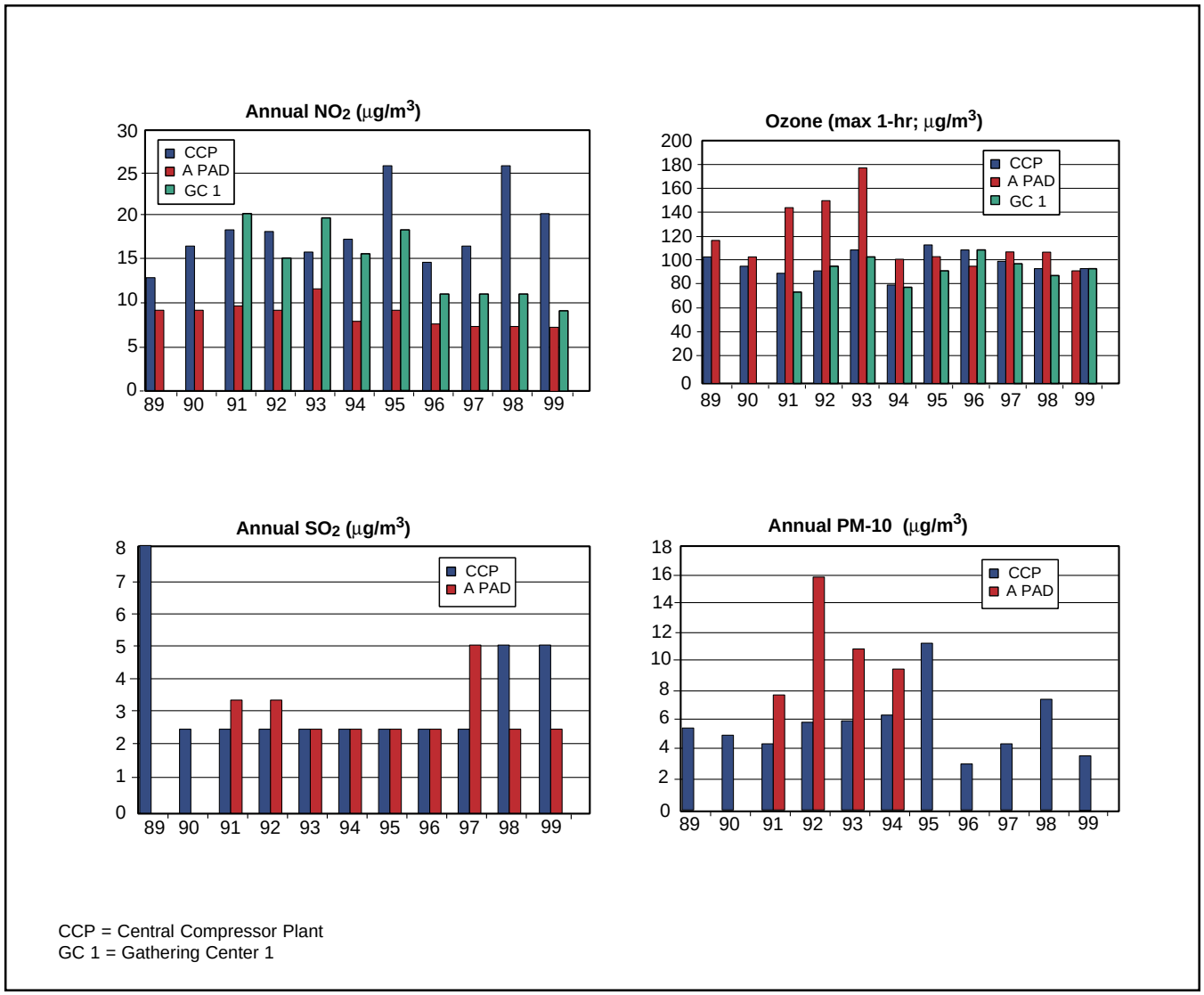


Figure 4.3-17. *Prudhoe Bay air quality, 10-year trends.*

Table 4.3-8. *Impacts on visibility from VMT tanker vapor recovery.*

Area of Concern	Background	Delta E (a)		Contrast (b)	
		Criteria	Impact	Criteria	Impact
Tuxedni	Sky	2	0.557	0.05	0.008
	Terrain	2	0.241	0.05	0.003
Wrangell-St. Elias	Sky	N/A	4.544	N/A	0.069
	Terrain	N/A	5.727	N/A	0.058
Recreational Vehicle Area	Sky	N/A	31.5	N/A	0.846
	Terrain	N/A	63.4	N/A	0.420

Note: The criteria shown are for Class 1 areas within 100 kilometers of the source. Wrangell-St. Elias and the recreational vehicle area are Class II areas with no established criteria.
(a) Delta E is the degree of light extinction when viewed through an exhaust plume.
(b) Contrast is the degree of change of background visibility when viewed against the sky or terrain.

the Valdez area from the eruption of Mount Spurr in August 1992.)

A PSD analysis was conducted in 1995 for the addition of the marine vapor-recovery system at the VMT (SECOR, 1997b). An ambient-impact modeling study was carried out to assess emissions resulting from the increased power-generation requirements and the additional vapors incinerated in association with tanker vapor recovery. The modeling study (Table 4.3-6) showed that incremental criteria pollutants from the tanker vapor-recovery system and the adjacent Petro Star refinery would not exceed the maximal allowable Class II increments of deterioration for the Valdez area. The PSD increment consumption was predicted to range from of 2.9 to 35 percent, depending on the location of the receptor points. The study also showed that the total impacts from the VMT with the tanker-vapor recovery system were predicted to approach but not exceed the AAAQS for SO_x outside the VMT fence-line or the marine safety-zone boundary under maximum and worst-case operating conditions. The impacts relative to the AAAQS were predicted to range from 21 to 91 percent. Actual VMT operations have been significantly below those modeled by the study.

Atmospheric inversions occur anywhere when the atmospheric temperature gradient is reversed — i.e., the air temperature increases rather than decreases with increasing altitude. Under these conditions, the atmosphere becomes "stable" and loses its ability to disperse air pollution vertically. With extremely strong inversions and calm winds, air-pollutant concentration can exceed standards or even reach danger levels. Monitoring and modeling data collected in connection with TAPS do not indicate the presence of such conditions at any TAPS facilities (Table 4.3-6).

Non-Attainment Areas. Alaska has three air-quality non-attainment areas: the Mendenhall Valley in Juneau for particulate matter, and Anchorage and Fairbanks/North Pole for carbon monoxide. TAPS passes through the Fairbanks/North Pole non-attainment area. Under specific atmospheric conditions, the emissions from Pump Station 8 (currently in standby mode) and the motor vehicles operated by TAPS can contribute emissions to the non-attainment area. The non-attainment pollutant is carbon monoxide, which is emitted primarily from motor vehicles during cold-start conditions in winter. An effective measure to reduce such emissions is the use of engine block heaters. Alyeska provides electrical outlets at TAPS facilities. In addition, Alyeska's light trucks are powered by diesel engines that have very low CO emissions compared to gasoline engines.

Impacts on Visibility. In the 1977 amendments to the Clean Air Act, Congress established a national goal of preventing any future and remedying any existing impairment of visibility resulting from man-made air pollution in 156 national parks and wilderness areas. Such "Class I" areas in Alaska include Denali National Park, the Bering Sea National Wildlife Refuge, the Simeonof National Wildlife Refuge, and the Tuxedni National Wildlife Refuge.

Visibility measurements were made in and around Denali National Park and Preserve as part of the federal IMPROVE visibility monitoring network administered by the National Park Service during 1997 and 1998 (NPS, 1997). The lowest seasonal visibility, measured during the summer, was 134 km, while the highest readings were taken during the winter at 225 km. Organics and sulfates were the largest contributors to aerosol light extinction.

The evaluation of impacts on visibility in Class I areas is required as part of a PSD analysis for projects causing major air-emission increases if the source is located less than 100 km from the Class I area. In 1990-91, Alyeska performed Level 1 visual effects screening analyses for Pump Stations 2 and 7 for Denali National Park and Preserve, even though TAPS is more than 100 km from the park (APSC, 1990). The results did not predict any adverse impacts on visibility in the park.

The 1995 VMT tanker vapor recovery PSD application evaluated the project's visibility impacts on the nearest Class I area and selected Class II areas (Fluor and TRC, 1995). The nearest Class I area is Tuxedni National Wildlife Preserve, approximately 200 miles to the west. Visibility impacts related to the project also were assessed at the nearest Class II area, Wrangell-St. Elias National Park and Preserve, located approximately 55 miles to the east, and at a second Class II location frequented by recreational vehicle users approximately 3 miles east of the site.

As shown in Table 4.3-8, project-related impacts in the Class I area are predicted to be well below the EPA-established significance thresholds and did not require a more advanced Level II visibility analysis.

Acid Rain. Acidic deposition, or acid rain, is generally a regional problem caused NO_x and SO_2 emissions from large industrialized areas. The emissions eventually convert to sulfuric and nitric acid mist over significant atmospheric transport distances. Acid rain has been associated primarily with long-range transport of pollutants from major industrial areas over regional, interstate, and intercontinental scales (Cooper and Alley, 1994).

While the acidification of lakes due to wet deposition occurs in the eastern U.S., acid deposition is not considered a problem in the western U.S. and Alaska. The 1990 Clean Air Act Amendments do not require any specific legislation

for the western states to control acid deposition.

The quantitative impact of TAPS NO_x and SO_2 emissions on pristine areas in Alaska is not known. However, considering the magnitude of emissions from large industrial centers in northern Europe, Asia, and the eastern U.S., far greater impacts can be expected on pristine regions in Alaska from these sources. In addition, the relatively short intrastate distances do not provide the same time for acid formation compared to regional and global transport. The lowest concentrations of sulfate and nitrate in precipitation measured at four prototype parks in the U.S. were recorded at Denali National Park (NPS, 1997).

Noise Impacts. The original TAPS EIS (BLM, 1972) estimated that the noise levels from a TAPS pump station would be 74 dBA at a distance of 600 feet (183 meters). This estimate was overly conservative when compared with actual sound measurements at similar facilities at the North Slope. Measurements in the Prudhoe Bay area in 1979 identified sound levels from the Central Compressor Plant of 74 dBA at 15 m from the turbine air intake and 60 dBA at 120 m from the vapor-relief flare operation (BLM and USACE, 1988).

Although the TAPS ROW itself is developed, most of the area adjacent to the route is undeveloped and sparsely populated, and ambient noise levels are generally low. Disturbances to wildlife have not been observed in connection with any of the stationary sources at the pump stations, however disturbances have been observed from air traffic, particularly helicopters during pipeline overflights. Wind and other atmospheric conditions can affect ambient background levels. Noise carries considerable distances during calm, cold conditions due to increased air density. Generally, the noise from pump station equipment and activities are not audible outside the facility property lines. Actual noise measurements outside the facility property lines along the TAPS ROW were not found. The author is not aware of any complaints about excessive noise from the public or residences near the TAPS ROW.

Background noise in the Valdez area is quite low, with road traffic and aircraft the most significant sources. Valdez is typical of many small Alaskan cities with moderate traffic and limited sources of noise. Some ambient noise originates from the VMT, mainly from sources associated with power/vapor operations; however, beyond the facility boundaries it is generally not audible. Natural background noise levels are low except when transient boats and aircraft pass by (Fluor and TRC, 1995).

Ice Fog. Ice fog is generated by the emission of exhaust gases from combustion sources in subzero temperatures. The amount of water vapor generated from the combustion process alone is substantial. With the use of wet fuels such as coal, wood, solid waste, etc., and the application of wet emission controls such as wet scrubbers, the amount of water vapor generated can be much higher. In severely cold climates like Alaska's Interior, the formation of ice fog can be a serious visibility problem that can last for days at a time. When winds are from the southeast, water vapor emitted from Pump Station 8 (when in operation) has some potential to contribute to ice fog in the Fairbanks/North Pole area, as do the several hundred cars, trucks and heavy equipment operated by Alyeska in and around Fairbanks and along the pipeline route in the Interior. Pump Station 7 is too far from Fairbanks to have any significant impacts on the greater Fairbanks/North Pole area. Located within the North Slope production area, Pump Station 1 may have the highest potential for impact on periodic ice-fog episodes of all TAPS sources, even though its overall contribution of water vapor compared to most other facilities at the North Slope is minor. All other stations are sufficiently distant from ice-fog-prone areas that they do not contribute significantly to periodic ice-fog episodes.

Oil Spill Response/In-Situ Burning. In-situ burning is a tool for removing oil from a spill on land or water. In-situ burning is only performed when approved by a state or federal on-scene coordinator. In contrast to the combustion of hydrocarbon fuels in a controlled environment like a combustion chamber, in-situ burning produces a wide range of intermediate combustion by-products. By-products can be categorized into airborne components, unburned oil, and combustion residues (ADEC, 1999).

The airborne components of smoke plumes may contain a wide variety of criteria and toxic air pollutants including polynuclear aromatic hydrocarbons (PAHs), CO_2, CO, NO_x, and PM-10. McGrattan et al. (1997) determined that 10 to 15 percent of the original amount of crude oil was converted into smoke or airborne particulate matter when burned. The particulate portion of the smoke is about 90 percent elemental carbon. Particulates from emissions from oil fires appear to pose the greatest health risk. This includes both soot (elemental carbon) and hydrocarbon particulates (unburned oil). While particles larger than 10 microns are considered to be non-inhalable, the fraction less than 10 microns can be inhaled. Other laboratory studies have shown that approximately 95 percent of the fuel was converted to CO_2 and 2 to 3 percent was converted to soot. Concentrations of total particulates measured at experimental burn sites as well as at sites in Kuwait in the aftermath of the war in Iraq showed that the levels can be significantly higher than the levels set by the NAAQS for PM-10. Measurements of gaseous or toxic components did

not show any concerns for exceedances of the ambient or health-related standards.

State and federal agencies, along with the oil transportation industry, are currently developing various tools to predict ambient-air-quality impact levels during or after an in-situ burn operation. These tools involve ambient-impact prediction methods and comparisons with pollution standard index values, supplemented with descriptor words, generalized health effects, and cautionary statements. The proper use of these tools will make it possible to prevent significant short- or long-term impacts on local residents.

Projected Ambient Air Quality Impacts

In order to evaluate the potential impacts of the next 30 years of TAPS operation, several aspects need to be examined. First, the extent of existing impacts from the operation of TAPS during the last 20+ years should be considered. Impacts from the operation and, to a minor extent, from construction need to be evaluated since the continued operation of TAPS may entail some construction activities. Secondly, projected operational configurations subject to long-range operations plans must be evaluated. These plans may increase or decrease future emissions and consequently can impact the environment. For example, standby pump stations will significantly reduce local emissions and ambient impacts. However, the facility air permits contain emission limits that ensure that the ambient impacts are within the allowable standards and increments.

A third aspect is to search for and to evaluate any dynamic effects that may cause future impacts that significantly differ from past effects.

Impacts on Ambient Air Quality Standards. Ambient air-pollutant levels at North Slope operations areas have not shown any measurable changes since the start of the air-quality monitoring program in 1986. It can thus be concluded that no additional degradation of the ambient air quality has occurred beyond any increases in air pollution levels prior to 1986 due to the start of exploration and production activities. An extrapolation into future operating phases may be appropriate. However, careful consideration must be given to any known potentially adverse effects. One such known and potentially adverse effect is the steady increase in the H_2S content of the fuel gas consumed at the North Slope facilities and Pump Stations 1 to 4. The fuel-gas H_2S content has increased from levels in the single digits typical in the early years of operation to approximately the mid-twenties today. On a rough scale it can be concluded that the H_2S content has doubled over the last 20 years — with a resultant doubling of the SO_2 emission rates for all stationary fuel-gas-burning equipment (SO_2 results from the combustion of H_2S). However, before the conclusion is made that emission rates have doubled, the actual fuel-gas consumption rates would have to be assessed for any specific facility.

If the overall station fuel consumption has decreased because of lower oil throughput rate, this would offset emission increases. Also, it is incorrect to assume that actual increases in SO_2 emissions would automatically cause a proportionate increase in measurable ambient impacts. As mentioned earlier, the Prudhoe Bay monitoring sites have not measured any increases in ambient SO_2 levels in recent years despite an increase in fuel-gas H_2S levels. Part of the reason is that actual emissions of SO_2 are quite low (about 1 percent) compared with other pollutants. Thus, any changes in the emission rates of SO_2 will likely have little effect on measured levels or airborne pollution and practically no effect on any climatic factors. Existing global climatic trends like atmospheric warming will likely have a significantly stronger effect on local climate regimes.

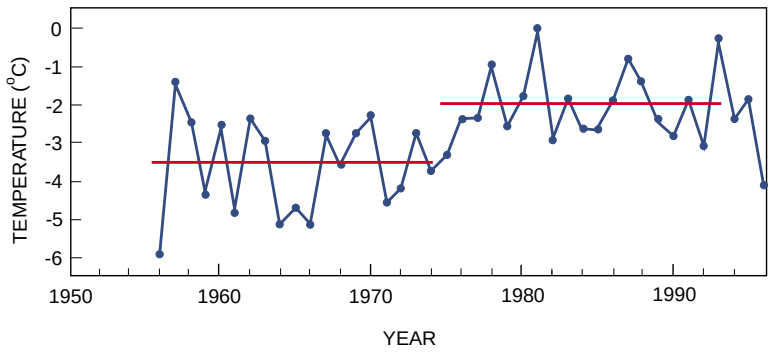
Currently, all pump stations can operate all mainline turbine units and other stationary equipment up to their maximum permitted levels. Generic modeling has been conducted based on the worst-case normal operating conditions (APSC, 1997c). It is unlikely that these operating conditions will be exceeded. Consequently, it is unlikely that the potential emission increases from the remaining stations in future throughput cycles will create any additional impacts over existing or past levels, which were found to be in compliance with all applicable standards.

As stated earlier, the SO_2 emission rates at Pump Stations 1 to 4 will increase at a direct ratio with increased H_2S levels in North Slope fuel gas minus an overall fuel usage reduction due to reduced throughput. However, no matter how high the H_2S level in the fuel gas, the amount of SO_2 emitted from the fuel-gas-fired stations will always be significantly lower than the SO_2 emission rates from the fuel-oil-fired pump stations. The amount of sulfur present in fuel oil is several orders of magnitude higher than in fuel gas. The generic modeling discussed above was carried out with the assumption of liquid fuel-oil use. The expected SO_2 impacts from the fuel-gas-fired stations will be significantly lower than those from the fuel-oil-fired stations.

4.3.1.4 Global Climate Change

By R. Dugan

There are numerous ongoing debates on the rate and duration of the current apparent global-warming trend in Alaska. Global-warming forecasts indicate that the high latitudes of the earth may warm by several degrees by the



NOTE:
The horizontal lines for the air temperature are 20-year averages (Osterkamp and Romanovsky, 1999)

Figure 4.3-18. *Mean annual air temperature at Fairbanks.*

middle of the next century as a result of an effective doubling of carbon dioxide (CO_2) , methane (CH_4) and other greenhouse gases (Esch and Osterkamp, 1991; Nixon, 1991, Vyalov et al., 1993, 1998). One study in interior Alaska indicated that an air temperature shift to a warmer regime began with the winter of 1976. After 1976, the mean annual air temperature in Fairbanks increased 1.5°C for the next 20 years as shown in Figure 4.3-18 (Osterkamp and Romanovsky, 1999). These studies suggest that a warming trend is occurring, although the cause of the temperature increase is not well-understood and may be related to the cyclic nature of the climate.

The likely range of mean annual air temperature increases over the ROW renewal period is 2°C to 5°C if the warming trend observed in the Fairbanks area continues. Over time, warmer air temperatures would increase ground temperatures. This would result in warming of the relatively cold permafrost on the North Slope and Brooks Range and lowering of the permafrost table in southern portions of the pipeline where permafrost temperatures approach 0°C.

A thaw bulb has already developed in some permafrost areas along the ROW as a result of the construction of the workpad and other facilities. Pipeline construction unavoidably compressed or disturbed the vegetative cover that formerly protected the permafrost (see Section 4.3.1.1). A gradual increase in the size if the thaw bulb can be expected as a result of continued climatic warming.

Since the beginning of TAPS operations in 1977, the consequence of any climate change-induced permafrost thawing to pipeline operations has been negligible (Cole et. al., 1999). Continued warming of the air temperature will also have negligible impact on TAPS operations or pipeline integrity for the following reasons:

- Where above-ground pipe is located in areas of relatively warm permafrost, heat pipes are used to help maintain frozen conditions.
- Heat pipes can be added, if necessary, to VSMs that do not currently require them.
- In areas that are ice-rich (i.e., areas of high moisture content), the rate of ground temperature change will be slow, especially at depth.
- Continued monitoring and maintenance will identify and repair any areas where settlement or heave may exceed operational standards.

Continued operation of TAPS will not have a significant effect on global warming. The pipeline currently conveys about 1 million bbl per day compared to world oil production of approximately 75 million bbl per day (World Oil, 1999). Assuming that the oil delivered by the pipeline would impact global warming when it is eventually consumed, it would represent only a small fraction of the world's oil consumption. World demand determines oil production. If the oil were not produced in Alaska, it would be produced elsewhere; therefore, the net impact to global warming would not change. Non-petroleum-related contributors to global warming include volcanic eruptions and burning of coal, wood, and other combustible materials.

4.3.2 Biological Resources

This section assesses the potential biological impacts of the renewal of the TAPS ROW and continued operations. Limited written information is available on the TAPS ROW itself, compared to other areas such as the North Slope oil fields and Prince William Sound. However, much of the in-

formation available for other areas is relevant to TAPS. Written information has been augmented with interviews of Alyeska and government agency managers and regulators who have worked directly with TAPS. These interviews provided practical, first-hand-experienced views of TAPS and its potential impacts.

The written and interview information indicates that routine operation and maintenance of TAPS has not directly affected the size, distribution, or productivity of vegetative communities or fish and wildlife populations. TAPS is a relatively benign feature on the landscape, and maintenance/monitoring activity is well-regulated and restricted in space and time. The potential for impacts to areas other than the TAPS ROW itself that are in some way related to TAPS is dealt with in the Section 4.5 of this report. The literature review and interviews with TAPS managers and regulators suggest that of the extensive list of predicted impacts from TAPS, the major issues with regard to continuing operations of TAPS are:

- Spills of crude oil or refined petroleum products (e.g., diesel fuel) along the TAPS ROW and adjoining sections of the Alaska highway system, and in the marine environment.
- Blockage of fish passage and/or disturbance of fish habitats from culvert failure, improper use or maintenance of low-water crossings, and stream siltation from excavation runoff of TAPS workpads and access roads.
- Increased human access to remote areas resulting from growing public use of the Dalton Highway.

TAPS-related activities and facilities result in a small number of direct mortalities to terrestrial mammals and birds each year. Vehicles on the Dalton Highway occasionally kill caribou, moose, small mammals, and low-flying birds such as ptarmigan; and individual birds may be killed when they collide in flight with the pipeline, pump stations, or terminal facilities. Small numbers of freshwater fish, particularly fry, are sometimes entrained or stranded by local, temporary construction or excavation for pipeline maintenance. Individual mortalities such as these do not affect the species composition or population-level abundance of mammals, birds, or fish along the ROW.

The following sections describe potential impacts of the proposed action on special areas and special management zones, vegetation (including wetlands), fish, birds, terrestrial mammals, and threatened and endangered species. Most of the potential impacts involve habitat disturbance, displacement of individual animals, and direct mortality. Impacts resulting directly from TAPS operation and maintenance will necessarily be limited by lease stipulations that confine pipeline operations to the ROW. The gradual increase in human access from the Dalton Highway to formerly remote areas has the greatest potential to produce lasting population-level changes. This is a matter of public policy that will require management by federal, state, and local jurisdictions, and by the larger private landowners associated with the right-of-way for the Dalton Highway.

4.3.2.1 Special Areas, Special Management Zones, and Zones of Restricted Activity

By H. Whitlaw, R. Ritchie, and J. McKendrick

Evaluation of environmental consequences associated with the proposed action in special areas and special management zones (SASMZ) was based principally on an understanding of the historical impacts of TAPS operation and maintenance on fish and wildlife resources. In addition, several state and federal regulations on mitigation and environmental compliance apply to activities in SASMZs, and impact evaluation was also based on a review of these restrictions. SASMZs in the vicinity of the pipeline include the following (APSC, 1993):

- *Zones of restricted activity (ZRA)* created and implemented under Stipulation 2.5.3.1 of the Federal Grant. Activities are restricted during fish and falcon breeding, nesting, spawning, and migration periods.
- *Areas of critical ecological concern (ACEC)* proposed in BLM (1989) and established with BLM (1991). These pertain to critical and sensitive terrestrial-mammal and falcon habitats.
- *Long-term vegetation monitoring and restoration sites* established for monitoring willows, revegetation efforts, and vegetation response to oil spills.

Vegetation

The proposed action would involve ground-impacting ROW maintenance, in addition to revegetation monitoring and restoration. Long-term vegetation-monitoring SASMZs would not be adversely affected by ROW renewal because maintenance activities in these sites are restricted (APSC, 1993). It is likely that the proposed action would allow for continued opportunities to monitor revegetation efforts and vegetation response to disturbance (i.e., oil spills, TAPS construction, and ground-impacting maintenance).

Fish

The proposed action would involve ground-impacting ROW maintenance, in addition to activities in watersheds, wetlands, riparian areas, and streams. Work in ZRAs (i.e., all fish-bearing streams crossed by the pipeline and its fa-

cilities) is restricted during all breeding, spawning, and migration periods. However, there is concern that maintenance activities may obstruct fish movement, alter habitat, and/or increase mortality. In addition to restrictions imposed by ZRA stipulations, activities that may impact fish resources are reviewed under ADF&G Title 16 and Fish Habitat permit processes, and the U.S. Army Corps of Engineers Section 404 (Clean Water Act) permit process for jurisdictional waters (SPCO, 1993, 1995). Through continued and effective use of permit review processes, in addition to compliance with ZRA stipulations, the proposed action will likely have little impact on fish resources in ZRAs within the TAPS ROW.

Terrestrial Mammals

The proposed action would involve ground-impacting ROW maintenance in and near BLM-designated ACECs (APSC, 1993; BLM, 1989). In these special management areas, activities are restricted to meet designated sensitive habitat and management objectives (BLM, 1989 and 1991). ACECs primarily contain Dall sheep lambing areas and mineral licks in the vicinity of the Brooks Range. Through the continued and effective protection provided to terrestrial mammal habitats through ACEC activity restrictions, the proposed action is expected to have little impact on these resources (Sections 4.3.2.5 and 4.2.3).

Threatened and Endangered Species

Two species listed as threatened under the federal Endangered Species Act (Spectacled Eider and Steller's Eider) and two delisted subspecies of Peregrine Falcon (the *tundrius* and *anatum* races) would potentially be affected by activities associated with the proposed action. Occupied peregrine falcon nests, as designated by FWS through the Authorized Officer, constitute ZRAs. In these special areas, precautions must be taken for activities during breeding and nesting periods. In addition, FWS permits under Section 7 of the Endangered Species Act are required for some activities that may affect threatened and endangered species. Through continued and effective use of permit review processes, in addition to compliance with ZRA stipulations, the proposed action is expected to have little impact on threatened and endangered species in ZRAs along TAPS.

4.3.2.2 Vegetation and Wetlands

By J. McKendrick, D. Funk, T. Jorgenson, and J. Kidd

This section describes the environmental consequences of ROW renewal on vegetation and wetlands. This analysis of consequences is based on estimates of the ground-impacting maintenance expected during the period of renewal. The discussion includes a comparison of construction and maintenance impacts, common ecological effects, and characterization of the overall level of impacts to be expected from renewal. Also included is a summary of the extent, frequency, and duration of anticipated impacts, and the mitigative measures that have been taken to minimize changes in the natural vegetation from maintenance activities in the ROW. Impacts to vegetation and wetlands in the ROW and surrounding area have been grouped into the following categories:

- Habitat loss, alteration, and enhancement;
- Drainage and water flow issues;
- Thermokarst;
- Air pollution;
- Oil, fuel, and chemical fuel spills;
- Fire and fire management; and
- Revegetation.

Habitat Loss, Alteration, and Enhancement

Loss of wetlands associated with the TAPS ROW can occur as a result of pipeline replacement, pipeline reroutes, workpad maintenance and construction, and the development of material sites (JMM, 1990). Loss is primarily due to the placement of fill, but also may occur from dredging and excavation of wetlands or oil spills. Wetland loss from pipeline replacement and workpad construction typically occurs in the ROW, while pipeline reroutes, material sites, and oil spills also may include wetlands outside the ROW.

Only three pipeline replacements/reroutes have occurred along the TAPS ROW since startup: Dietrich River (1985), Atigun Pass (1987), and Atigun River (1991). The frequency of pipeline replacements/reroutes is expected to continue to be rare for the next 30 years because of advancements in pipeline integrity monitoring. Less than 1 mile (1.2 km) of pipeline was involved for the Dietrich River and Atigun Pass projects (see Section 4.1). Assuming a mean construction width of 80 ft (24 m), a maximum of 7 acres (15.4 ha) would have been affected for both sites if the two project areas included only wetlands. The pipeline replacement at Atigun Pass in the Brooks Range affected up to 11.9 acres (26.18 ha) (JMM, 1990). The losses were attributed to workpad, trench, and access-road construction.

The development of material sites during pipeline construction was one of the greatest impacts to wetlands, mostly riverine and palustrine, because many of the sites were located in floodplains (Pamplin, 1979). During construction, the Joint Federal/State Fish and Wildlife Advisory Team found numerous problems associated with the selection and development of several TAPS material sites

(Burger and Swenson, 1977). The most common problems included alteration of hydrology and increased siltation, but the loss of riparian habitat also occurred.

Because future maintenance of the ROW is not expected to require frequent pipeline replacements or reroutes, wetland losses should be minimal. The development of new material sites is expected to be limited as large volumes of gravel fill will not be needed for future ROW maintenance activities.

The alteration of wetland habitats along the TAPS ROW can occur from de-watering, water impoundment, thin gravel fill or dust outfall, compaction, and contamination from oil spills. Natural occurrences such as stream migration or erosion can also impact wetland habitat. No surveys of wetland alteration have been conducted along the ROW, but studies in the Prudhoe and Kuparuk oil fields (Walker, Cate et al., 1987; Kertell, 1993) found localized impacts to wetlands. It is reasonable to expect similar impacts from structures or activities that occur along the ROW.

Wetlands may be enhanced in areas adjacent to roads and pads where soil temperatures are higher and water impoundments have formed. Impoundments alter both the hydrology and species composition of wetlands. Plant productivity may increase biomass in a few species, or productivity may decrease as plants are lost to the development of deep open-water areas. In most cases, impoundments lead to a decrease in plant species richness (Klinger et al., 1983; Walker, Cate et al., 1987).

Hydrocarbon spills affect wetland communities by physically covering and killing vegetation, creating toxic soil conditions (Haag and Bliss, 1973; Deneke et al., 1974; Brown, J. and Grave, 1979; Jorgenson and Cater, 1996; Everett, 1978) and increasing the depth of the active layer in permafrost soils (Brown, J. and Grave, 1979; Lawson, D.E. et al., 1978). The effects of oil spills on vegetation are detailed under a separate heading in this section.

Dust. No studies have examined dust effects on vegetation along the TAPS ROW. However, impacts are probably minimal because of low vehicle speed and the limited frequency of vehicle passes. The effects of dust on vegetation have been documented along the Dalton Highway (Everett, 1980; Spatt, 1978; Walker, D.A. and Everett, 1987; Auerbach et al., 1997). These studies found early snowmelt, reduced soil-nutrient concentrations, lower moisture, altered soil organic horizon, and higher bulk density and depth of thaw. Plant species richness was reduced near the road, especially in naturally acidic soils. A decrease in acidophilous mosses, some lichen species, and certain heath taxa (Walker, D.A. and Everett, 1987) altered species composition. In areas with heavy dust fallout, native plant communities have been killed and replaced by early-successional colonizers. The magnitude of these effects depends on the duration of dust exposure (i.e., road traffic intensity) and the distance from the source. Dust loads decrease logarithmically with distance from the road (Everett, 1980). The zone of maximum dust fall is within the first 300 m from the road, and the area beyond this distance is essentially undisturbed (Everett, 1980).

Off-Road Use. Most off-road use along the TAPS ROW occurs in the winter by snow machines. Off-road terrain along the ROW is not easily traversed by off-road vehicle (ORV) in the summer. Alyeska activities are restricted to developed roads or workpads, and Alyeska can operate off these with agency approval only in winter snow-cover conditions. In areas where a heavy snow cover exists, impact to vegetation is minimal. However, in low snow years, prior to freeze-up, or in mountainous areas where windblown ridges are frequently free of snow, damage to vegetation from snow machines can be considerable. Based on studies of seismic trails on the Arctic Coastal Plain, the plant communities most sensitive to ORV traffic along the ROW include Tussock Tundra, shrub-dominated communities, and Sedge-Willow Tundra (Felix and Raynolds, 1989; Emers et al., 1995). Alpine plant communities sensitive to ORV use include Mesic Shrub Birch-Ericaceous Shrub, Mountain-Heath Dwarf Shrub Tundra, and Cassiope Dwarf Shrub Tundra (Racine and Johnson, 1988). The impacts associated with ORV use include torn and crushed vegetation mats with broken or abraded terminal branches, loss of mosses and lichens, and disturbance of the surface organic mat (Walker, Cate et al., 1987; Slaughter et al., 1989). In permafrost-rich soils, permafrost degradation and water ponding can occur when vehicle disturbance goes beyond the vegetative mat into the underlying soil. This can happen from either soil churning or extensive compaction of the vegetation that exposes the underlying soil. Water impoundment, especially in moist shrub-dominated communities, will likely alter the species composition in favor of sedges and other wetland graminoids. Disturbance of the vegetative mat alters plant community composition, favoring early successional grasses and forbs.

Drainage and Water Flow Issues

Drainage and water flow impacts likely to occur include permanent impoundments, erosion and sedimentation along stream channels and near culverts, sedimentation associated with erosion-control structures in floodplains, alteration of natural drainages through channelization and concentration of flow, and icings.

Impoundments typically occur in flat, wet areas where

surface runoff is blocked by gravel roads and pads that have inadequate cross-drainage structures. Along the ROW, impoundments are primarily restricted to the Arctic Coastal Plain, where the flat topography, indistinct drainage, and the presence of thaw-lake basins promote their occurrence. In the Prudhoe Bay oil field, impoundments covered 22 percent of a highly developed portion of the oil field and 3 percent of a broader portion of the oil field (Walker, Webber et al., 1987). Noel et al. (1996) put the percent of impoundment coverage in the Prudhoe Bay Unit at 0.8 percent based on more recent photos. Along the West Dock Road, Klinger et al. (1983) measured 331 acres (134 ha) of impoundments, although most of the flooding was only temporary. Impoundments also were noted at numerous locations on the upslope sides of material-site access roads which initially did not have culverts or low-water crossings (Berg, 1980). Along the ROW, approximately 2,225 acres (900 ha) of terrestrial habitat were converted to areas of ponded or flowing water, although most of this was associated with flooded mine sites (Pamplin, 1979). Many temporary impoundments are due to icing and temporary blockage of culverts during breakup (Hickok, 1981; Walker, Cate et al., 1987).

On the Arctic Coastal Plain, impoundments cause a wide range of ecological effects depending on depth and duration of water levels. These effects include thermokarst, large water-level decreases during the summer, increased plant productivity, and changes in species composition. In shallow areas, sedges become more common, whereas in deeper areas, complete plant mortality may occur (Klinger et al., 1983; Walker, Cate et al., 1987). These changes can in turn affect habitat use. Kertell (1993) found that although overall invertebrate and bird abundance was similar between impoundments and natural ponds, the modification of wetland habitats may benefit some species at the expense of others. Overall, impoundments probably will continue to impact vegetation adjacent to the workpad on the Arctic Coastal Plain, but current construction practices are helping to minimize impoundments. Along the remainder of the ROW, impoundments will be of only minor concern where drainages on sloping terrain are more distinct and culverts generally are more effective.

Erosion and sedimentation were widespread problems during initial ROW construction, but have mostly been eliminated by corrective maintenance. While 190 noncompliance reports related to erosion control and surface drainage problems were issued by Alyeska's environmental monitors in 1977, identified problem areas were reduced to 24 in 1979, and to 3 in 1980 (GAO, 1981) and have occurred only sporadically since 1980. The most serious problems were associated with cross-drainage, caused by combined thermal and hydraulic erosion downslope from the Haul Road, because of altering or concentrating drainage patterns in areas where runoff was more diffuse. In a few instances, such as adjacent to the road at Alyeska Material Site 135-A, the erosion channels formed a deep polygonal pattern in the ice-rich permafrost (Berg, 1980).

The ecological effects from the erosion and sedimentation included habitat destruction from gully formation, and minor habitat alteration and degradation of water quality and fish habitat from sedimentation. These problems, however, were generally confined to the Brooks Range. Although no data are available on the extent of habitat impacts, they were sufficiently small as to be a negligible component of habitat impacts (Pamplin, 1979). Mitigative measures included use of mulches, benches, diversion barriers, and sandbars for land-surface protection and use of rock-filled wire baskets, rock armoring, and revegetation for stream-bank protection. Many culverts were replaced with low-water crossings. Overall, maintenance of the TAPS ROW and work pad were considered excellent by the U.S. General Accounting Office (GAO, 1981) given the size of the project. Because stream channels and hydrologic processes are dynamic, monitoring and maintenance will continue after the ROW renewal to address minor continuing problems.

Sedimentation of barren riverbars and riverine willow communities can occur in slackwater areas behind erosion control structures constructed in floodplains. In the floodplain of the Sagavanirktok, Dietrich, and Delta rivers, most of the pipeline is buried in thaw-stable gravel, and numerous dikes and other erosion-control structures are in place. Data are lacking on the potential impacts of sedimentation behind these structures, but conceptual models of floodplain development in the Arctic (Bliss and Cantlon, 1957; Peterson and Billings, 1978; Jorgenson et al., 1998) and Subarctic (Viereck et al., 1993) indicate that the areas receiving siltation should be prime habitat for colonization by willows and other fast-growing colonizers.

Icings on large floodplains and along small stream and hillside watercourses are common occurrences in the Brooks Range and Alaska Range regions, and to a lesser extent in the Interior Forest region (Sloan et al., 1975). Icings at stream crossings are a continuing maintenance problem which can cause culvert blockage and delayed drainage during breakup (Berg, 1980), and tree mortality in small areas where icings persist in early summer.

Aufeis may also cause maintenance problems at stream crossings. Aufeis forms during winter when water flowing in a deep stretch of river is dammed by ice that has formed

in a more shallow stretch of river. The dammed water overflows the banks of the river and freezes. This may happen repeatedly, forming extensive layers of ice several meters thick (Pielou, 1994). Because of its thickness, this ice is slow to melt and may cause culvert blockage, flooding, and drainage problems along watercourses.

Thermokarst

Permafrost is sensitive to changes in surface conditions that alter the surface energy balance and increase heat flow into the ground. Even small disturbances to vegetative cover and soil moisture regime can increase the depth of the active layer, melt ice-rich permafrost below the active layer, and lead to the development of thermokarst — i.e., settlement of the ground after thawing (MacKay, 1970; Webber and Ives, 1978; Brown and Grave, 1979; Lawson, 1986; Jorgenson, 1986; Walker, Cate et al., 1987). The magnitude of the impact, however, depends mostly on the volume and type of ground ice, its distance from the surface, the soil texture, and the degree of initial disturbance (Brown and Grave, 1979; Lawson, 1986). Thermokarst is particularly problematic because small initial settlement can increase moisture at the surface. This change alters the energy balance and increases heat gain, and can lead to additional thermokarst (Jorgenson, 1986; Hinzman et al., 1997).

Thermokarst has resulted from a variety of disturbances associated with the North Slope oil fields and TAPS ROW, including:

- Impoundments (Lawson, 1986; Walker, Cate et al., 1987; Truett and Kertell, 1992);
- Dust deposition (Walker and Everett, 1987);
- Placement of thin gravel fill (Nelson and Outcalt, 1982; Lawson, 1986; Jorgenson and Joyce, 1994);
- Heavily used seismic trails (Felix and Raynolds, 1989; Emers and Jorgenson, 1997);
- Off-road traffic (Rickard and Brown, 1974; Brown and Grave, 1979; Walker, Cate et al., 1987; Slaughter et al., 1989; Racine and Ahlstrand, 1991);
- Heated structures (Burgess, Grechischev et al., 1993);
- Buried pipelines where adjacent surficial material is ice-rich (Thomas and Ferrell, 1983);
- Cleanup of oil spills (Jorgenson et al., 1991); and
- Removal of gravel for rehabilitation (Jorgenson and Joyce, 1994; Kidd et al., 1995).

In a heavily developed portion of the Prudhoe Bay oil field, 3 percent of the total area was affected by construction-related thermokarst, and this area appeared to be increasing with time (Walker et al., 1986). Along the ROW, permafrost degradation also is widespread (Brown, 1980; Hickok, 1981; Cuccarese, 1990), but has not been quantified. Most of the thermokarst along the ROW is associated with impoundments and cross-drainage problems. A limited amount of thermokarst was associated with buried sections of the pipeline and affected adjacent terrain, such as at MP 19, 574, and 734 (Thomas and Ferrell, 1983). These features usually were evident within the first few years after burial, and thermokarst was mitigated by filling sinkholes with gravel.

The ecological effects of thermokarst usually include increased thaw depths and soil temperatures, enhanced organic-matter decomposition and nutrient release associated with the increased temperatures, increased moisture, enhanced primary productivity, and shifts in species composition due to changes in soil properties (Ebersole and Webber, 1983; Emers et al., 1995). Thermokarst also is a natural process that is fundamental to plant distribution in many regions.

Ecological responses, however, can be as varied as the ecosystems involved. In the Arctic Coastal Plain and Arctic Foothill ecoregions, impoundments and dust typically cause ice wedges to melt, leading to development of permanent water in polygonal troughs and shifts in species composition to aquatic sedges (Brown, 1980; Ebersole and Webber, 1983; Walker, Cate et al., 1987). Much less information is available on thermokarst along the ROW in other ecoregions. In the Interior Forest ecoregion, impoundments, icings, dust, and clearing have much less effect on thermokarst development because ice wedges and segregated ice in general are less abundant. In the Copper Plateau ecoregion, where glaciolacustrine sediments are fine-grained, ice-rich, and near the melting point, substantial thermokarst has been noted along roads and clearings under powerlines (Ferrians et al., 1969; Péwé and Reger, 1983). Thermokarst associated with VSMs on slopes at Pump 11 Hill (MP 687) and Squirrel Creek (MP 717) are confined to the workpad (Thomas and Ferrell, 1983).

ROW renewal probably will cause few additional impacts. Thermokarst impacts from impoundments, icings, and dust are likely to persist with small amounts of additional settlement, but impacts to new areas should be negligible. Effects of clearings are poorly known, and it is likely that maintenance work could lead to minor thermokarst from changes in surface thermal regimes.

Air Pollution

The pump stations and the VMT emit air pollutants including nitrogen oxides (NO_x), O_3, and SO_2. Numerous studies in other locations have shown impacts of these pollutants on both vascular and non-vascular plants (Treshow, 1970; Nash, 1973; and others). The ambient-impact mod-

eling studies carried out for Pump Stations 2 and 7 for turbine rim cooling in 1990 included an evaluation of impacts of gaseous emissions on the local vegetation (APSC, 1990). No detrimental effects were predicted from the impacts of the modeled air emissions. The 1995 tanker vapor recovery air permit application evaluated impacts to soils and vegetation based on projected emission increases (APSC, 1990). It was determined that it is highly unlikely that there will be significant impacts on soils and vegetation due to project emission increases.

No direct studies of pollutant effects on vegetation near the pump stations or VMT have been conducted. However, Kohut et al. (1994) measured air-pollutant concentrations and their effects on vegetation adjacent to the Prudhoe Bay CCP, where gas-powered turbine pumps compress natural gas prior to injection. The CCP is the oil field's largest source of nitrogen oxides and produces O_3 and SO_2. Emissions from the CCP did not adversely affect local vegetation (Kohut et al., 1994). Results did show an increase in foliar nitrogen near the CCP, but no visible injury to plants was found. Physiological changes (photosynthesis and respiration) in plants were not apparent in either field or growth-chamber experiments for any of the pollutant gases, even at concentrations greater than those measured near the CCP. It is unlikely that pollutant emissions from the pump stations or the VMT exceed those of the CCP, and detrimental effects on vegetation around these facilities would not be expected. However, primary productivity in arctic and alpine tundra is often limited by nutrient supply, particularly nitrogen and phosphorus (Chapin et al., 1980; Chapin and Shaver, 1985; Funk and Bonde, 1986; McKendrick et al., 1978). Fertilizing leads to higher productivity and changes in the structure of arctic plant communities (Chapin and Shaver, 1985; McKendrick, 1997) and may alter carbon balance at the ecosystem level (Billings et al., 1984). Chronic pollution has been shown to have fertilizing effects on nutrient-limited vegetation (Funk and Bonde, 1986). Over a 30-year period, even low-level emissions may provide a nutrient source that alters the productivity of some plant species in communities near the pump stations and VMT, but these emissions are unlikely to have large impacts on nutrient availability.

Fire and Fire Management

Fires along the TAPS ROW are subject to the jurisdiction of various state or federal agencies. The Alaska Division of Forestry provides fire protection and management for the southern half of the ROW, while the northern part is covered by BLM's Alaska Fire Service and the U.S. Forest Service. The Alaska Interagency Fire Management Plan (ADNR, 1999b) provides for a full range of suppression responses from aggressive control that extinguishes the fire to surveillance. Suppression action is based on the fire's threat to human life, inhabited property, designated physical developments, and structural resources such as those designated as National Historic Landmarks, high-value natural resource areas, and other high-value areas such as identified cultural and historical sites. Decisions on fire suppression are at the discretion of the state or federal agency involved. Fires that threaten pump stations receive more control action than most of the pipeline route.

Operation and maintenance of TAPS do not directly affect fire-suppression decisions. Fire is a natural force in the Alaskan Interior, and most forest communities have been extensively influenced by recurring fire (Dyrness et al., 1986). There has been much debate on the effect that fire suppression has on the natural fire cycle, which has been estimated to range from 50 to 200 years (Heinselman, 1978; Yarie, 1981; Dyrness et al., 1986). Gabriel and Tande (1983) suggest that Alaska may still be in a "wilderness fire" stage and that fire suppression has had no pronounced effect on the natural fire cycle.

Oil, Fuel, and Chemical Spills

Responsibility for oil spill monitoring along TAPS has been delegated by EPA to the BLM for federal lands crossed by the pipeline. The Alaska Department of Environmental Conservation was designated to monitor spills on state lands by EPA (BLM, 1984). Most of the spills reported along TAPS occurred on the workpad and were small product leaks. Only a few significantly impacted vegetation.

Information on revegetating oil-damaged sites along TAPS has not been published and is confined to observational comments and photos. Before construction of TAPS, there was much interest and research on oil spill mitigation and revegetation in Alaska and Canada, and controlled experiments were conducted (Wein and Bliss, 1973; Mitchell and McKendrick, 1975). The Alaska oil industry, including Alyeska, sponsored meetings between Alaskan and Canadian researchers to exchange findings and report on progress. The first Joint Canadian-Alaskan Arctic Workshop was held November 6-7, 1974 in Anchorage. The second was held in Banff, Canada, the following year. Subsequently, interest in controlled research diminished, and much of the information available has since been derived from studies of spills. One exception was an ARCO-sponsored experiment on oil recovery from tundra (Cater et al., 1996). With the discontinuance of controlled studies and the Alaska-Canada meetings, progress on oil spill

revegetation research in Alaska has been slower than previously.

One of the first field investigations of spills of opportunity in Alaska was an evaluation of oil spills along the Haines-Fairbanks military pipeline (Richard and Deneke, 1972). Conclusions from observing 15-year-old accidental jet-fuel spills were that plants recovered better in wet drainages than in drier habitats. Authors attributed that to leaching, which removed the contaminant. However, controlled studies lead to conclusions that wet areas are more resistant to oil spills, probably because water perches the oil, preventing it from penetrating deeply into the soil (Walker et al., 1978; McKendrick, 1999a). Reserve pit leaks in NPR-A provided an opportunity for investigation in 1983 (McKendrick, 1986). Subsequent inspections revealed significant recovery of tundra vegetation in leak areas, primarily by hydrophytic sedges and grasses (McKendrick et al., 1992).

The BLM monitored and documented the vegetation recovery on six crude oil spills along TAPS (Table 4.3-9). That report contains photos showing that certain indigenous plants affected in the tundra region and the forest zones were able to recover. Only one site affected by crude oil spills in the BLM monitoring report was seen during the 1999 field evaluation (Check Valve 7) (Table 4.3-9), and the 1999 observers were unaware that a spill had occurred at that location. Apparently, tundra recovery during the 22-year period following the spill was satisfactory (McKendrick et al., 1992).

After inspecting one of the earliest tundra spills, Mitchell (1977) warned that cleanup activities could intensify the damage to vegetation, and recommended that minimal efforts be expended where possible. The BLM observers and L.A. Johnson (1981) reported such was the case at that spill site. Damage from cleanup activities was also intensified at a crude oil spill in the Kuparuk oil field (Cater et al., 1996).

Revegetation

No revegetation project in Alaska has equaled the scope of TAPS revegetation, which was conducted to protect soils from erosion, restore wildlife habitat, and improve visual appearances where vegetation was removed.

Before TAPS, expertise, crucial information, suitable plant materials, and application industries for revegetation were minimal in Alaska. Because the route spanned arctic and subarctic environments, difficulty for planning and review of the proposal by agencies and environmental groups was compounded. It was hoped that the TAPS route could be revegetated with native plant species (Dabbs, 1976; Johnson, L.A., 1981). Research on plants and soils along the route began in 1970 and extends to the present at some locations (Anonymous, 1970; Johnson, L.A., 1981; McKendrick, 1976, 1991, 1997; Mitchell, 1970a, 1970b, 1971, 1973, 1974, 1976, 1978, 1979, 1981, 1982, 1986, 1988; Mitchell and Allen, 1973; Mitchell et al., 1972; Mitchell and McKendrick, 1974; Mitchell et al., 1974; Neiland, 1978; Van Cleve and Manthei, 1973). Studies were conducted along the proposed ROW at Prudhoe Bay and in the Matanuska Valley. Results of these studies and need for commercial seed production in Alaska prompted the state legislature to create a Plant Materials Center in Alaska (Logsdon, 1973).

However, it was not possible to use indigenous plant seed for much of the ROW. The availability of plant materials developed more slowly and in insufficient quantities for project needs. Thus, most of the grass seeds applied were introduced forage, pasture, and turf varieties. Four mixtures were specified for various sections of the route, according to environmental conditions. Grass seed mixtures

Table 4.3-9. *Six crude oil spills monitored by BLM along the TAPS ROW (McKendrick et al., 1992).*

Location Name	Spill Date	Gallons	Cause	Revegetation Action	Photo Record
Check Valve 7	July 19, 1997	75,600	Valve damaged	Mulch + seed + fertilizer	July 19, 1977 July 11, 1988
Check Valve 68A Washington Creek	October 11, 1977	3,700	Valve not tight	Unknown	August 1978 July 9, 1986
Steele Creek	February 15, 1978	672,000	Sabotage	Burned, buried, seeded 1981-82	February 15, 1978 June 10, 1986
Atigun Pass	June 10, 1979	221,200	Pipe cracked	Hydroseeded 1979	June 1983(?) August 5, 1986
MP 734	July 15, 1979	168,000	Pipe cracked	Seeded & fertilized Proposed burial	June 1979 June 14, 1988
Check Valve 23	January 1, 1981	84,000[a]	Valve failed	Applied 300 lb/a	January 1981 July 12, 1988

(a) From JPO records. Alyeska records indicate that the spill volume was 63,000 gallons.

included: *Agrostis alba* (creeping bentgrass or redtop), *Alopecurus pratensis* (meadow foxtail), *Arctagrostis latifolia* (polargrass; indigenous selection), *Bromus inermis* (smooth brome), two varieties of *Festuca rubra* (red fescue; one indigenous selection), *Festuca ovina* var. *duriuscala*, *Lolium multiflorum*, *Phleum pratense*, and two varieties of *Poa pratensis* (bluegrass; one originating in Alaska). Hultén (1968) listed *Poa pratensis* as an introduced weed to Alaska, even though it is a major turf grass in this state. These mixtures were modified slightly in 1977 (Johnson, L.A., 1981). *Poa glauca* (glaucous bluegrass), *Deschampsia beringensis*, and *Calamagrostis canadensis* (bluejoint) were added to, and *Agrostis alba* and *Poa pratensis* were removed from, the arctic seed mix in 1984 (McKendrick et al., 1992). Modified mixtures are now used where pipeline maintenance disturbs vegetation along TAPS.

Concerns were raised over introducing weeds and exotic plant species along TAPS. The bulk of the grass seed was produced outside Alaska, in Canada, Oregon, and Washington (Johnson, L.A., 1981). Straw and hay mulches were applied. The imported seed and mulches were likely sources for exotic species. L.A. Johnson (1981) and Johnson and Kubanis (1980) reported on the presence and distribution of weeds along TAPS. During the summer of 1999, locations along the ROW were investigated for presence of weeds (Table 4.3-10) (McKendrick, unpubl. data). Most exotic species were seeded grasses, with *Festuca rubra* the most common and widely distributed. Broad-leaved weeds (forbs) were most common in the Interior from about MP 250 south. Numbers of exotic species were elevated in the vicinity of settlements such as Fairbanks and Delta Junction, where agriculture and landscaping are practiced, suggesting introductions on the ROW were related not only to revegetation practices, but also to the surrounding human activities.

None of the plants found is classified as a noxious weed. Species that L.A. Johnson (1981) specifically mentioned as possible problems were: *Chenopodium album* (pigweed) and *Bromus tectorum* (cheat grass) (both exotics), and *Corydalis sempervirens* (rock harlequin) and *Senecio congestus* (marsh fleabane) (both indigenous). During the 1999 survey, *Chenopodium album* was found at two sites near Delta Junction. *Bromus tectorum* (cheat grass) and *Senecio congestus* were not observed at any of the locations in 1999; however, it has been observed as a common pioneer in wet areas along the Dalton Highway and was recorded at the Franklin Bluffs pad in 1987 (McKendrick et al., 1992). *Corydalis sempervirens* was found in one location, a recent black spruce forest burn next to the ROW on

Table 4.3-10. *Numbers of graminoid and forb "weeds" and/or introduced vascular plant species found at each of 52 locations along the TAPS ROW during July-September 1999 survey (McKendrick, unpubl. data).*

Pipeline	Latitude		Number of Species		
			Weeds		
MP	Degree	Minute	Grami-noids	Forbs	Total Weeds
0.25	70	1.5	1		1
16.00	70	2	2		2
31.00	69	49	2		2
58.70	69	30	1		1
69.00	69	19	1		1
85.00	69	5	1		1
100.00	68	53	1		1
119.70	68	40	1		1
139.60	68	28	1		1
154.00	68	17	1		1
163.40	68	11	1		1
165.10	68	8	2		2
166.00	68	7	2		2
168.50	68	6	2		2
173.70	68	2	2		2
176.50	68	1	1		1
188.00	67	52	2	1	3
190.00	67	51	1		1
208.30	67	36	2		2
226.00	67	24	1		1
245.40	67	9	3	2	5
258.25	66	59	2	2	4
276.00	66	47	3	2	5
299.70	66	29	2	1	3
322.60	66	12	2	1	3
346.90	65	55	3	3	6
360.20	65	50	3	5	8
396.00	65	29	4	5	9
406.00	65	23	5	5	10
412.30	65	19	4	6	10
420.60	65	10	4	5	9
438.70	65	2	3	0	3
441.80	65	1	3	7	10
461.00	64	49	3	2	5
489.20	64	33	4	5	9
521.10	64	15	3		3
542.00	64	1	3	3	6
547.70	63	56	1	3	4
559.40	63	47	1	1	2
587.50	63	23	2		2
599.00	63	15	1		1
606.50	63	12		1	1
613.40	63	5	2	1	3
639.80	62	43	3		3
654.80	62	31	2	4	6
685.15	62	6	2	3	5
688.90	62	2	3		3
709.70	61	47	2	1	3
724.60	61	35	2	3	5
745.20	61	22	3	2	5
769.00	61	11	3		3
777.50	61	6	4	4	8

Ft. Greely.

Concerns have also been raised over the possibility that grasses seeded to the ROW and other disturbances may interfere with the recovery of natural vegetation on such sites (Johnson, L.A., 1981; Cargill and Chapin, 1987; Densmore et al., 1987; Densmore, 1992; McKendrick, 1997; Strandberg, 1997; Forbes and Jeffries, 1999). That was apparent along the ROW in 1999 (McKendrick, unpubl. data). Generally, native plant invasion was greater in locations where seeded grasses failed to persist. In the Arctic, *Festuca rubra*, *Arctagrostis latifolia*, and *Poa glauca* often prevail over indigenous plant species. In the Subarctic, *Festuca rubra, Alopecurus pratensis, Bromus inermis, and Phleum pratense* (alpine timothy) will endure and prevent natural reinvasion. Indigenous graminoids can also dominate open ground and prevent other species from recolonizing. *Calamagrostis canadensis* often slows the return of trees and browse species in the mixed forests of the Interior and coastal regions.

For the TAPS ROW, however, the effects of seeding introduced grasses, applications of fertilizer — which also redirect natural succession — and construction of a drier, gravelly workpad (Table 4.3-11) cannot be individually distinguished. Thus, it is impossible to quantify effects of these factors on natural species reinvasion. The 1999 survey of the ROW shows that at least two introduced species in the seed mixtures [*Agrostis alba* and *Lolium multiflorum* (Italian ryegrass)] failed to persist and were least likely to alienate natural species from the ROW. *Poa pratensis* failed to persist when seeded to abandoned drilling pads in NPR-A (McKendrick, 1987). This suggests that revegetation research objectives would better serve projects such as TAPS if the species selected established readily to control erosion, but are either short-lived or poorly adapted to the environment and thereby noncompetitive to indigenous species. Examples of such species for the Prudhoe Bay region are the arctic alkali grasses *Puccinellia arctica* (*P. borealis)* (McKendrick, 1987, 1991) and *Puccinellia langeana.*

Vegetation along the ROW from Atigun Pass south has often been dominated by the reinvasion of native shrubs and trees, including alder, willow, blueberry, soapberry, dwarf birch, cottonwood, paper birch, spruce, and at some locations, larch. Since this invasion of woody plants has created a maintenance problem for the safe operation of the pipeline, the ROW is periodically cleared of brush. In locations near Fairbanks, the cut brush has been observed to regrow as much as 3 ft (1 m) during the balance of the growing season, if cut in spring (Duncklee, 1999, pers. comm.). Seeding of a persisting herbaceous cover to prevent invasion by tall shrubs and trees in that ecoregion appears desirable for the safe operation of the pipeline.

Soil conditions were altered in the ROW with the application of soil and gravel to provide a firm surface for construction and maintenance operations. With respect to vegetation, this fill created a drier and more rocky substrate with less total carbon and nitrogen (Table 4.3-11). Applications of fertilizer were still apparent in levels of available phosphorus (P) and potassium (K) in 1999, more than 25 years since construction began. Nitrogen applications were no longer apparent in the soil tests. Even though the substrate was markedly altered throughout much of the ROW, recolonization of natural vascular plants was apparent in varying amounts throughout. Cryptogams (mosses, liverwort, and lichens) had also colonized, particularly in the boreal zone, accounting for part of the organic mat accumulation recorded in the 1999 survey (Table 4.3-11).

Most of the land disturbed during TAPS construction was seeded to grasses to control soil erosion, including thermokarst in permafrost zones. In some areas, trees were transplanted to screen the view of disturbances from roadways (Johnson, L.A., 1981), and willow cuttings were used to create wildlife habitat at several locations in 1977 and 1978. Rooting potentials for *Salix alaxensis, S. novaeangliae, S. scouleriana, S. glauca,* and *S. bebbiana* were

Table 4.3-11. *Means from 49 locations along TAPS (July-September 1999) from within the ROW (either under elevated or over buried pipe) and adjacent control sites. Standard errors are given in parentheses. Upper 15 cm (6-in) of soil beneath organic mat were sampled and analyzed in Alaska Agricultural & Forestry Experiment Station Laboratory, Palmer, AK. Thickness of surface organic mat was recorded. Fifty-two locations were examined, and three had no soil to sample.*

Soil Moisture (%)		Gravel (%)		Organic Mat Thickness (cm)		Total Carbon (%)		Total Nitrogen (%)	
ROW	Control	ROW	Control	ROW	Control	ROW	Control	ROW	Control
9.2 (.782)	62.1 (13.651)	60.3 (2.061)	19.1 (3.254)	2.0 (.205)	12.6 (1.226)	1.7 (.201)	5.4 (.852)	.056 (.007)	.236 (.039)
pH		**Available NH_4-N**		**Available NO_3-N**		**Available P**		**Available K**	
ROW	Control	ROW	Control	ROW	Control	ROW	Control	ROW	Control
7.45 (.131)	6.40 (.151)	1.4 (.245)	0.9 (.286)	1.4 (.236)	1.6 (.277)	8.2 (2.394)	7.6 (3.208)	39 (3.325)	33 (3.533)

tested by Densmore and Zasada (1978). The use of non-rooted cuttings was reported to have been more successful than rooted cuttings (Johnson, L.A., 1981); however, there were other complicating factors that may have been as much or more influential than whether or not cuttings were rooted. In 1999, a vigorous stand of *Salix alaxensis* at MP 122 in the Saganavirktok River channel was observed and photographed. This planting is part of a long-term monitoring of large-scale willow reintroduction (Zasada et al., 1981).

L.A. Johnson (1981) reported that Alyeska transplanted trees and shrubs at select locations where the pipeline crossed roads and material sites were particularly visible. Species included *Betula papyrifera* (paper birch), *Picea glauca* (white spruce), *Picea mariana* (black spruce), *Populus tremuloides* (quaking aspen), willow, and alder. Most obvious to the public were the staked spruce (*Picea* spp.) transplants at pipeline crossings. These stands can still be observed.

Following construction and seeding of the ROW, the industry and agencies measured revegetation success by estimating plant canopy cover, which included litter and standing dead. Plant vigor was also rated. The target cover was reduced where soils were obviously limiting vegetation in natural communities and in those remaining after disturbance (Alaska Pipeline Office, 1978; Johnson, L.A., 1981). Roads used for pipeline maintenance and operation were also excluded from revegetation criteria.

Fertilization was considered necessary to encourage rapid establishment of plants on the open soil and to control erosion. Surface soils were extensively sampled along the route and analyzed to evaluate nutrient status before construction (Johnson, L.A., 1981). Fertilizers were formulated to supply macro- and micronutrients according to information acquired from those laboratory data and short-term tests (Van Cleve and Manthei, 1973). Where seedlings were not developing quickly, fertilizer containing only the macronutrients was applied again. Just as there was a necessary compromise between species desired and those available for seeding, so too there was a compromise on fertilizer use. Practically no correlation data existed among laboratory soil tests, fertilizer applications, and indigenous plant responses in Alaska at the time the pipeline was built. Consequently, fertilizer formulations were based on correlations derived from temperate-zone agricultural production. Furthermore, the soils on the surface following construction were often subsoils and geologic rubble (gravel). How their nutrient-supplying capacities related to the surface soils which were sampled and used to derive fertilizer recommendations is entirely unknown. Most likely, their nutrient status differed markedly from those soils which were sampled and tested.

There were incidences of erosion even on seeded areas. These occurred primarily in cuts where slopes failed (Johnson, L.A., 1981). It is impossible to know whether or not the grass seedings were effective in limiting the extent of that erosion or not, because there were no controls for comparison. No serious erosion problems related to the pipeline construction and operation were observed in the 1999 survey. The only erosion that presented a significant risk to the elevated pipe was actually a natural landslide in the Atigun Canyon. High amounts of precipitation in the mountains created rock and mud slides that carried debris including large boulders down side canyons. The mass moved down the alluvial fan, across the Dalton Highway, and under the elevated pipe. This type of erosion has been periodically observed in the Atigun and Dietrich valleys since TAPS construction, and may occur any time during summer.

4.3.2.3 Fish

By R. Fechhelm and L. Moulton

Impacts on fish and their habitat can occur from continued operation and maintenance of TAPS as a result of a number of activities that can potentially alter habitat or water quality. These impacts fall into four general categories: (1) obstructions to movement, (2) habitat alteration or loss, (3) mortality, or (4) overharvest.

Obstructions to Movement

Obstructions to fish movement are most common when culverts or low-water crossings are not properly sized to allow passage at the desired migration time (Gustafson, 1977; Rockwell, 1978; Elliott, 1982). Movement can be obstructed at either high or low flow (Elliott, 1982). Elliott (1982) investigated stream crossings and channel modifications in the Atigun River in 1980 and described a number of fish passage problems associated with culvert placement and design. DenBeste and McCart (1984a) concluded that most of the passage problems were from pipeline construction, with substantially fewer problems during pipeline operation. However, in low-water crossings, vehicular traffic causes rutting and accumulation of cobbles that can interfere with fish passage during low flow. Low-water crossings, which were identified as creating passage problems early in construction (Gustafson, 1977; Rockwell, 1978), continue to be an issue (Brna, 1999, pers. comm.; Montgomery, 1999, pers. comm.).

Obstructions to fish movement can occur where work in

active channels, such as instream gravel mining, spread flow or cause flow to go subsurface (Woodward-Clyde Consultants, 1980; Elliott, 1982). Such a loss of surface flow occurred at the Atigun River where flow went subsurface into the pipeline trench, which was buried in the active floodplain (Elliott, 1982). These obstructions to movement were recognized either during the construction phase or early in operation and have been addressed with subsequent permitting and monitoring.

Activities that can obstruct movements are reviewed under the ADF&G Title 16 and Fish Habitat permit processes. ADF&G issues notices of permit violations when a passage problem is identified, at which time Alyeska corrects the problem (Brna, 1999, pers. comm.). Effective use of these review processes has minimized, and will likely continue to minimize, obstructions to fish movement along TAPS (SPCO, 1993, 1995).

Habitat Alteration or Loss

Habitat alteration from erosion and siltation during pipeline construction and maintenance was recognized early as potentially having the greatest impact on fish habitat (FWS, 1970). Sedimentation occurred from instream gravel mining during pipeline construction (Woodward-Clyde Consultants, 1980). Erosion of workpads may also increase sedimentation, which in turn affects the productivity of streams crossing the pipeline alignment (DenBeste and McCart, 1984a). Increased sediment can reduce levels of invertebrate prey species and can affect fish spawning success and egg survival. Introduction of fine materials into spawning gravels can adversely affect incubating eggs and alevins.

In some cases, habitat alteration may provide some benefit to aquatic systems. For example, at MP 47, a spur dike caused a scour pool that added overwintering habitat in the Sagavanirktok River (Martin et al., 1993). Increased overwintering habitat in pits created by gravel mining in inactive floodplains has been well-documented (Woodward-Clyde Consultants, 1980; Hemming, 1993, 1994, 1995).

During operation and maintenance of TAPS, there has been progressive restoration of stream banks and erosion control (Thompson, 1999, pers. comm.). Effective use of the ADF&G permit review processes will likely continue to minimize habitat alteration and loss along TAPS (SPCO, 1993, 1995).

Anadromous fish species may be affected by deposits of airborne pollutants onto surface waters that can be subsequently dissolved into the water column. The ambient-impact modeling studies carried out for TAPS Pump Stations 2 and 7 for the addition of turbine rim cooling in 1990 included an evaluation of impacts of gaseous emissions on nearby wildlife species (APSC, 1990). Air quality effects on anadromous fish streams were examined for the Sagavanirktok and Chatanika rivers. The Sagavanirktok is approximately 1/8 mile east of Pump Station 2, while the Tatalina River (a tributary to the Chatanika) is approximately 1.6 miles north of Pump Station 7. The Tatalina flows into the Chatanika approximately 50 miles southwest of the pump station. The levels found in modeling studies carried out for the pathway of deposition of the main criteria pollutants NO_X and SO_2 for both river systems were below EPA screening levels. The studies did not predict significant impacts on existing anadromous fish species.

Mortality

Direct mortality is a potential impact when overwintering habitat is altered or lost, when flow is altered, or water quality degraded. Overwintering has been identified as the most critical life stage for fish inhabiting arctic and subarctic freshwater environments (Power, 1997; Reynolds, J.B., 1997; Moulton and George, 2000). Because overwintering areas are scarce in many river systems, mortality to a large segment of the fish population in a stream system can result when flow is diverted from an overwintering area or water quality is degraded by increased turbidity or toxic materials. Potential effects to overwintering areas were identified as concerns during Sagavanirktok River flood repairs and corrosion digs in 1993 and 1994, Dietrich River spur dike construction, and Phelan Creek corrosion digs in 1993 (SPCO, 1993, 1995).

Entrapment during low summer flow is another source of mortality associated with pipeline construction and maintenance. Entrapment occurs where decreasing flow strands fish in isolated pools, which can then dry out, become too hot to support fish, or freeze during winter. Flow often becomes discontinuous when the stream bed is disturbed by activities that increase porosity or spread flow. Gravel mining in active floodplains has been found to lead to entrapment (Woodward-Clyde Consultants, 1980; Elliott, 1982; DenBeste and McCart, 1984a).

Another source of entrapment is the attraction of fish to water heated by the pipeline. In these cases, the pipeline buried in an active floodplain heats subsurface water. The water emerges at a higher temperature than the receiving water, and fish are attracted during fall as they search for overwintering areas (DenBeste and McCart, 1984a). Mortality occurs when water freezes during the following winter or the pools become anoxic. Thermal irregularities were found in the Atigun, North Fork Chandalar, Dietrich, and

Middle Fork Koyukuk rivers. DenBeste and McCart (1984a) concluded that small numbers of fish were being lost in those streams where extensive instream pipeline burial caused such thermal irregularities.

Oil and Chemical Spills. Potential sources of spills during pipeline maintenance and operation include fuel spills from vehicles, spills of various chemicals used at the pump stations, and spills of crude oil from the pipe itself. Oil spills have a range of effects on fish depending on the concentration of oil present, the length of exposure, and the life-history stage of the fish involved (Starr et al., 1981; Hamilton et al., 1979; Malins, 1977; Neff and Stubblefield, 1995; MMS, 1996a). Fish eggs, larvae, and juveniles are the most sensitive life-history stages. Mortality caused by petroleum is seldom seen outside the laboratory, and most acute toxicity values for fish are on the order of 1 to 10 ppm (BLM and MMS, 1998). Even during the *Exxon Valdez* spill, the concentration of oil in water was not sufficient to cause fish mortalities (Neff and Stubblefield, 1995). Sublethal effects may include changes in growth rates, feeding, fecundity, and survival rates, as well as reductions in food resources and consumption of contaminated prey (BLM and MMS, 1998). Temporary displacement may occur through interference with movements to feeding, overwintering, or spawning areas.

Most oil and chemical spills are small and confined to workpads where they would not impact fish. A large off-pad spill to water could have lethal or sublethal effects on fish and their food resources in the immediate spill area. Effects would be greatest if the spill occurred where and when fish were migrating, in overwintering areas while fish were present, or in small waterbodies with restricted water exchange. A spill of sufficient size under the above conditions would be expected to have lethal and sublethal effects on most of the fish present. BLM and MMS (1998) suggested that recovery of a small waterbody with restricted water exchange would take more than 5 years. Water with high exchange rates would recover more quickly, although flushing of contaminated water would impact a greater area with lower concentrations of oil.

Overharvest

Potential overharvest of fish populations by humans was identified as an issue early in the original TAPS evaluation process (FWS, 1970). Overharvest can occur when access is provided to desirable resources and fishing regulations and enforcement do not adequately control harvest. Developments in remote areas, such as the TAPS ROW and associated road, can allow access to previously unavailable harvest opportunities, and concern was expressed that such access may lead to excessive harvests (FWS, 1970). The problem is magnified in northern areas because productivity is low and populations are more susceptible to excessive harvest. BLM and USACE (1988) state that sport fishing pressure has increased since construction of the TAPS haul road (now the Dalton Highway) and that fish are smaller and less numerous than before road access. Issues regarding overharvest of fish on the North Slope are described in detail in the cumulative effects section of this document (Section 4.5).

4.3.2.4 Birds

By B. Anderson, R. Day, S. Johnson, R. Ritchie, and D. Troy

The effects of the proposed action on birds can be grouped into the following general categories:

- Obstructions to movements by the ROW and pipeline, activities at pump stations, and during maintenance along the pipeline and, at the northern end of the corridor, by TAPS-related vehicular activity on the Dalton Highway;
- Disturbance and/or displacement of birds by operational or maintenance activities (e.g., vehicular traffic, human activity, noise);
- Habitat loss, alterations, or enhancement from operational or maintenance activities;
- Mortality or injury associated with operational or maintenance activities, including oil spills; and
- Changes in harvest of game species associated with the TAPS ROW, primarily via increased hunter access.

Obstructions to Movements

The pipeline, associated facilities, and access roads along the TAPS ROW do not obstruct bird movements because birds can fly. There is no evidence that TAPS has caused population reductions in birds. Collisions of birds with pipelines or TAPS facilities are rare. The elevated pipeline, facilities, or roads would possibly act as barriers to movement only when birds are flightless, such as waterfowl during molt and brood rearing. Roads can temporarily obstruct movements of brood-rearing waterfowl in the North Slope oil fields when traffic levels are high (>10 vehicles/hr; Murphy and Anderson, 1993), but long-term studies have shown that molting and brood-rearing Snow Geese are not affected by roads and pipelines (Johnson, 1998). Elevated pipelines adjacent to roads appear to have little effect on movements of brood-rearing waterfowl in the oil fields (Murphy and Anderson, 1993). In 1987, brood-rearing Snow Geese showed some “initial hesitancy”

in crossing under the new Endicott pipeline (Burgess and Ritchie, 1991). The birds became habituated, and this reaction disappeared in later years as these long-lived birds repeatedly encountered the pipeline and adjacent roads while using their traditional brood-rearing areas (Johnson, 1998; Burgess, 1999, pers. comm.). Disturbance reactions by birds, which may affect local movements, probably do not apply to the TAPS pipeline because it has been in place for over 20 years. The cited studies suggest that in the absence of traffic on adjacent roads, most elevated pipelines do not affect bird movements.

Disturbance and Displacement

Equipment noise, vehicles, pedestrians, aircraft operations, boats associated with spill response drills, and other maintenance and operation activities of TAPS could result in some disturbance of birds near facilities. Disturbance due to pipeline construction may have reduced nest densities near Franklin Bluffs on the northern end of the TAPS ROW (Hanson and Eberhardt, 1982). Scheduling of most construction activities during winter would minimize disturbance and mitigate most impacts on birds. Most bird species along TAPS are not residents and few birds are present in winter. Exceptions include resident Gyrfalcons near traditional nesting sites, ptarmigan, grouse, and ravens.

At the northern end of the TAPS ROW, disturbance from operations at pump stations is similar to the well-documented effects of oil field operations (Hampton and Joyce, 1985; Woodward-Clyde Consultants, 1985; Anderson et al., 1992; Burgess and Rose, 1993; Murphy and Anderson, 1993; TERA, 1993b; Troy, 1993). Vehicles are the most ubiquitous source of disturbance, but are less disturbing than humans on foot or natural predators (bears, foxes or gulls). The level of disturbance increases with increasing traffic rate and the numbers of large, noisy vehicles (and those with unusual profiles such as boom cranes) (Murphy and Anderson, 1993). Most human disturbance occurs close to roads and pads. In the Lisburne Development Area at Prudhoe Bay, most reactions of geese and swans occurred within 500 to 700 ft (150 to 210 m) of pads and roads (Murphy and Anderson, 1993). The greatest disturbance occurred within 600 ft (180 m) of roads when traffic exceeded 6 vehicles/hr, although less than 1 percent of all vehicles elicited reactions from geese and swans (Murphy and Anderson, 1993).

Based on these findings, traffic-related disturbance would be highest for waterfowl and other birds using habitats within 700 ft (210 m) of the pump stations and within 500 ft (150 m) of access roads and the Dalton Highway. South of Fairbanks, most traffic is on the Richardson Highway (the closest adjacent road) and is not related to TAPS. Although some disturbance would occur from TAPS traffic related to the proposed action, the incremental contribution would be small. Disturbance effects at the pump stations in this region would be similar to those reported above, although the magnitude probably would be lower due to sound dampening by the taller vegetation found in Interior Alaska.

Continued brush clearing along the TAPS ROW would cause short-term disturbance of birds in the immediate vicinity and would displace nesting birds that use shrub vegetation. This disturbance may cause nesting birds to shift into adjacent undisturbed habitats. Disturbance and displacement of birds in the immediate area of the clearing operations also could occur from the high noise levels and visual impacts of humans and equipment removing brush along the ROW. The magnitude of this impact would be moderate to severe in the short term for passerine birds nesting in the habitats being cleared, but the low frequency of this activity and its short duration would minimize its impact on most birds. Adjusting the seasonal timing to avoid the early summer nesting period of most birds could mitigate brush-clearing impacts.

Potential disturbance effects on birds also could occur from the regular (about once a week) helicopter surveillance flights along the TAPS ROW by Alyeska Security at approximately 500 ft (150 m) above ground level. Most studies of aircraft disturbance in the Arctic have focused on low-flying helicopters (LGL, 1974; Barry and Spencer, 1976; Simpson et al., 1982; Ritchie, 1987; Derksen et al., 1990, 1992). Some waterfowl species, such as Brant and Snow Geese, are more sensitive to disturbance by helicopters, particularly at altitudes less than 800 ft (240 m), than are other geese (Canada and Greater White-fronted Geese) and other birds species groups (LGL, 1974; Derksen et al., 1992; Murphy and Anderson, 1993; Ward et al., 1994). Other studies on the North Slope have shown that some species of nesting and molting ducks may be displaced by disturbance (Johnson, 1982, 1983, 1984, 1990a, b, 2000b). The visual and auditory impacts of helicopter overflights on birds inhabiting forest habitats along TAPS would be mitigated to some extent by the visual and sound barrier provided by surrounding vegetation. The low frequency and short duration of surveillance flights and the potential habituation by some birds would also mitigate these impacts.

Chronic disturbance by human activities at facilities may cause adjacent habitats to be less attractive to some birds. This change is less an immediate behavioral reaction to noise than a long-term reduction of bird use in areas exposed to constant disturbance. Early studies of noise effects

on birds in the Arctic found that simulated compressor noise did not affect nesting Lapland Longspurs (Gollop and Davis, 1974a), but decreased habitat use by fall-staging Snow Geese (Gollop and Davis, 1974b). More recently, a study of the effects of increased noise at the Central Compressor Plant in the Prudhoe Bay oil field found that Spectacled Eiders and pre-nesting Canada Geese were displaced from habitats near noise sources (Anderson et al., 1992). Most species, including nesting Canada Geese and brood-rearing Brant, habituated to the noise levels (Anderson et al., 1992). Other studies (Johnson et al., 1987) showed that mitigation greatly reduced disturbance impacts on eiders. A study to quantify the effect of a new processing facility (CPF-3) in the Kuparuk oil field provided equivocal results (Hampton and Joyce, 1985). However, the Brant nesting colony located approximately 0.5 mi (0.8 km) from CPF-3 has not been affected adversely by the constant noise from the facility, and this nesting location has been used continuously since operation began (Stickney et al., 1994; Anderson et al., 1995, 1996). Because facilities along TAPS have been operating for over 20 years, most birds using adjacent habitats probably have habituated to the noise.

Habitat Loss, Alteration, and Enhancement

Thick gravel fill used for most workpads and roads in the TAPS ROW covers some wildlife habitats. New placement of gravel fill during the next 30 years is expected to be minimal. Studies in the Prudhoe Bay oil field suggest that birds, particularly shorebirds, that lose nest sites to gravel placement are not prevented from nesting in subsequent years, but shift their nesting efforts to adjacent undisturbed habitats (Troy and Carpenter, 1990). Given the relatively small area that would be covered by newly placed gravel, the direct effects on bird populations of gravel placement are expected to be minor.

Bird use of habitats adjacent to the Dalton Highway and pump stations could be affected by dust fallout, gravel spray, persistent snowdrifts, impoundments, thermokarst, contaminants, and water withdrawal. The magnitude of these impacts depends on habitat type, volume of ground ice, and hydrologic regime (Brown and Grave, 1979; Walker, Webber et al., 1987). Temporary loss of habitats along TAPS would occur from ground-impacting activities (primarily trenching) associated with pipeline corrosion maintenance and testing (<1 ha/yr), cathodic protection monitoring and remediation (~0.5 to 5 ha/yr), and installation of “coupons” for testing cathodic protection (no estimate of area affected, but substantially less than that for corrosion maintenance; see Section 2.2). Temporary habitat losses also occur from delayed snowmelt in areas where snow is dumped or compacted during winter maintenance activities. The effects of delayed snowmelt would be confined primarily to the first growing season following use, whereas the effects of vegetation compaction may persist longer. Changes in timing of snowmelt are a function of the amount of traffic-generated dust; early melt is the rule along the Dalton Highway, but persistent snowdrifts occur along the pipeline. At TAPS MP 12, persistent snowdrifts occupied a 250-m-wide band along the pipeline, precluding nesting by all but late-nesting birds (Hanson and Eberhardt, 1982). These indirect impacts affected 3.5 times as much breeding habitat as the footprint of the pipeline, workpad, and access road in their study area (14 ha vs. 4 ha; Hanson and Eberhardt, 1982). TERA (1993b) found that dusting by light traffic could have beneficial effects on birds and bird habitats by counteracting the snowdrift effect without increasing disturbance or other indirect effects associated with higher traffic loads. The small geographic extent of these temporary losses would limit their impacts on birds and bird habitats along TAPS.

Dust fallout from gravel structures can advance snowmelt by up to 2 weeks along the downwind side of roads and pads. The magnitude of dust effects depends on traffic intensity and the distance from the source, and is greatest within 35 ft (10.5 m) of the road or pad (Everett, 1980; Walker and Everett, 1987). Advanced snowmelt in dusted areas also occasionally results in impoundment of runoff and can lead to early green-up of plant species (Makihara, 1983; Walker and Everett, 1987). In spring, open water and available plants attract waterfowl, shorebirds, and ptarmigan to habitats near roads (Walker and Everett, 1987; Murphy and Anderson, 1993; Noel et al., 1996). These areas provide early access to forage but increase exposure to traffic-related disturbance and potential vehicle strikes. Near the Lisburne Development, snow-free areas near roads supported large numbers of foraging geese and swans during pre-nesting, although birds moved away from roads to rest and sleep (Murphy and Anderson, 1993). However, high bird use of dust shadows does not carry over into the breeding season. Nesting density in the Dalton Highway dust shadow was approximately half that in the rest of a study area at Franklin Bluffs (Hanson and Eberhardt, 1982).

The presence of birds in the dust shadow and the availability of perches (e.g., snow depth markers, road markers and signs, pipeline and VSMs) also attracts predatory birds to the road, including Golden Eagles, Rough-legged Hawks, Short-eared and Snowy owls, Gyrfalcons, and Peregrine Falcons. This increases the risk of vehicular collisions. Some species (e.g., Rough-legged Hawk) have

nested in this dust shadow because earlier snowmelt provided a substrate for nesting while the rest of the tundra was still snow-covered (Ritchie, 1991).

Water impounded by gravel roads and pads along the northern end of the TAPS ROW displaces or attracts birds, depending on the species (Hohenberger et al., 1981; Kertell and Howard, 1992; Kertell, 1993, 1994; Troy, 1993; Noel et al., 1996). Impoundments can be temporary, disappearing by mid-June, or can persist through the summer. Temporary impoundments eliminate habitat for ground-nesting birds (Walker, Webber et al., 1987; Noel et al., 1996), but create and enhance feeding habitat for other birds (Kertell, 1993, 1994; Troy, 1993; Noel et al., 1996). Troy (1993) found that some shorebirds and Lapland Longspurs avoided a 330-ft-wide (100-m) zone along the West Road in the Prudhoe Bay oil field, whereas other shorebirds and Snow Buntings (this species nests in pipeline supports) were more abundant than expected. These changes were attributed to impoundments adjacent to the road, early availability of some habitats because of the dust shadow produced by traffic, and reduced habitat availability from persistent snowbanks created by snow removal and drifting (Troy, 1993). Most of these impacts have been or can be reduced by ensuring cross-pad drainage to reduce development of permanent impoundments, but temporary impoundments would likely occur each spring (Noel et al., 1996).

For several bird species, the Dalton Highway has resulted in habitat enhancement by creating a dust shadow that initially provides open water and ground for use during spring arrival and later, early green-up for nesting birds, as discussed above. Also, TAPS and oil field facilities have provided structures for nests and perching and resting sites for birds such as ptarmigan and raptors. Semipalmated Plovers nest on gravel pads and disturbed roadsides at Prudhoe Bay. This species occurs along the entire TAPS ROW and likely makes use of workpads throughout the length of TAPS. On the North Slope, Baird's Sandpiper and Ruddy Turnstone colonize areas of tundra disturbances (Troy, 1991; Troy and Carpenter, 1990) and may do so along the northern portion of TAPS. At the northern end of TAPS, the pipeline and VSMs are used for nesting by Gyrfalcons, Common Ravens, and Snow Buntings (Ritchie, 1991). Along the middle and southern sections of the ROW, Cliff Swallows construct nests on the pipeline and on nearby facilities (turbine buildings; Shoulders, 1999, pers. comm.), and an American Kestrel has nested on a check valve (Lawlor, 1999, pers. comm.).

The removal of brush in the ROW probably has affected the relative numbers of various species, increasing habitats for some species and reducing habitats for others. For example, the presence of low shrub or grassy habitats in forested regions provides habitats for some sparrow species (e.g., Savannah Sparrow) that might not otherwise occur in the area. Conversely, the loss of tall shrub and forested habitats probably reduces populations of birds associated with these habitat types (e.g., Varied Thrush).

Mortality

Along the TAPS ROW, bird mortalities directly associated with the pipeline and facilities have been relatively few, consisting of an occasional collision of birds with the pipeline or with facilities (Shoulders, 1999, pers. comm.). Another minor source of mortality was deaths of swallows drawn into pump station turbines (Shoulders, 1999, pers. comm.) This source of mortality has been limited by putting screens on turbines at pump stations and by removing nests (with federal permits) from turbine areas. The largest identified source of bird mortality associated with the TAPS ROW is road kills along the Dalton Highway (Brown, D., 1999, pers. comm.; Schmidt, 1999, pers. comm.; Shoulders, 1999, pers. comm.). Ptarmigan, grouse, and passerines are the primary species groups killed by vehicle collisions. Although numbers of individuals are not known, total mortality is likely low compared to area populations of these species. These collisions occur mainly in the north where the Dalton Highway dust shadow causes early snowmelt that attracts birds close to the road. Raptors have infrequently been identified as collision victims along the Dalton Highway, primarily in the north (Ambrose, 1999, pers. comm.). Raptors that hunt along the road and dust shadow, including Rough-legged Hawks, Northern Harriers, and Short-eared Owls, would be most susceptible to collision with vehicles. Mortality due to early fledging of young raptors or increased predation from human disturbance of nests has not been reported along TAPS.

Increased predation due to larger predator populations because of anthropogenic food sources is also an indirect effect for some birds, primarily tundra-nesting waterfowl, shorebirds, and passerines (Truett et al., 1994; Day, 1998; Johnson, 2000a, b). Impact levels are inferred from the higher number of foxes and increased density of fox dens, (Eberhardt et al., 1982; Burgess and Banyas, 1993; Burgess, Rose et al., 1993) and higher numbers of brown bears (Shideler and Hechtel, 1995), gulls, (Murphy et al., 1987), and ravens (ABR, Inc., unpubl. data) in the oil fields now compared to 20 to 30 years ago and compared to undeveloped areas on the North Slope today. Gulls and ravens prey on bird eggs and young; foxes prey on birds and their eggs and small mammals; and bears prey on caribou, muskoxen,

ground squirrels, and ground-nesting birds (primarily colonial nesting waterfowl). Along TAPS, proper garbage handling at pump stations, worker education, and disciplinary actions to eliminate feeding of wildlife have substantially reduced this impact (Montgomery, 1999, pers. comm.; Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.).

Oil Spills

Birds exposed to spilled oil usually do not survive moderate to heavy contact. Oil ingestion during preening or feeding may impair endocrine and liver function and may reduce breeding success and nestling growth (King and Lefever, 1979; Peakall et al., 1980; Harvey et al., 1982; Holmes, 1985; Holmes and Cavenaugh, 1990; Hughes et al., 1990; Burger and Fry, 1993; Stubblefield et al., 1995). Egg contamination by adults can significantly reduce hatching success (Stickel and Dieter, 1979; Albers, 1980; Butler et al., 1988; Harfenist et al., 1990). Oil reaching ponds or lakes can have longer-term effects on invertebrate prey populations and emergent vegetation. These effects could reduce food availability and escape cover for birds in the area impacted by the spill (Barsdate et al., 1980; Hobbie, 1982). Spills entering streams or rivers during the breeding season could contact waterfowl adults and young and would potentially affect the greatest number of individuals. Spills on terrestrial habitats generally remain in limited areas and would usually affect only a few brood-rearing or foraging passerines or waterbirds in the immediate area.

Most oil and fuel spills are small and are confined to workpads, and the potential for contact with birds is low. Larger-scale oil spills from a major pipeline break or valve malfunction could cause high bird mortality depending on the location and time of year. During a visit to the site of the 1979 Atigun River spill, two nests and one incubating Semipalmated Plover were seen with moderate oiling (Rothe et al., 1983). The effects of larger spills on wildlife have been well-documented (e.g., *Exxon Valdez* Oil Spill Trustee Council, 1994; Wells et al., 1995; Day et al., 1995; Wiens, 1996; Wiens et al., 1996) and include mortality, displacement, habitat loss, and secondary effects on breeding success and propensity.

Harvest and Recreational Effects of Humans

Construction of TAPS increased access for hunters, but the resulting post-construction changes in harvest of game birds that likely occurred are not documented. The primary species affected by increased hunting effort would be grouse (Spruce, Ruffed, and Sharp-tailed grouse) and ptarmigan (Willow, Rock, and White-tailed ptarmigan). Increased access also has likely resulted in increased sport harvest of waterfowl, Sandhill Cranes, and Common Snipe, particularly in the area between Fairbanks and Thompson Pass, where the ROW crosses waterfowl habitats. The proposed action would continue to provide access for harvest of game birds. Although much of the northern end of the ROW passes through waterfowl habitat, the timing of bird use of the area and prohibitions on firearms use along TAPS currently limit harvest by humans.

Increased recreational use of areas along TAPS has occurred, particularly since the opening of the Dalton Highway to the public. To variable extents, wildlife tours, birding groups, and individual recreationists all use the Dalton Highway to access habitats adjacent to the TAPS ROW. Although these non-project-related activities do not involve harvest for human consumption, they are not entirely benign in their impacts on animal resources. For most bird species, the relative impacts of recreational activities are probably minor, but for rare birds, such as the Bluethroat, increased access to their nesting habitats near Pump Station 2 may have some detrimental effects, although the magnitude is unknown. Falconry permits from the State of Alaska allow for the taking of Arctic Peregrine Falcons and Gyrfalcons along the TAPS ROW. Gyrfalcons have not been taken in this region, although they nest close to the ROW north of the Brooks Range and along the Sagavanirktok River (Wright, 1999, pers. comm.).

4.3.2.5 Terrestrial Mammals

By W. Ballard, H. Whitlaw, B. Lawhead, B. Burgess, S. Murphy, and M. Cronin

Potential impacts of the proposed action on terrestrial mammals were identified from several sources including review of the original TAPS EIS (BLM, 1972), review of scientific literature and unpublished reports, and interviews of personnel with TAPS-related field experience. Evaluation of environmental consequences was based largely on an understanding of the impacts of TAPS operation and maintenance over the past 30 years. Difficulty in assessing these effects occurred as a result of the paucity of baseline studies before TAPS construction (Norris, 1997; Klein, 1991a). In addition, as summarized by Klein (1991a, p. 378), “studies of wildlife populations adjacent to the pipeline…often lack the ability to evaluate the complicating variables, such as differences in weather conditions, predator levels, and human hunting pressure that also, and perhaps independently, may have influenced the population dynamics of the wildlife species being studied.”

Impacts on terrestrial mammals can be placed in the fol-

lowing categories:

- Obstructions to movements;
- Disturbance and displacement;
- Habitat loss, alteration, or enhancement;
- Mortality;
- Harvest by humans.

Obstructions to Movements

Issues. Impacts addressed in this section resulted from a synthesis of the originally predicted impacts (BLM, 1972), and review and evaluation of research conducted over the last 30 years (Cronin, Amstrup et al., 1998; Forman and Alexander, 1998; Cronin et al., 1994; Smith and Cameron, 1992; Carruthers and Jakimchuk, 1987; Curatolo and Murphy, 1986; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Bergerud et al., 1984; Banfield et al., 1981; Van Ballenberghe, 1978). BLM (1972) predicted that the TAPS ROW (i.e., the pipeline, roads, and associated traffic) would present a barrier or obstruction to movement, restricting the free passage of terrestrial mammals. Predicted barrier effects of pipelines and roads included isolation of habitat, alteration of distributions, obstruction to range expansion, alteration of migrating group composition, and range abandonment.

Pipelines. Caribou, moose, and bison encounter the pipeline during seasonal migrations, and as components of their annual home range (i.e., nonmigratory populations). During TAPS construction, designated big-game crossings were built along sections of the pipeline to ensure free passage and movement of big game animals (JSFFWAT, 1977). Elevated big-game crossings were built to a minimum height of 3 m above the workpad, extending for a distance of at least 18 m, and were located at sites "known to be regularly used by bison, moose and/or caribou as well as those sites with a high probability of utilization based on tradition or habitat characteristics" (JSFFWAT, 1977, p. 1). In addition, buried sections (i.e., sagbend crossings) were built to accommodate caribou movement. Evaluations of the use of these crossing sites provide the majority of our understanding of the effects of the pipeline as a barrier, or obstruction to movement, for terrestrial mammals (see Carruthers and Jakimchuk, 1987; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Van Ballenberghe, 1978).

The Nelchina Caribou Herd (NCH) crosses the TAPS ROW in the Copper River Basin during spring and fall migrations (Eide et al., 1986; Carruthers et al., 1984). Traditional migration routes were established by the NCH prior to pipeline construction (Eide et al., 1986). During the first winter of pipeline operation, Eide et al. (1986) reported that migrating NCH caribou tended to select buried, rather than elevated, pipeline sections. When caribou crossed under elevated sections, they selected heights greater than 2.4 m and against those less than 2.1 m. Deflections were recorded for 2.7 percent of the caribou that encountered the pipeline; 99 percent of these deflections occurred at elevated sections. Eide et al. (1986) and Carruthers and Jakimchuk (1987) both determined that NCH caribou showed strong selection for long buried-pipeline sections that were intentionally located in traditional migration locations and agreed that caribou did not show selection for designated big-game crossing locations. Eide et al. (1986, p. 207) concluded "efforts to assure free passage of caribou across the pipeline appear to have been adequate." There is no evidence that the TAPS pipeline has been a barrier to NCH caribou movements, although it may obstruct or deflect a small proportion of individuals (Trudgen, 1999, pers. comm.; Tobey, 1999, pers. comm.; Carruthers and Jakimchuk, 1987; Dixon, 1984; Eide et al., 1986). The NCH has grown since TAPS construction, and no population-level impacts of TAPS have been reported (Section 3.2.5).

The Delta Caribou Herd (DCH) has recently grown in numbers resulting in a general range expansion, and individual caribou have been observed east of the Delta River and the TAPS ROW (Section 3.2.5.2). Although the TAPS ROW has not traditionally been in the range of the DCH, its presence has not hindered recent eastward range expansion of DCH caribou.

The Central Arctic Herd (CAH) crosses the TAPS ROW during spring and fall migrations (movements between the coastal plain and the Brooks Range), and during the summer insect season (movements between the coast and inland feeding areas) (Pollard et al., 1996b; Carruthers et al., 1984). Cameron et al. (1985) reported that crossings of the TAPS ROW were predominately by bulls, with calves comprising only 3 percent of the caribou crossing during spring and summer 1977-82. They concluded that maternal cows were sensitive to human activities. Whitten (1999, pers. comm.) indicated that the pipeline was a "hindrance to movement, rather than a barrier." He elaborated that caribou did not fail to cross the pipeline, although they did not "linger" near it. Mumford (1999, pers. comm.) commented, "In my opinion, the pipeline did not affect the migratory path of caribou" north of Fairbanks. The combined studies and observations along the length of TAPS indicate that the pipeline is not a barrier to free passage of caribou, although it may deflect or hinder movements to some extent.

Moose in the Copper River Basin and Interior Alaska cross the TAPS ROW during spring and fall migrations, and some nonmigratory moose encounter the pipeline as a com-

ponent of their annual home range (Van Ballenberghe, 1978; Gasaway et al., 1983; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Ballard et al., 1991; Hundertmark, 1997). Van Ballenberghe (1978) reported that both migratory and nonmigratory moose populations came into contact with TAPS while it was still under construction. Of 1,068 recorded successful crossings of the TAPS pipeline, 87 percent occurred where the vertical clearance between pipeline and ground was less than 2.4 m. Of 466 radio-collared moose crossings, 84 percent were successful crossings, 13 percent were deflections followed by successful crossing, and 3 percent were unsuccessful crossings. Van Ballenberghe's (1978) study occurred during a winter of below-normal snowfall, and he speculated that at snow depths greater then 0.75 m, the pipeline would cause more deflected movements.

During the first winter of pipeline operation, Eide et al. (1986) found no consistent pattern of selection by moose for vertical heights of elevated pipeline, for buried versus elevated pipe, or for designated big-game crossing sites. They indicated that moose were not influenced in their selection of crossing sites by pipeline characteristics and concluded "moose populations appear unaffected by the pipeline" (Eide et al., 1986, p. 207). Similar to the cautions provided by Van Ballenberghe (1978), they suggested that winters with deep snow might change pipeline characteristics and hinder moose crossings.

During 1982-83 in Interior Alaska near Big Delta, Sopuck and Vernam (1986a, b) found that 94 percent of 175 nonmigratory moose trails examined successfully crossed the pipeline upon entering the ROW, independent of pipe mode (i.e., buried or elevated) or pipe height. Of those animals that crossed under elevated sections, heights between 1.5 and 2.7 m were adequate. Moose did not select for designated big-game crossing sites. Sopuck and Vernam (1986a, b) concluded that in the Delta area, habitat appeared to be the most important factor influencing the selection of moose crossing sites, rather than the physical characteristics of the pipeline.

There is no evidence that the TAPS pipeline has been a barrier to moose movements, although it may obstruct or deflect a small proportion of individuals (Trudgen, 1999, pers. comm.; Tobey, 1999, pers. comm.; Sopuck and Vernam, 1986a, b; Eide et al., 1986; Dixon, 1984; Van Ballenberghe, 1978).

Bison in the Delta area encounter and cross the TAPS pipeline during spring and fall migrations. Kiker and Fielder (1980) reported that bison used the TAPS ROW as one of several traditional migration corridors. Muskoxen have been observed bedding on the workpad within 2000 yards of the highway for several days (Comins, 1999, pers. comm.). There is no evidence that the TAPS pipeline is a barrier or obstruction to the free passage of bison.

Ballard et al. (1987) studied wolves in the Copper River Basin with radiotelemetry during the 1970s and 1980s. Radio-collared wolf packs maintained territories that were bisected by TAPS ROW. Ballard (1999, pers. comm.) observed that the movements and behaviors of these packs were unaffected by the presence of the pipeline. There is no evidence that the TAPS pipeline is a barrier or obstruction to the free passage of wolves (Ballard and Gipson, 2000; Ballard et al., 1987; Gasaway et al., 1983).

Roads and Traffic. The effects of roads as barriers to movements for terrestrial mammals depend on traffic volume and speed, roadside vegetation, proximity to pipelines, traditional movement patterns, and environmental factors concurrently affecting animal movement (i.e., insect harassment, predator avoidance) (Curatolo and Murphy, 1986; Cronin et al., 1994).

Caribou, moose, and bison encounter roadways and associated traffic during seasonal migrations and as components of their annual home range (i.e., nonmigratory populations). The CAH crosses the Dalton Highway during spring and fall migrations (movements between the coastal plain and the Brooks Range), and during the summer insect season (movements between the coast and inland feeding areas) (Pollard et al., 1996b). As with the TAPS pipeline, the Dalton Highway may impede caribou movement, although it is not an absolute barrier (Cameron et al., 1985; Whitten, 1999, pers. comm.). As indicated by Shoulders (1999, pers. comm.), caribou "may be more cautious about the road with traffic," and barrier effects of the highway will need to be evaluated as traffic levels change.

The NCH crosses the Richardson Highway between Paxson Lake and Squirrel Creek during its spring and fall migrations. Traditional routes crossing the highway were established by the NCH and recognized by biologists before the pipeline was built (Eide et al., 1986). Carruthers and Jakimchuk (1987), Eide et al. (1986), and Carruthers et al. (1984) documented the continued use of traditional migration routes after TAPS construction. The DCH has recently grown in numbers, resulting in a general range expansion, and individual caribou have been observed east of the Delta River, the Richardson Highway, and the TAPS ROW. Although the highway has not traditionally been in the range of the DCH, its presence has apparently not hindered range-expansion movements. Available evidence thus suggests that the Richardson Highway is not an obstruction to NCH and DCH caribou movements.

Studies on the effects of roads as barriers to movement

have been conducted in other areas. Russell and Martell (1984) and F. Miller (1984) documented successful crossing of the Dempster Highway by the Porcupine Caribou Herd (PCH) involving seasonal migrations and crossings while on winter range. In addition, Russell and Martell (1984) concluded that no significant energetic disruption could be attributed to the presence of the highway under moderate traffic levels. Dyer (1999) reported that in the boreal forests of Alberta, woodland caribou crossed roads less than expected, and that crossing was lower with higher road density.

Since the early 1980s, muskoxen have been reported near the Dalton Highway and west of the TAPS ROW (Reynolds, P.E., 1998). This range expansion as far west as the Colville River required movement across the ROW and/or travel through the oil-field complexes of the North Slope. Muskoxen have been regularly observed near Pump Station 3 and along the Dalton Highway (Thompson, 1999, pers. comm.; Stephenson, B., 1999, pers. comm.; Hunter, 1999, pers. comm.). Concerns regarding muskox response to traffic have been raised (Martin, P., 1999, pers. comm.); however, there are no data to suggest that the presence of the Dalton Highway has been a barrier to movements of muskoxen on the coastal plain.

Moose in the Copper River Basin and in Interior Alaska encounter the Richardson Highway during spring and fall migrations and as part of annual home ranges (i.e., nonmigratory populations) (Van Ballenberghe, 1978; Sopuck and Vernam, 1986a, b). Delta bison also encounter and cross the Richardson Highway during spring and fall migrations. There are no data to suggest that the Richardson Highway is a barrier to either moose or bison movements.

Jakimchuk et al. (1984) observed sheep in the northern Brooks Range successfully crossing the Dalton Highway in spring and fall. In contrast, Dalle-Molle and Van Horn (1991) reported two observations of Dall sheep unsuccessfully attempting to cross the Denali National Park Road during a seasonal migration. They concluded that sheep became habituated to traffic where the road passes through their home range, whereas those individuals occupying ranges away from the road and encountering it during seasonal migrations had not become habituated. There are no reports of sheep movements being adversely affected or obstructed by roads or traffic associated with TAPS.

Singer and Doherty (1985) reported the successful use of highway underpasses in managing mountain goats across a roadway in Glacier National Park, Montana. Disturbance of goats was greatest during the pre-construction period and decreased during general construction and after completion of the underpasses. Only 0.4 percent of all crossing goats moved around the ends of the facilities to cross the highway. Crossing success was reduced from 100 to 85 percent when traffic or humans were present on the bridge (Singer and Doherty, 1985). There are no reports of mountain goat movements being adversely affected or obstructed by roads or traffic associated with TAPS.

Summary: Obstructions to Movements. The TAPS ROW (elevated and buried pipeline) and the Dalton Highway are not barriers to movements of terrestrial mammals. There is evidence of deflected movements of individual moose and caribou, and of unsuccessful crossing attempts, but the proportions are minimal and there are no data indicating adverse effects at the population level. North of the Brooks Range, there is evidence that maternal cows are hesitant to cross the TAPS ROW during the calving and post-calving periods, although the majority do cross. There is no evidence of TAPS serving as a barrier to range expansion in caribou or muskoxen. It has been demonstrated that wolves incorporate the TAPS ROW into pack territories. Population data for terrestrial mammals in the vicinity of TAPS show increasing or stable numbers, and state management objectives are being met. Therefore, although a small proportion of animals are unsuccessful in crossing the TAPS ROW, traditional migration routes are still in place, populations are stable or increasing, and several populations have expanded their range across the ROW.

On the basis on this review of scientific and unpublished literature and information provided by knowledgeable personnel, the proposed action will have no adverse effects on the movements and free passage of terrestrial mammals in the vicinity of the TAPS ROW.

Disturbance and Displacement

Aircraft and Vehicle. Terrestrial mammals encounter various types of disturbances associated with maintenance and operation of TAPS. These include disturbances from aircraft, vehicles, snow machines, off-road vehicles, foot traffic, and disruptions of wildlife feeding activities.

The effects of aircraft overflights on wildlife vary among species, populations, environmental variables, and habitat types (McKechnie and Gladwin, 1993; Miller and Gunn, 1984). In addition, aircraft disturbance responses are dependent on aircraft type and flight altitude, with helicopters and low-flying military jet aircraft being generally more disturbing to terrestrial mammals than light fixed-wing aircraft (Maier et al., 1998; Côte, 1996; Bleich et al., 1994; McKechnie and Gladwin, 1993; Murphy et al., 1993; Davis et al., 1984; Valkenburg and Davis, 1984; Fancy, 1982). Animals that range near airports or other continuous sources of aircraft disturbance may be exceptions to this

pattern and appear to become habituated (Maier et al., 1998; McKechnie and Gladwin, 1993; Davis et al., 1984; Valkenburg and Davis, 1984).

Côte (1996) investigated mountain goat responses to helicopters in Alberta. Between June and August, goats were disturbed by 58 percent of the flights and elicited greater disturbance responses when helicopters flew within 500 m. Helicopter altitude, goat group type, behavior, or group size did not appear to influence reactions of goats. He indicated that helicopter flights caused social group disruption and on one occasion, injury to an adult female. Côte (1996) recommended that helicopter flights over goat habitat be restricted to more than 2 km from these areas. No reports of adverse effects of aircraft on mountain goats in the TAPS ROW were found.

Sheep elicit stronger responses to helicopter disturbance than to fixed-wing aircraft (Bleich et al., 1994; McKechnie and Gladwin, 1993; Krausman and Hervert, 1983). Bleich et al. (1994, p. 1) reported that bighorn sheep in California responded "dramatically" to helicopter disturbance. Effects on individuals included abandonment of sampling blocks and changes in habitat use before and after helicopter surveys. Bleich et al. (1994) also observed that sheep did not habituate or become sensitized to repeated helicopter overflights. Krausman and Hervert (1983) determined that fixed-wing flights less than 100 m in altitude elicited disturbance responses from sheep (i.e., increased heart rate and escape response). No reports of adverse effects of aircraft on sheep in the TAPS ROW were found.

Andersen et al. (1996) demonstrated that responses of moose in Norway were greater to human disturbance (i.e., individuals or groups on foot and on skies) than mechanical disturbance (i.e., ATV, snowmachine, helicopter and F-16 jet). Human stimuli elicited flight responses at greater distances than mechanical stimuli, and heart rates were elevated for longer periods. They suggested that moose were reacting to a fear of hunters, were becoming habituated to nonthreatening vehicles, and were able to adapt to predictable activities. Moose moved distances greater than 1 km only in response to extreme stimuli from snowmachines driven to within 5 m and helicopters flying at altitudes of less than 50 m (Andersen et al., 1996). Colescott and Gillingham (1998) reported that in Wyoming, moose that were bedded within 300 m and feeding within 150 m of passing snow machines altered their behavior in response to the disturbance. The average duration of response was 7 minutes. They concluded that snow machine traffic did not appear to alter moose activity significantly, although individuals within 300 m of the snowmachine trail were displaced to less favorable habitats. No reports of adverse effects of aircraft on moose in the TAPS ROW were found.

Miller and Gunn (1984) examined muskoxen-herd defense formations in response to helicopter overflights. The majority (75 percent) of muskoxen that moved in response to helicopters came together into defense formations. They reported that the durations of defense formations were brief (average of 5 minutes, range 2 to 12 minutes) and concluded that much of the defense formation behavior was moderated by exposure to many environmental variables and augmented by past learning experience. McLaren and Green (1985) also concluded that although disturbance to muskoxen raises energy costs of individuals, these costs would be reduced as muskoxen habituate to disturbances. They reported that the mean initial reaction distance by muskoxen to snowmachines was 345 m (range 162 to 650 m), distance of closest approach averaged 267 m (range 87 to 645 m), and duration of reaction varied from 2 to 6 minutes. P. Reynolds (1998) cautioned that because muskoxen are present on the Arctic Coastal Plain year-round and are limited by winter weather and food availability, they are vulnerable to human activities and should be avoided before, during, and after calving (April to mid-June).

Numerous studies have investigated the reactions of brown bears to aircraft disturbance (McKechnie and Gladwin, 1993; Harting, 1987; Quimby, 1974). Brown bears are more sensitive to helicopters than light fixed-wing aircraft and often run and/or seek cover in response to aircraft disturbance (Harding and Nagy, 1980; Klein, 1974). Klein (1974) documented that brown bears reacted more severely to all types of aircraft than did ungulate species, although Harting (1987, and references therein) reported that individual bears vary in their tolerances to helicopter disturbance. Responses to helicopters and fixed-wing aircraft depend on degree of habituation, availability of cover, and flight characteristics (Harting, 1987 and references therein). No reports of adverse effects of aircraft on brown bears in the TAPS ROW were found.

The effects of disturbance by helicopter and light fixed-wing aircraft on caribou have been studied extensively (McKechnie and Gladwin, 1993; Valkenburg and Davis, 1984; Davis et al., 1984; Miller and Gunn, 1979; Calef et al., 1976; McCourt and Horstman, 1974). Most studies reported a fixed-wing tolerance threshold of 60 m, below which panic and escape responses in individual caribou were apparent. Above 150 m, reactions were rarely observed (McKechnie and Gladwin, 1993 and references therein). As with most other terrestrial mammals, responses elicited from helicopter disturbances are greater than those from light fixed-wing planes. The tolerance threshold for helicopters was estimated to be 330 m in altitude (Miller

and Gunn, 1979).

Responses of caribou to aircraft disturbance are also dependent on season, activity before overflights, and habituation. Valkenburg and Davis (1984, p. 9) concluded that "aircraft disturbance has been overemphasized." They reported that the DCH had become habituated to aircraft (or had never learned to fear them), whereas Western Arctic Herd caribou, which had minimal exposure to aircraft overflights, appeared to react adversely because such flights were likely life-threatening since WAH caribou are hunted from snowmachines and aircraft. Valkenburg and Davis (1984, p. 7) suggested that disturbance response studies should move away from documenting overt reactions and focus on "determining predictable aspects of inherent and learned behavior." Davis et al. (1984, p. 5) concluded that sensory disturbances had been of "minor importance" to the growth of the Delta herd.

Caribou and reindeer also exhibit disturbance responses to snow machines and other moving vehicles (Tyler, 1991; Horejsi, 1981). Horejsi (1981) reported that 86 percent of individual caribou (n = 34) approached by vehicles along the Dempster Highway in northwestern Canada at speeds of 56 km/hr ran or trotted away, with mean flight duration of 73 seconds for females and 38 seconds for males. Twenty-nine percent of individual caribou reversed their direction of movement or split from their group. Responses of females with calves were not different from males or non-maternal females (Horejsi, 1981). Tyler (1991) reported that the first visible responses of reindeer to an approaching snowmachine involved independent behavior by several different individuals, whereas the secondary flight response was a coordinated group response. Groups fled an average of 160 m, with maximum response duration of less than 5 minutes. Tyler (1991) concluded that he was unable to detect effects of snowmachine disturbance on Svalbard reindeer.

Animal Feeding. The intentional feeding of wildlife and/or the use and habituation of some species to anthropogenic food sources such as garbage was a common problem during construction of TAPS, particularly in camps and at pump stations (Schmidt, 1999, pers. comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.; Follmann and Hechtel, 1990; Milke, 1977). During this time, active feeding of bears, wolves, foxes, squirrels, gulls, and ravens by pipeline workers, in addition to improper garbage handling and disposal, resulted in "large numbers" of animals being attracted to camps and areas of human activity (Milke, 1977, p. 1). In the late 1970s, Milke (1977) reported that animal feeding problems initiated during construction continued during operation, although the frequency and magnitude had decreased. Current Alyeska policy mandates that employees be disciplined and/or fired for intentionally feeding wildlife. On occasion, foodstuffs are inadvertently made available at specific job sites; for example, at RGV 60, food was left in vehicles, and garbage management by external contractors was not appropriate (Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.; Brown, D., 1999, pers. comm.). Nuisance animals are hazed by trained Alyeska personnel, and may be translocated or killed if problems persist. There is general consensus among state and Alyeska biologists and environmental personnel that animal feeding by Alyeska personnel is no longer a problem within the TAPS ROW (Stephenson, 1999, pers. comm.; Schmidt, 1999, pers. comm.). However, animal-feeding problems associated with public and commercial use of the Dalton Highway may still occur (Brown, D., 1999, pers. comm.). Black bears continue to be a problem in Valdez as a result of city garbage management and lack of fencing at the Valdez Marine Terminal (Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Brown, D., 1999, pers. comm.).

Displacement. BLM (1972) predicted that terrestrial mammals would be displaced as a result of activities associated with TAPS construction, operation, and maintenance. Displacement could potentially occur as a result of disturbances, obstructions to movements, and/or habitat change. Potential effects of displacement could be realized at the individual and/or population levels, including displacement to adjacent habitats, increased mortality, increased activity budgets, and/or changes in group composition. Most displacement research has investigated the effects of oil-field development and associated disturbances on CAH caribou (Cronin, Amstrup et al., 1998; Cronin, Ballard, et al., 1998; Cameron et al., 1995; Cronin et al., 1994; Pollard et al., 1996b; Cameron et al., 1992; Smith and Cameron, 1992; Klein, 1991a, b; Murphy and Curatolo, 1987; Dau and Cameron, 1986a; Smith and Cameron, 1983; Whitten and Cameron, 1983a; Banfield et al., 1981). These research efforts have focused primarily on the relationships between roads, road/pipeline configurations, and associated traffic, and caribou distributions, movements, and group composition. Although general disturbance patterns from aircraft and traffic on the North Slope may be comparable to those encountered during operation and maintenance of TAPS, the level of infrastructure development is dissimilar in terms of pipeline and road configuration and density. Therefore, this discussion focuses on the TAPS ROW and draws on relevant conclu-

sions from North Slope studies. (See Section 4.5 section for a discussion of North Slope caribou.)

Roby (1978) reported that during summer, caribou with calves were the group most sensitive to the Dalton Highway. His activity-budget analyses indicated that groups tended to bunch up and move more rapidly after being disturbed by traffic. Cameron et al. (1979) investigated caribou distribution, group size, and composition along the Dalton Highway between Pump Station 4 and Prudhoe Bay. During 1975, systematic road surveys indicated that the mean summer calf percentage of the herd was approximately one-third lower in the TAPS ROW than adjacent areas. However, mean percentages in the fall were not different. Mean group size was also generally lower along the Dalton Highway compared to adjacent areas (Cameron et al., 1979). Cameron and Whitten (1980a) examined 1975-78 survey data and reported that caribou, primarily cows with neonatal calves, avoided the TAPS ROW. They suggested that this was a group response to vehicular traffic and construction activity, and concluded "Human activity apparently represents the principal impediment to local movement since avoidance of the ROW occurs irrespective of the pipe structure…" (Cameron and Whitten, 1979, p. 483). Upon examination of additional road-survey data from 1978 to 1982, Cameron et al. (1985) concluded that parturient and maternal cows were sensitive to human activities along the Dalton Highway north of Pump Station 4. Based on marked animals, Whitten and Cameron (1983a) concluded that in spring, the cow/calf segment of the CAH appeared to avoid disturbed areas more so than bulls.

In contrast to Cameron and Whitten (1979), Carruthers et al. (1984) investigated factors besides human activity which may affect the distribution of cows and calves adjacent to TAPS. Their 1981-83 survey results indicated that the CAH had "strong habitat associations, which varied according to the sex of the animals" (Carruthers et al., 1984, p. 11). In particular, they reported that cows with calves avoided river valleys and riparian habitats, whereas bulls preferred riparian habitats, and that the habitats preferred by females were not associated with the TAPS ROW. They concluded that variables such as habitat and sexual segregation influenced the distribution of caribou adjacent to the ROW.

Jakimchuk et al. (1987) further proposed that cows with calves avoided riparian habitats, not the TAPS ROW, as a predator avoidance strategy. These antipredator tactics were also proposed for caribou in British Columbia (Bergerud and Page, 1987). However, Young and McCabe (1998) reported that calving PCH caribou did not avoid river corridors, and hypothesized that nutritional demands ultimately regulated habitat-use patterns.

There is no evidence that other caribou herds in the vicinity of the ROW (i.e., NCH, DCH) have been displaced as a result of TAPS operation and maintenance (Valkenburg, 1999; Carruthers and Jakimchuk, 1987; Eide et al., 1986; Gasaway et al., 1983). Caribou south of the Brooks Range have maintained traditional migratory routes and in some cases have expanded their ranges across the ROW. BLM (1972) reported that the range of the Fortymile herd overlapped the ROW. However, Valkenburg and Davis (1986) demonstrated that this herd had frequently changed its calving distribution since the mid-1950s and that the herd's greater range had gradually decreased since the 1920s.

There is no evidence that populations of Dall sheep, muskoxen, bison, or moose have been displaced as a result of the operation and maintenance of TAPS (DuBois and Rogers, 1999; Reynolds, P., 1998; Eide et al., 1986; Jakimchuk et al., 1984). Aircraft and vehicle disturbances have been reported to elicit behavioral and physiological responses in individual ungulates, but they are generally short-term and are not reflected at the population level. In California, Bleich et al. (1994) reported that mountain sheep were sensitive to helicopter disturbance and may alter their habitat use as a result, but this has not been demonstrated for Dall sheep in the vicinity of TAPS.

Brown bears have been locally displaced from roads in British Columbia, Montana, Alaska, and Yellowstone National Park, Wyoming (Mattson, 1988; McLellan, 1988; Archibald et al., 1987; Harting, 1987 and references therein). In most cases, individual bears avoided areas within 1 km of roads, but no population-level effects were reported. McLellan and Shackleton (1989) reported that predictable human activities might displace bears and that the strongest responses were to the presence of humans on foot in open areas of low human use. S. Miller and Ballard (1982) reported that following translocation, three sows with cubs were delayed or deflected by the Glenn Highway.

Habituation. Many wildlife species have developed situation-specific responses to humans (Valkenburg, 1999; Whittaker and Knight, 1998; Thompson and Henderson, 1998; Van Dyke and Klein, 1996; Cronin et al., 1994; Thurber et al., 1994; Mattson et al., 1992; Klein, 1991b; Mattson, 1988; Valkenburg and Davis, 1984). Although individual and group responses to humans and their activities vary, Whittaker and Knight (1998) proposed that it was necessary for wildlife managers to use descriptions of wildlife responses. Knight and Cole (1991) suggested the following broad response classes:

- *Attraction* (the strengthening of an animal's behavior

due to positive reinforcement, and movement toward the stimuli);

- *Habituation* (the waning response to a repeated neutral stimuli); and
- *Avoidance* (aversion to negative consequences associated with a stimulus).

As proposed by Thompson and Henderson (1998), habituation is a management issue of emerging importance as wildlife and human populations expand and overlap. Whittaker and Knight (1998) suggested that responses of a few animals to stimuli are often extrapolated to characterize the entire population. In contrast, Whitten and Cameron (1986) proposed that data must be based on individuals for distribution determinations. These views are not mutually exclusive and can be resolved by ensuring clarity about whether observations refer to past behavior or distribution, or predicted future tendencies (Whittaker and Knight, 1998).

Summary: Disturbance and Displacement. Ground- and air-based disturbances have been reported to elicit responses in individuals of various terrestrial mammal species. In general, helicopters create stronger responses than light fixed-wing aircraft. Disturbance responses are also dependent on levels of habituation; group size; age and sex structure of the group; activity prior to disturbance; disturbance characteristics (i.e., height above ground level, speed of vehicle); season; habitat characteristics; and availability of cover. The above-discussed disturbances affect individuals, and there is no evidence of effects at the population level for any of the terrestrial mammals addressed here.

The intentional feeding of wildlife was a major concern during TAPS construction, but Alyeska policy and state regulations now prohibit this practice. Animal-feeding problems associated with public and commercial use of the Dalton Highway are still of concern.

Available evidence suggests that most terrestrial mammals in the vicinity of the TAPS ROW have not been displaced as a result of pipeline operation and maintenance. Caribou cows with calves may be under-represented along the Dalton Highway during the calving season. This may be due to avoidance of the road, habitat selection, or predator avoidance. Regardless, the CAH has grown in numbers since the mid-1970s, and any redistribution of caribou in the spring has apparently not affected population growth.

On the basis of this review of published and unpublished literature, and information provided by personnel with direct TAPS experience, the proposed action will not displace terrestrial mammals in the vicinity of the TAPS ROW. Air and ground disturbances associated with the proposed action may affect individuals locally and in the short-term. However, available evidence suggests that they may become habituated to these regular activities and that current stipulations and mitigation are effective in minimizing effects. In addition, management data indicate that disturbances to individuals are not realized at the population level (Section 3.2.5).

Habitat Loss, Alternation, and Enhancement

Some habitat alteration and loss occurred as a result of TAPS construction. Impacts of these activities are now part of the affected environment and will not change with implementation of the proposed action. Construction-related habitat impacts are not addressed in this review of habitat issues for the proposed action. Predicted impacts of TAPS operation and maintenance on terrestrial mammal habitat are related to wetlands and riparian areas, oil spills, fire suppression, habitat loss and reclamation, and species-specific sensitive habitats (McKendrick, 1999a, b; Cronin and Bickham, 1998; Bridges et al., 1997; Dominske, 1997; Doucet and Garant, 1997; Hurst, 1997; Duffy et al., 1996; Cameron et al., 1995; Armentrout and Boyd, 1994; Jorgenson and Joyce, 1994; Truett et al., 1994; Garant and Doucet, 1993; Maki, 1992; Walker and Walker, 1991; Gasaway et al., 1989; Senner, 1989; MacCallum, 1988; Morgantini and Bruns, 1988; Morgantini and Worbets, 1988; Walker, Webber et al., 1987; Gasaway and DuBois, 1985; Hartley et al., 1984; BLM, 1981; Kavanagh and Townsend, 1977; BLM, 1972).

Wetlands. Wetlands and riparian areas provide habitat in the form of feeding areas, travel corridors, cover, and shelter for many terrestrial mammal species (Senner, 1989). Concern has been expressed about the role of wetlands in limiting wildlife, primarily in arctic regions (Senner, 1989). Statewide wetland losses due to the petroleum industry are estimated to be about 0.02 percent of Alaska's total wetlands (Senner, 1989). The TAPS ROW and the Dalton Highway account for approximately 68 percent of these petroleum-related wetland losses (Pamplin, 1979) and about 25 percent of statewide wetlands reductions due to human activities since 1867 (Senner, 1989). The greatest amount of wetland loss occurred from the development of material sites followed by workpad construction and construction of the Haul Road (Pamplin, 1979). Although wetlands provide seasonal habitat for terrestrial mammals in the TAPS ROW, minimal losses in these areas due to corrosion digs and other TAPS operation and maintenance activities should not adversely affect nearby wildlife populations.

Oil Spills. Diesel and other product spills were common during TAPS construction (Kavanagh and Townsend,

1977). However, since operation began, spill prevention and response plans have been prepared for TAPS, spill reporting and consistency have improved, employee training and education have been enhanced, and spill regulations are strictly enforced.

The effects of land-based oil spills on terrestrial wildlife have not been thoroughly investigated. Duffy et al. (1996) reported that after exposure to crude oil, individual animals might exhibit acute and/or chronic immune system responses. They suggested that any subsequent secondary infections or tissue damage could lower individual survivorship and thus impact the population. No data were presented to support this hypothesis.

The effects on terrestrial mammals of land-based oil spills occurring as a result of TAPS operation and maintenance have not been directly investigated. Assuming that oil spills associated with the proposed action will be similar to those over the past 30 years, land-based spills will not adversely affect terrestrial mammals in the vicinity of TAPS.

Wildfire. Wildfire is a natural occurrence in Alaskan ecosystems and is a primary agent of change in the boreal forest. Periodic fires create or improve habitat for many browsing and grazing species such as moose and bison (BLM, 1981). Moose populations may increase following fire due to increased browse production, unless they are limited by factors other than habitat — such as predation and hunting. Many of the moose populations near the TAPS ROW seasonally use burned areas (Gasaway et al., 1989; Gasaway and DuBois, 1985). Wildfires are also beneficial to bison because fire stimulates new growth of grasses and forbs (DuBois and Rogers, 1999; BLM, 1981). Caribou may be adversely affected by fire in the short-term; however, long-term benefits of fire include rejuvenation of stands of lichen with declining production (BLM, 1981). Available evidence suggests that terrestrial mammal populations in the vicinity of TAPS are not limited by food and have not been adversely affected by state-mandated and TAPS-associated fire-suppression efforts. Fire suppression associated with the proposed action should not adversely affect terrestrial mammal populations.

Direct Habitat Loss and Reclamation. Minimal direct loss of terrestrial mammal habitat occurred with TAPS construction (Jorgenson and Joyce, 1994; Truett et al., 1994; Pamplin, 1979). Many disturbed areas have since been revegetated to restore wildlife habitat and are used by a variety of species (McKendrick, 1999b; Jorgenson and Joyce, 1994; Senner, 1989). Small-scale disturbed areas are also used by wildlife (Truett et al., 1994). Structures such as gravel pads and elevated pipelines and buildings provide insect-relief habitat for caribou (Schmidt, 1999, pers. comm.), and abandoned materials sites and gravel mines have also been restored for wildlife use as forage sites, escape cover, and mineral licks (MacCallum, 1988; Morgantini and Bruns, 1988; BLM and USACE, 1988; Jorgenson and Joyce, 1994). Rights-of-way and associated maintenance activities in other areas of North America have been reported to provide and enhance wildlife habitat by creating edge habitats, successional stages, habitat diversity, and travel corridors (Dominske, 1997; Doucet and Garant, 1997; Hurst, 1997; Hartley et al., 1984).

Ground-impacting maintenance activities associated with the proposed action are described in Section 4.1.1. These activities will disturb and perhaps alter vegetation patterns, but are not likely to adversely affect terrestrial mammal populations in the vicinity of TAPS.

Species-Specific Sensitive Habitats. Loss or alteration of species-specific sensitive habitats are potential impacts associated with continued TAPS operation and maintenance. Calving areas and mineral licks have been identified as critical areas for caribou, moose, and bison along the ROW. Many of these sensitive habitats have been protected through implementation of BLM-designated areas of critical ecological concern (BLM, 1989). Activities in all identified sensitive habitats for terrestrial mammals near the TAPS ROW are regulated by federal and state mitigation stipulations, which are in place to minimize adverse impacts on wildlife. Assuming all current stipulations and mitigation measures continue with the proposed action, renewal of the TAPS ROW is not expected to adversely impact sensitive habitats.

Summary: Habitat Loss and Alteration. Available evidence and experience suggest that the proposed action will not adversely affect terrestrial mammal habitat. Ground-impacting maintenance activities and minor land-based spills will create small-scale and short-term disturbances in a variety of habitats. These disturbances will not adversely impact terrestrial mammal populations and will continue to be regulated under existing mitigation measures. Current fire suppression have likely reduced browse, grass, and forb productivity along TAPS, but most terrestrial mammal populations in these areas are not limited by forage.

Mortality

Sources of mortality that were predicted to occur in association with TAPS operation and maintenance included increased vehicle collisions, increased kills in defense of life and property and for nuisance animals, increased predation, and mortality from oil spills (BLM, 1972). As described below, mortality of wildlife directly associated with

TAPS has been small in magnitude and has not measurably affected populations.

To put the impact of TAPS operation and maintenance on wildlife mortality in perspective, consider other causes of human-induced mortality in the Alaska. These causes include intentional mortality (i.e., sport and subsistence harvest; management and research mortality) and unintentional mortality (i.e., railroad and road kills; unreported harvests; defense of life and property mortality). These are considered by resource agencies in defining management objectives and policies. Sport and subsistence harvests are often the primary objective of ADF&G management activities, and are considered desirable causes of mortality. Road and railroad kills are not planned or desired, but they are accepted as consequences of highway and railroad operation. Prevention or mitigation measures may be implemented (e.g., warning signs for animals crossings), but highways and the railroad continue to operate and related mortalities occur annually.

A review of the literature and agency data sources indicates that direct mortality associated with TAPS is negligible compared to the other sources of human-induced mortality in the area. The average annual number of non-TAPS human-caused mortalities is summarized in Table 4.3-12 for the major wildlife species. The harvest of wildlife by sport and subsistence users is considerable. Estimates of the unreported harvests are also shown. Tables 4.3-13, 4.3-14 and 4.3-15 show data for moose and caribou. Note the annual toll of hundreds of moose killed on State of Alaska roads and the Alaska Railroad. In addition, University of Alaska researchers killed 193 caribou on the North Slope for research projects, and the FWS killed approximately 800 feral reindeer on Hagemeister Island in a management action.

As described in Section 3.2.5, it is important to note that the population or herd is the unit of management for fish and wildlife in Alaska. As a result, management objectives are set for population and herd numbers, as well as for sport harvest numbers. Intentional and unintentional mortality of individual animals results from various activities (e.g., human harvest, road and railroad kills), but objectives are often achieved nevertheless. As summarized in Table 4.3-12, the number of mortalities due to non-TAPS causes (e.g., sport and subsistence harvest) is much greater than those associated with TAPS operation and maintenance. There is no evidence that TAPS operation and maintenance has prevented ADF&G's management objectives from being met.

Two primary points should be noted from these data. First, fish and wildlife populations can sustain substantial levels of human-induced mortality. Second, the amount of mortality associated with TAPS is small compared with other actions.

Vehicle Collisions. Vehicle collisions with terrestrial mammals, particularly moose, are an issue of public safety as well as a notable source of wildlife mortality. In 1996, the Alaska Department of Transportation (ADOT) identified rural two-lane highway segments with the highest moose/vehicle accident reports (ADOT, 1996) and concluded that most accidents occurred on rural highways surrounding major cities and towns. None of the identified segments was on the Richardson or Dalton Highways, but rather in areas near Soldotna and along the Glenn and Parks Highways (ADOT, 1996). Mitigation measures employed by ADOT to reduce moose/vehicle collisions on high-accident segments include moose fencing and underpasses, one-way gates, continuous illumination, and increased public awareness (ADOT, 1996; Del Frate and Spraker, 1991; McDonald, 1991).

In Alaska, moose/vehicle collisions averaged 630 per year between 1995 and 1997 (ADOT, 1997). In comparison, a minimum of 1,200 moose — a number that is approximately 10 percent of the annual allowable harvest — is killed each year on highways and railways in British Columbia (Child et al., 1991). In Game Management Unit 13, which is bisected by the TAPS ROW and the Glenn Highway, approximately 50 moose are killed per year (1994-98) as a result of collisions with motor vehicles (Sinnott, 1999, pers. comm.). A small proportion of these occur near the ROW (Sinnott, 1999, pers. comm.; Martin, 1999, pers. comm.; Billbe, 1999, pers. comm.). Vehicles annually kill fewer than 10 bison in the Delta area (Kiker and Fielder, 1980). Numbers of other terrestrial mammals killed in vehicle collisions are unknown. Whitten (1999, pers. comm.) and Billbe (1999, pers. comm.) indicated that vehicle collisions with wildlife are rare along the Dalton Highway.

Wildlife/vehicle collision rates increase as a result of increased traffic volumes and the proximity of wildlife to roadways. Attraction to roadways occurs because of roadside maintenance procedures, road-salt accumulation, and the presence of roads in concentration areas and travel corridors. The mitigation measures noted above are designed to reduce the number of collisions based on these wildlife attractants. Increased traffic volumes are a result of increased human population and improved access. As the Dalton Highway increases in recreational value and its use is advertised and encouraged (BLM, 1998), traffic volumes may increase.

None of the terrestrial mammal populations examined in this review is limited by vehicle-collision mortality. Numbers are limited primarily by predation, severe weather, and

Table 4.3-12. *Causes of human-induced mean annual animal mortality by species in Alaska (most representative data used as available; all numbers are estimates; decimals rounded to nearest whole number).*

Species	Rail-road Kill	Road Kill	Reported Sport Harvest [1]	Unreported Harvest [2]	Estimated Subsistence [3]	Management Mortalities [4]	Research Mortalities [5]	DLP	Total
Bison	—	2[7]	109[7]	10[8]	24	—	—	—	145
Black Bear	—	6[9]	1,674[10]	74[11]	1,178	—	—	32[12]	2,964
Brown Bear	—	1[13]	1,149[10]	59[13]	235	—	—	61[10]	1,505
Caribou	50[14]	3[15]	5,065[16]	30,639[17]	14,742	114[18]	19[19]	—	50,632
Dall sheep	—	—	1,092[20]	35[20]	198	—	—	—	1,325
Deer	—	52[21]	24,115[21]	5,905[22]	21,002	—	—	—	51,074
Elk	—	—	120[23]	1[23]	117	—	—	—	238
Fox	—	—	—	1,737[24]	9,006	146[25]	—	—	10,889
Moose	199[26]	759[27]	6,221[28]	1,010[28]	3,857	—	—	19[28]	12,065
Mtn. Goat	—	—	476[29]	7[30]	362	—	—	—	845
Muskox	—	—	63[31]	1[31]	23	—	—	—	87
Polar Bear	—	—	—	—	99	—	—	0[32]	99
Sea Otter	—	—	—	—[42]	2,146	—	—	—	2,146
Wolf	—	1[34]	1,276[34]	78[34]	732	20[34]	—	0[35]	2,107
Total	249	824	41,360	39,556	53,721	280	19	112	136,376

NOTES:

1. Most figures derived from 5-year mean taken from early to late 1990s. Includes some extrapolated results of hunter surveys and a small percentage of reported subsistence — excludes Tier II and other subsistence hunts when specified in cited reports.
2. Includes some estimates for wounding loss and illegal and unreported kills. Most of these numbers are greatly underestimated, as many regional biologists do not regularly publish their estimates in the cited reports. Unreported local harvests are difficult to estimate and are a persistent problem for regional wildlife managers (Carroll, 1995a; Anderson and Alexander, 1992). Excluding caribou, most unreported local harvest is not accounted for in this column.
3. Data by community taken from "most representative" year (Scott et al., 2001).
4. Single events including predator control, research mortalities, and local eradication divided by the number of years between the event and year 2000.
5. Most collaring deaths not accounted for.
7. Hicks (1996d, 1998h, 1998i).
8. Estimated wounding loss assuming 7 percent of permits issued for GMU 20D hunt (Hicks, 1998h, 1998i).
9. Hicks (1999a).
10. Miller and Tutterow (1997).
11. Estimated wounding mortalities and illegal kills from GMU 6, estimate from GMU 14 assuming 10 percent of reported harvest, and estimates from GMUs 16A and 16B assuming 15% and 20% of reported harvests (Hicks, 1996e).
12. Defense of life and property underestimated more for black bears than for brown bears due to more liberal sport hunting seasons (Miller and Tutterow, 1997).
13. Hicks (1995c).
14. Depending on snow depth, up to fifty caribou per year are killed by trains near Cantwell (See Note 16: Hicks, 1997d).
15. This number represents average annual roadkill of the Kenai Lowland Herd, consisting of approximately 100 animals, from 1991 to 1995; caribou roadkills for other parts of the state are undocumented (Hicks, 1997d).
16. Hicks (1997d).
17. Over 90 percent of this figure is attributed to unreported local harvest — 70 percent of which comes from the Western Arctic Herd (Hicks, 1997d).
18. Stimmelmayr and Renecker (1998).
19. Allaye-Chan (1991); Gerhart (1995); Manning (1998).
20. Hicks (1996f).
21. Hicks, (1997e).
22. Estimated illegal take and wounding loss by boat hunters (Hicks, 1997e).
23. Hicks (1998j, k, 1999b)
24. Includes arctic and all red fox phases. The State does not require sealing of foxes, so this figure is underestimated. Some estimates were made for certain GMU's by anecdotal information, fur acquisition and fur export permits. Due to low fur prices and relatively low populations in areas due to coyote competition, trapping effort for foxes was considered low during this reporting period (Hicks, 1995d).
25. Ballard et al. (2000a); Bailey (1993); Bailey and McCargo (1984); Byrd et al. (1996); Deines (1985); Deines and Willging (1985); Fischer and Palmer (1993).
26. Railroad data for moose-kills collected from GMUs 7, 13, 14 and 20, November through April, 1984-2000 (Reese, 2000, pers. comm.).
27. Road data for moose-kills collected from GMUs 7, 14, 15, 16 and estimated for GMU's 12, 13 and 20 from 1994 to 1999 (Sinnott, 1999, pers. comm.).
28. Hicks (1996g).
29. Hicks (1999c); Hicks (1998l).
30. Mostly from Unit 8 estimates for wounding loss/illegal take assuming 10 percent of reported harvest (Hicks, 1998f, g, i).
31. Hicks (1999d).
32. Polar bears taken as DLP categorized as subsistence (Shideler, 2000, pers. comm.).
34. Hicks (1997f).
35. One reported DLP kill of a radio-collared wolf on Fort Richardson in 1997 (Hicks, 1997f).
36. Carroll (1995a); Anderson and Alexander (1992).
37. Scott et al. (2001).
38. Hicks (1996e).
39. Hicks (1995d).
40. Reese (2000, pers. comm.).
41. Sinnott (1999, pers. comm.): Moose killed as a result of collisions with motor vehicles — documented kills; actual number killed by vehicles is certainly greater.
42. An unknown number — perhaps more than 100 — sea otters are intentionally killed every year by fisheries and recreational activities.

Table 4.3-13. *Caribou and reindeer killed in Alaska for wildlife management and research.*

Affiliation	Location	Years	Animals Taken	Rationale
U.S. Fish and Wildlife Service (a)	Hagemeister Island	1992/1993	Approx. 800	Removal of non-indigenous reindeer
University of Alaska Fairbanks (b)	North Slope	1989/1990	65	Research
University of Alaska Fairbanks (c)	North Slope	1987/1988	128	Research
Total	—	—	993	—

(a) Stimmelmayr and Renecker (1998).
(b) Gerhart (1995).
(c) Allaye-Chan (1991).

Table 4.3-14. *Moose killed by trains in Alaska.*

Winter	November	December	January	February	March	April	Total
1984-85	1	4	39	103	199	25	371
1985-86	1	3	3	9	5	0	21
1986-87	4	22	51	29	16	4	126
1987-88	11	81	60	98	64	14	328
1988-89	11	30	68	83	60	3	255
1989-90	28	65	306	160	123	29	711
1990-91	18	41	70	43	30	21	223
1991-92	3	23	34	40	35	7	142
1992-93	5	26	93	47	11	2	184
1993-94	1	12	21	20	15	4	73
1994-95	28	76	44	29	15	7	199
1995-96	4	0	2	15	26	7	54
1996-97	27	14	16	6	7	6	76
1997-98	9	25	29	16	1	7	87
1998-99	3	10	24	28	16	8	89
1999-2000	5	30	95	109			239
Total	159	462	955	835	623	144	3178
Average	10	29	60	52	39	9	199

Source: Reese (2000, pers. comm.)

Table 4.3-15. *Moose killed by documented collisions with motor vehicles in Southcentral Alaska (listed by GMUs).*

Year	7	13	14A	14B	14C	15A	15B	15C	16	Total
1994-95	34	50	260	34	239	168	59	53	4	901
1995-96	18	50	85	6	14	90	70	63	15	511
1996-97	27	50	185	10	136	160	80	44	4	696
1997-98	28	50	168	13	137	143	68	84	14	705
1998-99	46	50	130	15	152	178	74	76	10	731
Total	153	250	828	78	678	739	351	320	47	3,544
Average	31	50	166	16	156	148	70	64	9	709

Estimates made for Unit 13.
Very few roadkills in other parts of the state — perhaps 50 per year between GMUs 12 and 20.
As of 2/11/00, there were approximately 370 roadkills this winter (*Anchorage Daily News*).
Sinnott (1999): Moose killed as a result of collisions with motor vehicles — documented kills; actual number killed by vehicles is certainly greater.

hunting; and population management objectives are being met. The proposed action is not expected to adversely affect terrestrial mammal populations in the vicinity of the TAPS ROW at current traffic volumes.

Non-hunting (Human-Caused). Brown and black bears and wolves can become habituated or attracted to human activities, often leading to conflicts with people in many areas of Alaska (Whittaker and Knight, 1998; McCarthy and Seavoy, 1994; Mattson et al., 1992; Follmann and Hechtel, 1990; Follmann, 1989; McLellan, 1989; Miller, S. and Chihuly, 1987). S. Miller and Chihuly (1987) examined the circumstances during which non-hunting deaths of brown bears occurred throughout Alaska between 1970 and 1985. Human activities associated with TAPS operation and maintenance were not addressed in S. Miller and Chihuly (1987). They reported that of 224 persons who reported killing bears, 72 percent shot to avoid perceived danger, 21 percent to protect property, and 7 percent to eliminate nuisances. The number of non-hunting bear kills increased during the study period, with an average of 40 percent being reported from coastal areas near Juneau, Kodiak Island, and the Alaska Peninsula. S. Miller and Chihuly (1987) concluded that non-hunting kills were most prevalent when humans were in bear habitat and that areas with highest human densities (Anchorage, Kenai Peninsula, Matanuska Valley) had the highest ratio of non-hunting to sport harvests. Therefore, most non-hunting kills were related to human activities in bear habitat.

Follmann and Hechtel (1990) reviewed the history of nuisance-bear problems and TAPS between 1971 and 1979. They reported that 71 percent of the problems with bears occurred north of the Yukon River, where inadequate garbage disposal and widespread animal feeding created dangerous situations. Of the 192 officially reported bear problems associated with TAPS, 65 percent involved the presence of bears in camps or dumps, while remaining problems were associated with feeding of bears on garbage or handouts (13 percent), property damage or economic loss (10 percent), bears in and under buildings (7 percent), and charges by bears (5 percent) (Follmann and Hechtel, 1990). Control measures for nuisance bears included hazing, relocations, and/or shooting; 25 black bears and 13 brown bears were shot between 1971 and 1979 (Follmann and Hechtel, 1990).

Non-hunting kills of bears and wolves have not been identified as significant limiting factors for populations in the vicinity of the TAPS ROW. With improved garbage management by Alyeska and enforcement of their animal feeding policy, in addition to increased public awareness programs, it is not expected that the proposed action will adversely affect bear and wolf populations as a result of increased non-hunting kills. However, as human population numbers continue to increase in all areas of the state, concerns for human safety will continue to be the main factor in non-hunting mortality of bears and wolves. In particular, with increasing access and recreational use of remote areas such as the Dalton Highway (BLM, 1998), non-hunting mortalities of brown bears may increase. Accidents may sometimes result in mortality. For example, three moose have run into fences at TAPS facilities and died (Shoulders, 1999, pers. comm.)

Predation. BLM (1972) expressed concern that predator numbers might increase as a result of increased human activities during TAPS construction, operation, and maintenance. It was proposed that anthropogenic food sources would increase bear and wolf numbers, thus increasing predation pressure on prey species such as moose and caribou. Predator populations were low before TAPS construction due to federal wolf-control programs and increased through the early 1970s with the end of control efforts.

Many moose and caribou populations in Alaska are limited by predation. In efforts to increase the availability of these big game species, ADF&G has conducted several predator-control studies and projects in GMUs near TAPS over the past 20 years. These have included aerial killing of wolves from fixed-wing aircraft and helicopters, aircraft-assisted trapping, relocation of brown bears, liberal trapping seasons and bag limits for wolves, and liberal hunting seasons and bag limits for brown bears (Miller, S., 1997; Reynolds, 1997; Boertje et al., 1996; Ballard et al., 1991; Ballard and Miller, 1990; Bergerud and Ballard, 1989; Bergerud and Ballard, 1988; Van Ballenberghe, 1988; Ballard et al., 1987; Van Ballenberghe, 1985; Gasaway et al., 1983). Authors of this research did not indicate that predator numbers were influenced by TAPS construction, operation, and/or maintenance.

The proposed action is unlikely to adversely affect prey populations through increased predation in the vicinity of the ROW. Prey populations are largely limited by harvest by humans, predation, and severe weather; and ADF&G is successfully controlling predator numbers.

Oil Spills. Few data are available on oil-spill-related mortality of terrestrial wildlife; most information is anecdotal. This review found no reported terrestrial mammal mortalities due to land-based oil spills along the TAPS ROW, and available evidence does not indicate that this is a major source of mortality at the population level (Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.). Deer, mountain goats, and brown bears around Prince William Sound were potentially exposed to the

Exxon Valdez oil spill; an unknown amount of deer mortality occurred (Nowlin, 1993a, b, 1994, 1995a, b). Based on available evidence, no population-level impacts on terrestrial mammals occurred as a result of the *Exxon Valdez* oil spill. Assuming that oil spills associated with the proposed action will be similar to those over the past 30 years, land-based spills will not adversely affect terrestrial mammal populations through increased mortality along the TAPS ROW.

Summary: Mortality. Available evidence and experience suggest that the proposed action will not increase terrestrial mammal mortality. ADF&G population management objectives are being met for wildlife in most GMUs (Section 3.2.5). Terrestrial mammal populations examined in this review are not limited by mortalities due to vehicle collisions, non-hunting deaths, or mortality due to spills. Ungulate population numbers are controlled primarily by predation, severe weather, and hunting. In many areas, ADF&G actively manages predator populations.

Harvest by Humans

There are potential impacts of harvest by humans on terrestrial mammals with respect to TAPS operation and maintenance. The majority of this concern relates to impacts in previously undisturbed wilderness areas that are now accessed by the Dalton Highway. Issues are related to management and population objectives (i.e., harvest numbers, hunting pressure, animal wounding); compliance with regulations (i.e., Dalton Highway Corridor Management Area, firearms, monitoring and enforcement effort); and access. These issues are not unique to the TAPS ROW and have been addressed in other areas of North America (James and Stuart-Smith, 2000; Hay and Mohrman, 1993; Ricard and Doucet, 1993).

South of the Yukon River, relatively few concerns have been identified with respect to the TAPS ROW and harvest by humans. Since the Richardson Highway was in place before construction of TAPS, access into a previously undisturbed large area is not a new issue. However, public access has been created with trespass permission on Alyeska property (Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm; Shoulders, 1999, pers. comm.). In these cases, although hunting is not allowed from or within the ROW, the hunting and recreating public may travel within and across the ROW to previously isolated areas.

North of the Yukon River, the Dalton Highway has provided access to a previously remote area. Concern exists that this increased access has adversely affected moose, caribou, wolf, and bear populations with increased harvests (Yokel, 1999, pers. comm.) and the wounding of animals. Monitoring and enforcement of regulations along the Dalton Highway have been inconsistent and variable (Smith, W., 1999).

Beginning in 1980, summer traffic on the Dalton Highway was allowed as far north as Dietrich Camp, and year-round access was permitted starting in 1984. Travel was restricted to commercial vehicles north of Dietrich Camp (Smith, W., 1999). In 1991, the Dalton Highway was opened to public traffic along its entire length, but shortly thereafter was officially closed north of Dietrich Camp as a result of court challenges. The highway's entire length was reopened by state administrative order in December 1994 (Smith, W., 1999). According to W. Smith (1999, p. 1), "Although the northern section of the Dalton Highway was officially closed [between 1991 and 1994], the prohibition was largely ignored, and there was extensive hunting from the road. State policy dictated that the closure was not enforced as a primary statute, but was placed on a secondary status, similar to Alaska's seatbelt law. This meant violations of the road permit regulation were only cited in association with other violations."

Current hunting regulations north of the Yukon River include the Dalton Highway Corridor Management Area (DHCMA) in addition to regulations for each game management unit (GMU). DHCMA boundaries extend 8 km from each side of the Dalton Highway — including the highway's drivable surface — from the Yukon River to the Prudhoe Bay Closed Area. Restrictions in the DHCMA include the following:

- The DHCMA is closed to hunting with firearms, but big game may be taken by bow and arrow;
- No motorized vehicles, except aircraft, boats, and licensed highway vehicles, may be used to transport game or hunters within the DHCMA; and
- Any hunter traveling on the Dalton Highway must stop at any check station operated by ADF&G in the DHCMA (ADF&G, 1999g).

ADF&G has maintained a hunter check station on the Dalton Highway since 1991 to monitor hunting effort and to provide information to hunters in the Dalton Highway Corridor (DHC) and in GMUs adjacent to the road (Smith, W., 1999). More than half of all hunters registering at the check station were making their first trip up the Dalton Highway. Most (75 percent) hunters are Alaska residents, 69 percent of whom reported home addresses in Fairbanks, the northern Interior, Anchorage, Chugiak, or Eagle River. Approximately one-fourth of hunters using the DHC were on active military duty (Smith, W., 1999).

W. Smith (1999) reported that in any year, several factors combine to influence the number of hunters using the

DHC. Factors that encourage hunter use of the corridor include good weather, good road conditions, early-August influx of caribou near the road in GMU 26B, reduced availability of Tier 1 permits for the Nelchina Caribou Herd, lowered bag limits for other registration hunts, and state promotion of tourism. The State does not specifically promote use of DHC, although the BLM-Dalton Unit does (see BLM, 1998). Promotion of tourism is likely to increase use of the DHC (Smith, W., 1999). Factors that discourage hunter use of the DHC include the 8-km walk with firearms, closure of moose and non-resident brown-bear hunts in GMU 26B, reduced numbers of caribou near the road after August 15, lack of facilities from Coldfoot to Prudhoe, and lack of paving (Smith, W., 1999).

W. Smith (1999) concluded that although use of the DHC has increased since 1991, populations of moose, caribou, brown bears, and wolves have not been adversely impacted. The following is an excerpt from W. Smith (1999, pp. 7-8) regarding harvests of these populations:

> "The number of hunters for the 4 major big game species increased substantially in 1998, but harvest remained similar to previous years. As in the past few years, most caribou were taken in August near Toolik Lake, probably from eastward excursions of the large Western Arctic Herd (ca. 460,000) to the Dalton Highway. Consequently, the resident Central Arctic Herd in Unit 26B remains lightly harvested and, with current firearms restrictions with the DHC, should not be much affected by increased hunting pressure. Since the closure of Unit 26 to moose hunting, hunters using boats for access have shifted to waterways south of the Brooks Range such as the Koyukuk River and Bonanza Creek. This, along with increasing number of hunters using the road for access, resulted in the highest take of moose in Units 20F and 24 since 1991. Although hunting pressure has been localized along the road and the few navigable waterways off the Dalton Highway, moose harvest should be monitored in these units. Sheep brought through the check station represent only a small proportion of sheep harvested in units adjacent to the Dalton Highway. Since most successful sheep hunters use aircraft, increased hunting pressure from the road and by boat will have only minimal effects on sheep harvest. Changing the Unit 26B brown bear regulations caused a significant decrease in brown bear harvest to below the harvest quota. The increased harvest in Unit 24 was not caused by incidental take by higher numbers of hunters using the road or boats, but by an increased take by hunters using aircraft. However, similar to moose, brown bear harvest in Unit 24 should continue to be monitored carefully for increased incidental harvest."

The increase in Alaska's human population since TAPS construction has undoubtedly increased the hunting pressure on the state's wildlife. ADF&G has responded to this pressure where necessary by restricting seasons and bag limits. Many moose and caribou populations in the state are limited by predation, and ADF&G has implemented predator control programs to increase the number of ungulates available to hunt (Miller, S., 1997; Reynolds, H., 1997; Boertje et al., 1996; Ballard et al., 1991; Ballard and Miller, 1990; Bergerud and Ballard, 1989; Bergerud and Ballard, 1988; Van Ballenberghe, 1988; Ballard et al., 1987; Van Ballenberghe, 1985; Gasaway et al., 1983). Although these programs have been controversial, ADF&G management policies include direction to provide recreational harvest opportunities, which requires management for productive moose and caribou populations.

In addition, changes in land ownership and land uses in the early 1980s redistributed hunting pressure in the entire state by changing access for hunting and fishing. Areas that had previously been available for hunting were restricted due to federal land-use regulations for National Park Service lands such as Wrangell-St. Elias National Park and Preserve and Gates of the Arctic National Park (Mumford, 1999, pers, comm.; Heimer, 1980). Thus, hunting pressure in those areas not taken over by the federal government increased concurrently with TAPS-related accessibility.

Hunting pressure and harvests have increased for many wildlife species near TAPS since its construction. However, ADF&G management objectives are being met for most wildlife populations. Bag limits and seasons have been adjusted to allow for maximum sport-hunting opportunities without adversely impacting the population. Many populations are successfully managed through hunting. Increases in harvest and hunting pressure have not produced adverse population-level effects.

Furbearers and Small Mammals

Obstructions to Movements. Continued operation of TAPS would maintain a cleared area approximately 50 to 150 ft wide that may hinder or prevent movements of some small mammals. In particular, species preferring heavy cover in forested areas may be affected (Oxley et al., 1974; Forman and Alexander, 1998). Localized habitat fragmentation would result from vegetation clearing and operational maintenance, as well as from snow removal and compaction during winter maintenance activities. Compaction of snow under snow disposal areas and vehicle tracks elimi-

nates narrow linear areas of subnivean space used by small mammals that are active through the winter (Schmid, 1971). These impacts would be restricted to small-mammal populations immediately adjacent to the TAPS workpads and access roads, and are not likely to result in large-scale population declines or reduced prey availability for predators feeding on the small mammals.

Disturbance and Displacement. Most furbearers and small mammals residing near TAPS facilities probably have habituated to routine operations and are not expected to be disturbed by their continuation. Operation and maintenance activities could disturb individual animals residing in more remote portions of the ROW where human presence is less common. Such effects would be localized and unlikely to have significant consequences for the disturbed individuals. Foxes, coyotes, river otters, wolverines, or lynxes denning in these areas may be affected to a greater degree and could abandon dens if disturbance was great enough. However, it is unlikely that normal operation and maintenance activities would cause this type of disturbance. Routine overflights by surveillance aircraft would temporarily disturb animals along or near the ROW. However, because of habituation, such disturbance would constitute a minor impact to animals residing in those areas, provided that deliberate harassment did not occur.

Similarly, human presence and activities associated with response to spills of oil and other hazardous substances would disturb small mammals and furbearers in the vicinity of the spill site and spill-response staging areas. Such activities would be more intensive and prolonged than normal maintenance and operation and would disturb and displace larger numbers of animals. The magnitude of the disturbance would depend on the size of the spill. Furbearers and small mammals residing inside spill-zone boundaries, especially those denning, would be displaced. For medium and large furbearers, spill impacts would exclude them from relatively small portions of their home ranges, although behavioral disturbance by spill response activities would extend the functional loss of habitat area. The magnitude of disturbance associated with localized spill events would be small for furbearers and small mammals, increasing with spill size and response requirements.

Wildlife/human interactions can pose a threat to safety because of increased human risk of exposure to disease such as rabies. As with bears, some furbearers such as canids and squirrels are readily habituated and even attracted to human activities, primarily when a food source is accidentally or deliberately made available (Milke, 1977; Follmann et al., 1980). Beavers can also become problem animals because of their dependence on easily constricted flowing water that may occur near, or be enhanced by, human alterations of local terrain. A beaver dam may flood storage areas or sites and equipment critical to the safe functioning of the pipeline. Because wildlife/human interactions can pose a threat to both safety and property, attempts currently are made to displace or drive away problem animals (Brown, D., 1999, pers. comm.; Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Preston, 1999, pers. comm.).

Deliberate displacement or hazing of problem animals to protect human life and property would continue to be used as a control measure at levels similar to those presently employed (APSC, 1998e). A permit is not required for such hazing. Although a fairly common practice for problem bears, available records do not indicate deliberate displacement by Alyeska of foxes, coyotes, or ground squirrels. The removal of beaver dams from culverts and other sites would continue to be a common practice along much of the TAPS ROW. This activity requires a Title 16 permit from ADF&G for alteration of aquatic habitats. Beavers would continue to be live-trapped and physically relocated, although such efforts typically provide only short-term relief (APSC, 1998e), and exclusion devices would be employed to mitigate the effects of damming culverts. For furbearers and small mammals, the impacts of deliberate displacement would be unlikely to have significant population-level impacts.

Use of the TAPS ROW by snowmachines and all-terrain vehicles (ATVs) would disturb and cause temporary local displacement of furbearers. The ROW is used extensively for snowmachine and ATV access in recreational activities, mining, trapping, and subsistence hunting (Schmidt, 1999, pers. comm.; Trudgen, 1999, pers. comm.). In response to past vehicle accidents, especially near population centers, Alyeska has installed fluorescent tape on access gates and VSMs to improve their visibility at night (Brown, D., 1999, pers. comm.). Although state regulations forbid the use of motorized vehicles for the harvest or transport of game taken with a hunting license within 5 miles of each side of the pipeline along the Dalton Highway, motorized-vehicle use is allowed for trapping and other purposes in the highway corridor. The state specifically prohibits restriction of motorized access for mineral exploration and extraction. Federal rules allow use of motorized vehicles and firearms in the ROW for subsistence purposes by qualified residents.

The ROW is the main winter trail between Wiseman and Coldfoot (Brown, D., 1999, pers. comm.). Furbearers and small mammals in the vicinity could be disturbed by motorized vehicles. The consequences of such disturbance would likely be minimal for most furbearers. However, foxes, coy-

otes, lynxes, river otters, and wolverines that actively avoid humans to avoid being shot and which would be susceptible to disturbance during denning (Olliff et al., 1999). Although the magnitude of vehicle disturbance in the ROW is difficult to estimate due to a lack of specific data, it may occur in high-use areas.

Habitat Alteration/Enhancement. Habitat alteration would result from:

- Gravel placement and other earthwork during maintenance activities;
- Periodic clearing of vegetation in the ROW;
- Fire suppression in the vicinity of TAPS;
- Dust fallout along the highway, particularly the Elliott and Dalton Highways north of Fairbanks; and
- Waste discharges and spills.

Gravel placement and earthworks, waste discharges, and spills would normally alter small areas, primarily affecting small mammals such as shrews, voles, lemmings, and squirrels inhabiting those sites. Clearing of the ROW would occur mainly in forested areas and would act to maintain those sections of the ROW in an early stage of plant community succession. Vegetation management benefits small mammals that use early-successional habitats and their predators (such as hares and lynx), and adversely affects small mammals and their predators that occur in late-successional or forested habitats (such as red squirrels, red-backed voles, and marten). Fire suppression has the opposite effect, favoring species of late-successional or forested habitats. The immediate effects of dust fallout adjacent to unpaved highways are early snowmelt and vegetation green-up, making such areas highly attractive to many herbivorous animals and consequently, their predators (Thompson, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Martin, P., 1999, pers. comm.; Bright, 1999, pers. comm.; McIntosh, 1999, pers. comm.). The continued maintenance of the TAPS ROW will have little effect on small mammal and furbearer populations.

Poor garbage management and lack of instruction and control of personnel during TAPS construction resulted in large numbers of wildlife incidents involving bears, wolves, coyotes, red and arctic foxes, wolverines, and squirrels. Repercussions included attacks on people, roadkills, kills in defense of life and property, and damaged property (Milke, 1977; Follmann et al., 1980; Schmidt, 1999, pers. comm.). Improved food and garbage handling, education, and strict prohibition of wildlife feeding (APSC, 1998e), coincident with a large decrease in human presence throughout the ROW after the construction phase, largely removed these problems (Brown, D., 1999, pers. comm.; Shoulders, 1999, pers. comm.). However, occasional instances of property damage, inadvertent or deliberate feeding, and animal control measures, including shooting of offending animals, continue to be reported (Brown, D., 1999, pers. comm.; Schmidt, 1999, pers. comm.). Because they are the most serious and conspicuous, bear incidents are reported most frequently, but observations suggest that incidents involving other species occur more frequently than is reported, in part because workers are aware of penalties and enforcement is difficult. For example, similar regulations exist in the North Slope oil fields. However, the density of arctic foxes is higher and populations more stable in the oil field than in adjacent areas. The widespread use of dumpsters by arctic foxes and their habituation and attraction to parked vehicles with humans inside both suggest that human food sources remain available (Burgess, 2000). Reported incidents along the TAPS ROW, although uncommon, have included ground squirrels, wolverines, and red foxes, often resulting in property damage (Shoulders, 1999, pers. comm.; Brown, D., 1999 pers. comm.). Although any amount of deliberate or inadvertent attraction of wildlife poses a serious legal and health risk, occurrences are limited by Alyeska facilities being fenced, widely spaced, and relatively small. The attraction of predators and scavengers to Alyeska facilities is thus unlikely to result in regional population-level impacts.

Mortality. Accidental mortality of furbearers and small mammals can occur due to collisions with vehicles and to accidental oil or chemical spills. Although the magnitude of mortality events is difficult to document or predict, the history of TAPS does not suggest that significant population-level impacts for furbearer and small mammals are likely. As previously mentioned, concentrations of wildlife near the highway occur during spring snowmelt, and observers note increased numbers of roadkills during that period. Furbearer and small mammal species known to have been killed by vehicles include arctic and red foxes, ground squirrels, and porcupines (Brown, D., 1999, pers. comm.; Shoulders, 1999, pers. comm.).

Accidental oil or chemical spills and waste discharges may cause mortality in the spill area, potentially affecting small numbers of all species present. Aquatic or semi-aquatic mammals would be most vulnerable, including beaver, muskrat, mink, and river otter. Small spills would result in correspondingly minor impacts on small-mammal and furbearer populations. Larger spills are less likely but would impact larger numbers of small mammals and furbearers. Population-level impacts would not be expected unless the spills were very large.

Mortality of furbearers or small mammals may result from deliberate action taken against problem animals. Al-

though hazing is the preferred means of dealing with problem animals, nuisance animals have been destroyed (Brown, D., 1999, pers. comm.; Shoulders, 1999, pers. comm.; Preston, 1999, pers. comm.). Foxes or other animals exhibiting signs of rabies are shot and their heads sent to the University of Alaska for testing (APSC, 1998e). Alyeska periodically hires or cooperates with trappers to remove beavers (Preston, 1999, pers. comm.). Other furbearers and small mammals that may be killed to prevent disease transmission or property damage include red foxes, coyotes, ground squirrels, and voles and mice. Although nuisance animals are viewed as a serious problem and threat to human health, historically the number of animals killed is small, and such mortalities are unlikely to have population-level impacts on furbearers or small mammals.

Increased densities of predators and scavengers attracted to areas of human activity may result in increased predation pressure on prey populations. This has recently become a management issue, mainly for ground-nesting birds on the North Slope (Day, 1998), but it is difficult to document. Increases in the abundance of foxes are well-documented in the North Slope oil fields (Burgess, 2000). However, because pipeline facilities are more dispersed than oil-field facilities, this problem would be small south of Pump Station 1.

Similarly, increased densities of predators/scavengers may increase the occurrence and rate of transmission of enzootic diseases, including rabies (Follmann et al., 1988). The primary reservoir of rabies in the Arctic is arctic foxes, whereas south of the Brooks Range, red foxes and other carnivores are a greater concern (Winkler, 1975). As with other impacts associated with nuisance animals, the magnitude of this impact directly associated with TAPS would likely be minor.

Harvest by Humans. Access provided by pipeline access roads for hunting and trapping could result in continued harvest of all furbearer species. Alyeska currently allows vehicular use of access roads and work pads with prior notification and permission, although most such use occurs without permission (Brown, D., 1999, pers. comm.). Hunting with firearms and motorized access is legally prohibited by the state within 5 miles of TAPS along the Dalton Highway. Trapping in the Dalton corridor is allowed by the state (Whitten, 1999, pers. comm.), and federal rules allow the use of both firearms and motorized vehicles by qualified subsistence users. The ROW and access roads currently receive heavy use, and illegal harvest is a recognized problem (Montgomery, 1999, pers. comm.; Brna, 1999, pers. comm.; Schmidt, 1999, pers. comm.; Thompson, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.; Whitten, 1999, pers. comm.; Shideler, 1999, pers. comm.). Decreased monitoring and enforcement following TAPS construction dramatically increased the illegal take of animals along the TAPS ROW (Whitten, 1999, pers. comm.; Shideler, 1999, pers. comm.). In recent years, trapping pressure has been heavy, and there is competition for traplines along the TAPS ROW between Fairbanks and the Yukon River bridge. Trapping pressure is lower north of the Yukon River (Whitten, 1999, pers. comm.; Shideler, 1999, pers. comm.). Legal and illegal take by hunters and trappers who use the ROW and access roads would constitute the largest single impact of ROW renewal and continued operation of the TAPS system on furbearers. However, management regulations are designed to prevent serious impacts on populations. Hunter access would be available with or without ROW renewal.

The legal take of problem animals through notification (and occasional hiring) of local trappers by Alyeska would continue with renewal of the TAPS ROW Grant (Brown, D., 1999, pers. comm.; Schmidt, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Preston, 1999, pers. comm.). Decreased beaver trapping has resulted in increased populations (Preston, 1999, pers. comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.), which in turn has caused more problems with flooding of Alyeska facilities. There are no records of Alyeska hiring trappers to remove other species, although oil companies have done so periodically to remove arctic foxes on the North Slope. The legal take of problem animals attributable directly to TAPS would be unlikely to have significant impacts on furbearer and small-mammal populations.

4.3.2.6 Threatened and Endangered Species

By R. Ritchie, D. Troy, and J. Kidd

Two species listed as threatened under the federal Endangered Species Act (ESA) (Spectacled Eider and Steller's Eider) and two delisted subspecies of Peregrine Falcon (the *tundrius* and *anatum* races) may be affected by activities associated with renewal and continuation of existing operation and maintenance of TAPS. The endangered Short-tailed Albatross occurs in the tanker shipping lanes, mainly beyond Prince William Sound. The endangered Eskimo Curlew evidently no longer occurs in Alaska. No ESA-listed terrestrial mammals or plants occur along TAPS. Because of similarities among the remaining listed species, the discussions of environmental consequences have been combined for both eider species and for both peregrine subspecies. Recent EISs have also addressed endangered spe-

cies (e.g., BLM and MMS, 1998; USACE, 1999). Possible issues regarding other sensitive species are covered in the discussion of terrestrial mammals above.

Spectacled and Steller's Eiders

The continued operation of TAPS would have negligible effects on Spectacled or Steller's eiders. Spectacled Eiders occur regularly in low numbers in the general vicinity of the TAPS ROW in the northern end. Records near the area of operations or facilities are few, but not all areas of potential occurrence have been thoroughly surveyed. Spectacled Eiders have been reported at TAPS MP 12 (Hohenberger et al., 1981), and nesting has occurred adjacent to the Dalton Highway near Deadhorse (TERA, unpubl. data). Overall, the opportunities for interaction between Spectacled Eiders and TAPS operations are few. There are no records of Steller's Eider within the ROW, indicating that its occurrence is infrequent at best and that the chance or simultaneous occurrence of eiders and a deleterious event is unlikely. FWS recently proposed designating a large portion of the Alaska North Slope as critical habitat for these two species (65 FR 6114; 65 FR 13262).

Obstruction to Movements. Roads and pipelines do not appear to be major barriers to eider movements. The greatest potential for obstruction of movements would occur during brood-rearing, when flightless Spectacled Eiders with broods cross roads in the Prudhoe Bay oil field (TERA, 1995, 1996b). A minor gravel corridor structure, such as the pipeline workpad without traffic, would not be an obstacle. The Dalton Highway would be a more imposing barrier, posing some risk of mortality for eiders attempting to cross.

Disturbance and Displacement. The evidence for sensitivity of Spectacled Eiders to disturbance is mixed. Anderson et al. (1992) found evidence of some avoidance of a high-noise facility (Prudhoe Bay Central Compressor Plant); however, Spectacled Eiders make regular use of areas close to other noisy environments such as Prudhoe Bay Flow Station 1 (e.g., TERA, 1996b). Anderson et al. (1996) suggested that nest sites tended to be farther away from facilities than where pre-breeding birds were seen, perhaps indicating some sensitivity to disturbance. The only facility along TAPS within the range of Spectacled Eiders, Pump Station 1, is not situated near any known areas of use; hence, disturbance of this nature is unlikely. Helicopter overflights, such as for pipeline surveillance, can result in the disturbance of waterfowl. Spectacled Eiders appear to be relatively tolerant of low-flying helicopters during the breeding season, and the occurrence of Spectacled Eider use areas along TAPS is limited. The greatest potential for TAPS-related disturbance of Spectacled Eiders would occur along the Dalton Highway. As with many other waterfowl, eiders appear tolerant of, or habituate to, vehicular traffic but are prone to flush when approached on foot (Murphy and Anderson, 1993).

Habitat Alteration and Enhancement. Spectacled Eiders use roadside impoundments in the Prudhoe Bay and Kuparuk oil fields (Warnock and Troy, 1992; Anderson et al., 1996). Thus, this type of habitat modification along the TAPS workpad and Dalton Highway would potentially enhance those areas for Spectacled Eiders. However, use of TAPS or Dalton Highway impoundments away from Deadhorse has not been reported for Spectacled Eiders.

Mortality. No mortality of Spectacled Eiders due to TAPS infrastructure has been documented. Use of roadside impoundments poses a limited risk for traffic-associated mortality, especially near Prudhoe, although no records of such mortality have been located. To the extent that predator populations may be augmented by TAPS activities, Spectacled Eider nest success could be depressed to a minor degree. Oil spills would be a risk factor; however, the low use of areas adjacent to the TAPS ROW makes this a small risk. A Spectacled Eider successfully nested in an area affected by a spill the prior winter (Drill Site 5; Burgess, Jorgenson et al., 1995). A female Spectacled Eider died from oiling after landing in a waste pit with a light oil sheen in the east Prudhoe Bay oil field in 1983 (ABR, Inc., unpubl. data).

Harvest by Humans. Hunting of Spectacled and Steller's eiders is prohibited throughout Alaska. Even before the prohibition, it is unlikely that any shooting of these species occurred along TAPS. Limited waterfowl hunting takes place in the eiders' range near TAPS, and few, if any, eiders are present during waterfowl hunting season. Spectacled Eider eggs have been taken under federal collecting permits — perhaps due to mis-identification as King Eider eggs — in the Prudhoe Bay area as recently as the early 1990s. Permits are no longer given to collect eider eggs in Alaska for captive propagation.

Peregrine Falcon

The continued operation of TAPS is expected to have negligible effects on both the *anatum* (American) and *tundrius* (Arctic) subspecies of the Peregrine Falcon. Both populations continue to increase in numbers adjacent to the TAPS ROW, and no traditional sites appear to have been abandoned. Regular surveys monitoring productivity and success have not referenced specific concerns regarding TAPS and its activities (e.g., Wright and Bente, 1999; Ritchie and Rose, 1999).

Obstructions to Movements. Roads, elevated pipelines, and normal maintenance and operation activities along TAPS probably have little effect on the movement of Peregrine Falcons. No research has been conducted to determine whether individuals avoid TAPS. However, anecdotal observations of peregrines perching on the pipeline, VSMs, Dalton Highway signs, snow markers, and other elevated perches suggest regular use of the area.

Disturbance and Displacement. Ritchie (1987) documented the disturbance effects of pipeline operation and maintenance activities on *tundrius* Peregrine Falcons on the North Slope. Activities included surveillance helicopter monitoring of the pipeline, light trucks and ground parties along the ROW, heavy equipment associated with pipeline repair, and boats associated with spill-response drills. Behavioral observations of Peregrine Falcons — which were limited to a small sample of nest sites primarily during incubation through late nestling periods — documented few severe reactions or behaviors, suggesting that none of these activities influenced major behaviors including incubation, nest attendance activities, and provisioning (Ritchie, 1987). Productivity was similar between experimental and control groups. Similar results showing short-term behavioral reactions with little or no apparent effect on productivity have been reported in investigations of aircraft disturbance of peregrines (Windsor, 1977; Ellis et al., 1991).

Peregrines continue to occupy traditionally used cliffs within 1 mile of TAPS and the Dalton Highway, suggesting that long-term displacement has not occurred during operation of TAPS. If some sites were not used during construction of TAPS, explanations for those presumed displacements were masked by natural variation in numbers (White et al., 1977) and the smaller size of peregrine populations in the mid-1970s when both subspecies were at historical lows (Roseneau et al., 1981). Since then, numbers have recovered and now exceed population estimates made in the 1960s (Wright and Bente, 1999).

Habitat Alteration and Enhancement. Maintenance and operation activities along TAPS could result in both permanent and temporary changes in nesting and foraging habitats of Peregrine Falcons. Permanent actions would be limited to minor amounts of additional fill covering some prey habitats and to cliff modifications at quarries. Effects of these actions have not been quantified and may be positive. As *anatum* populations have expanded in Interior Alaska, rock quarries have been used for nesting (Ritchie et al., 1998). Quarries associated with TAPS may provide similar nest substrates, which would be disturbed if quarrying activities resumed during the nesting season. Mitigation would be achieved through adjustment of seasonal timing of such activities.

Temporary losses or enhancements of habitats for peregrines would include excavations associated with pipeline inspection, delayed snowmelt in the shadows of some facilities and gravel structures, dust fallout and impoundments associated with the Dalton Highway, and elevated structures including the pipeline, buildings, and snow markers. The impacts of these habitat modifications are difficult to quantify, however. In general, most of these actions probably would attract Peregrine Falcons, either as areas attracting prey (e.g., impoundments, dust shadows) or as platforms for resting and perching (e.g., VSMs). Although Peregrine Falcons have not been recorded nesting on TAPS facilities, other raptors have used TAPS facilities (Ritchie, 1991). Use of towers by tundra peregrines elsewhere on the Arctic Coastal Plain (Mauer, 1999, pers. comm.) indicates the potential value of elevated structures along TAPS for nesting, particularly at the northern end.

Mortality. Potential sources of mortality of Peregrine Falcons associated with pipeline operations and maintenance activities could include collisions with vehicles, aircraft, and facilities; disturbance of nesting adults causing egg and nestling death or premature fledging of young; contact with oil or other contaminants; and increased predation from increases in predator populations (Roseneau et al., 1981). The occurrence and frequency of such risks are poorly documented. Some vehicle-caused mortality of raptors, including Peregrine Falcons, has been documented along TAPS, but probably occurs infrequently. At least one dead immature falcon, whose death was attributed to a collision with a vehicle, was recorded near Pump Station 2 (Ambrose, 1999, pers. comm.).

No other references to direct mortality of peregrines due to pipeline activities have been identified, but monitoring for loss of nestlings or eggs due to human disturbance has not been undertaken. Some mortality probably has occurred due to curious or inadvertent visitation by recreationists and naturalists along the Dalton Highway.

Harvest by Humans. Falconry permits from the State of Alaska have allowed the taking of three Arctic Peregrine Falcons annually along TAPS since the delisting of the *tundrius* subspecies in 1995 (5 AAC 92.037. Permits for falconry). Since that time, two to three *tundrius* nestlings have been removed from nests each year along the Sagavanirktok River (Wright, 1999, pers. comm.). The FWS is currently defining conditions for allowable take of the *anatum* subspecies of Peregrine Falcon, which was delisted in 1999 (FWS, 1999e). No other type of harvest by humans for such uses as subsistence or research has been recorded along TAPS.

Plants

No threatened or endangered plants occur along TAPS.

Terrestrial Mammals

No threatened or endangered terrestrial mammals occur in Alaska.

4.3.2.7 Effects of Treated Ballast-Water Effects on Benthos in Port Valdez

By B. Haley

Studies to monitor environmental consequences of effluent discharge from Alyeska's ballast water treatment facility have been conducted in the vicinity of the VMT since the late 1960s. Biological information for the subtidal benthos has been collected between 1971 and 1999 for Port Valdez. The objectives of the program are to document and interpret distribution, abundance, and biomass of benthic organisms and detect changes in benthic fauna. Stations were assigned in 1987 to compare data between remote (far-field) stations, shallow near-field stations, and shallow and deep mixing-zone stations.

Fluctuations in distribution and abundance are common throughout the benthic communities studied. Several factors influence the health of the benthos there, including sediments from glacial stream and river runoff, seismic activities, and sediment deposition during coastal construction. Feder and Jewett (1988) suggest that the benthic system in Port Valdez is carbon-limited and that a "feast or famine" hypothesis is reasonable. Cyclic highs and lows in benthic community abundance and biomass noted from 1971 to 1996 are credited to variable carbon availability.

Station D25 is within approximately 120 m of the treated-ballast-water diffuser, and Station D33 is adjacent to the diffuser. Trends in abundance and number of benthic taxa at both stations indicate impacts potentially related to ballast-water disposal when compared to reference stations.

A potential change in benthos related to ballast water treatment discharge was apparent in 1995-97. Decreasing abundance and taxa number trends were measured at Station D25 in that period. Two replicates from D25 were visibly contaminated with petroleum product in 1997. Increased taxa dominance and lower diversity at D25 indicated a distinct difference in the benthic profile at D25 from other stations. In 1998, fauna abundance and number of taxa and biomass increased, suggesting that the environmental influences had moderated and that the benthos was recovering. The taxa ranking at D25 approached that which was previously common to the station, further indicating a moderation of negative effects. No difference in mean values at D25 from reference stations were observed in 1999.

The abundance of benthic suspension feeders (thyasirid bivalves) has occasionally been very high at D33, relative to other shallow stations. This fact supports the suggestion that enhanced elevated food levels exist there, presumably from particulate matter emitted in the treated ballast-water. Underwater television recordings of dense communities of suspension feeders and particulate material flowing from the diffuser ports support this (Feder and Shaw, 2000).

Little or no evidence of petroleum contamination was found in benthic communities in Port Valdez in 1973 (Hood et al., 1973). Under terms of the first NPDES permits, hydrocarbon in sediment measurements were conducted in the 1970s and 1980s. Detectable concentrations of petroleum hydrocarbons were measured in the vicinity of the VMT after operations began in 1977. Analysis of sediment samples taken between 1989 and 1996 measured higher concentrations of hydrocarbons in the vicinity of the terminal than at remote locations in Port Valdez. With rare exceptions, near-terminal hydrocarbon concentrations were well below the guidelines for marine sediment quality (i.e., Washington State Marine Sediment Quality Standards and EPA Draft Sediment Quality Criteria). Concentrations of hydrocarbons in Port Valdez mussels from 1989 to 1996 were apparently unrelated to terminal operations; compounds and concentrations present were highly variable and mostly biogenic in origin (Feder and Shaw, 2000).

Analysis of data on Port Valdez benthic fauna indicates that treated ballast-water does not negatively impact benthic communities at the deep-water stations and only rarely influences benthos at the shallow-water stations.

4.3.3 Social Systems

This section provides information on the likely impacts on social systems from renewal of the TAPS ROW.

4.3.3.1 Economy

By O.S. Goldsmith, L.D. Maxim, and R. Niebo

This section provides estimates of the economic effects of TAPS ROW renewal for the pipeline, Alaska North Slope (ANS) fields, marine transportation link, and other industries in Alaska. Included are direct, indirect, and cumulative economic effects. Economic effects are calculated by a model that addresses the pipeline and the ANS fields as a combined unit. Largely based on geography, it is possible to separate other social impacts of the proposed action, so that only direct and indirect impacts of the pipeline

are addressed here. Cumulative social effects are included in Section 4.5.

The economic effects of the proposed action alternative are beneficial, substantial, and wide-ranging. Moreover, these have not been addressed in any previous EIS or EA, which necessitates a more complete explanation.[1]

Except where noted, projected North Slope oil revenues are based on a constant real price for North Slope crude of approximately $16 per barrel (1998 dollars). Since completion of the economic analysis summarized here, oil prices have increased substantially (to more than $30 per barrel as of March 2000). It is not feasible to replicate this analysis in response to every crude-oil price movement. However, an upward shift in oil prices will magnify the economic impacts presented here. First-order impacts of this change include substantial (factor of 2) increases in revenues to various levels of government. If higher prices persist, marginal fields and other oil and gas developments become more attractive. Developing these fields would increase future ANS production and pipeline throughput and, therefore, revenues. In turn, greater revenues result in "ripple" (multiplier) effects throughout the Alaskan economy. Although some of these effects — such as higher prices for gasoline, diesel fuel, heating oil — would be adverse, most are beneficial for oil-producing regions. Thus, if crude oil prices increase above $16 per barrel, the economic benefits will increase as well.

Key Assumptions: The Pipeline

- **Pipeline Throughput:** Appendix A provides the baseline assumption for ANS production and TAPS throughput if the pipeline ROW is renewed until 2034.
- **Pipeline Operation:** The pipeline continues to operate until 2034. Operating employment declines as pump stations are closed due to reduced throughput. Contract workers and special project employment also decline. From 2,096 operations, contract, and special projects workers in 1999, employment falls to 1,716 in 2010 and remains there.
- **DR&R:** Pipeline dismantling, removal and restoration occurs sometime after 2033.
- **Oversight:** Government and other oversight of TAPS continues at the current level throughout the period of the proposed action.

[1]Each North Slope EIS addresses the proposed action, but these discussions do not include the total effects of oil and gas operations on the Alaska North Slope. Nearly all material in Section 4.3.3.1 is original, and all tables and figures in the section are from original analysis by the authors.

Key Assumptions: North Slope Oil-Related Activity

- **Oil and Gas Exploration, Development, and Production:** This activity continues on lands currently open for oil exploration, development, and production, but no activity occurs on lands currently closed, specifically the Arctic National Wildlife Refuge. Oil production gradually declines as the depletion of older fields is only partially offset by production from newly discovered fields (Appendix A). Oil and gas employment remains constant as smaller, marginal fields requiring more labor replace larger and more productive but depleted fields. Efforts continue to develop the substantial gas resources on the North Slope, but no specific project — such as gas to liquids, a gas pipeline parallel to the oil pipeline, or a gas pipeline through Alaska into Canada — is included in this economic analysis.
- **DR&R:** North Slope oil and gas facilities DR&R occurs sometime after 2033.
- **Module Construction:** Construction of some modules for North Slope oil production continues in Anchorage, Fairbanks, and Nikiski.
- **Refining:** Refineries at Fairbanks and Valdez operate throughout the renewal period using a constant volume from TAPS to produce petroleum products for the Alaska market.
- **Air Cargo:** The international air-cargo industry, centered in Anchorage, expands until 2010 in response to growth in the market, and then remains stable. This growth is facilitated by the availability of competitively priced jet fuel refined in the state.
- **Other Industries:** Competitively priced petroleum products are important to the health of all of Alaska's natural-resource-based private industries — fishing, timber, mining, and tourism. The military, particularly the Air Force, is a large consumer of petroleum products. The gradual decline of North Slope production does not adversely affect the availability of competitively priced petroleum products, and these industries are not impacted.
- **Shipping:** Lower TAPS throughput reduces the number of tanker trips taking crude oil to market from Valdez. Economic growth without increased capacity of existing refineries in the state slowly increases the number of tanker trips bringing petroleum products into Southcentral Alaska from refineries outside the state.
- **Oversight:** Government oversight of oil and gas con-

tinues at the current level throughout the ROW renewal period.

Key Assumptions: Other Economic Activity

- **Basic Industries:** Employment in Alaska's basic industries grows at an annual rate of 1 percent between 2000 and 2010, slows to half that rate between 2010 and 2025, and is constant thereafter (Table 4.3-16).
- **Tourism:** Tourism is projected to add the most jobs, with growth between 2000 and 2010 of 3.3 percent annually. Consequently, tourism surpasses seafood as the largest private basic industry in the state measured by jobs. However, because of the relatively low wages paid in tourism, its total economic impact is less than most other basic industries.
- **Mining:** Mining is projected to grow at 3.7 percent annually between 2000 and 2010, although it is starting from a relatively low base.
- **International Air Cargo:** This relatively new industry for the state is expected to expand through the next decade at an annual rate of 2.2 percent.
- **Other Industries:** The other private basic industries contribute little to growth in the number of jobs. Petroleum shows some growth between 2000 and 2010 as it recovers from the very low oil prices of early 1999. Seafood harvesting and processing employment remains constant. Timber has a modest recovery from the slump in the second half of the 1990s. Active-duty military employment remains constant.
- **Federal Government:** Federal civilian employment will trend upward at 0.3 percent per year. Federally funded construction activity continues at a high level through 2010 and then declines 5 percent annually.
- **State Government:** The state government has experienced a chronic General Fund deficit since the early 1990s precipitated by the decline in petroleum revenues as North Slope production decreased. The deficit has been covered through a combination of reductions in spending and the use of cash reserves. In the future, balancing the budget will also require the reimposition of the state personal income tax and the use of a portion of the earnings of the Alaska Permanent Fund. Real General Fund expenditures grow, but real expenditures per capita fall 1 percent a year. State government employment increases slowly as budget reductions are concentrated in transfer programs.
- **Permanent Fund:** The Alaska Permanent Fund grows at 0.6 percent per year in real value from continued contributions of a share of petroleum royalties and reinvestment of earnings to inflation-proof the fund balance. These contributions increase the fund balance from $24.2 billion in 2000 (1998 dollars) to $26 billion in 2010 and $28.1 billion in 2025. In the early years 70 percent of fund earnings (net of inflation proofing) are used to pay the Permanent Fund Dividend (PFD) to eligible Alaskans. The rest of the earnings is retained in the Earnings Reserve Account. Later it becomes necessary to use the Earnings Reserve Account, as well as a portion of the PFD, to maintain government services. The share of earnings used to pay the PFD falls to 30 percent in 2010 and 10 percent in 2025.
- **Local Governments:** State government support for local government, primarily education, grows with the state budget but does not keep pace with the increase in population. The drop in revenues from smaller petroleum-property-tax receipts is concentrated in the North Slope Borough (NSB) and the City of Valdez. In other communities there is growth in property tax receipts from other sources to help support necessary locally provided public services.

Economic Effects

Renewal of the TAPS ROW will result in substantial economic effects — some directly associated with the pipeline and others related to continued operation of the ANS fields and the marine transportation link. Economic effects associated with operation of the ANS fields and the marine

Table 4.3-16. *Basic-sector employment and projected growth rates for the proposed action.*

	Petroleum	Mining	Seafood	Timber	International Air Cargo	Tourism	Military	Federal Civilian	Total
Employment in 2000	8,800	1,797	19,115	2,029	2,100	16,518	18,054	17,429	85,842
Annual Growth									
2000-2010	0.8%	3.7%	0.0%	0.2%	2.2%	3.3%	0.0%	0.2%	1.0%
2010-2025	0.0%	1.3%	0.0%	0.3%	0.0%	1.7%	0.0%	0.2%	0.5%
2025-2034	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: Results of analysis using the model from the Institute of Social and Economic Research (ISER) of the University of Alaska, Anchorage.

transportation link, as well as indirect effects associated with all oil and gas activity, are cumulative effects. However, the econometric model used in this analysis treats these elements as one econometric system, and it would be difficult to disaggregate effects. Therefore, the economic analysis presented here addresses direct, indirect, and cumulative economic effects.

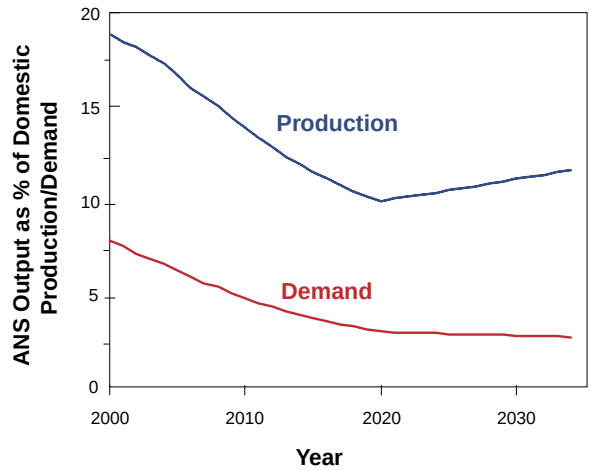
Continued operation of ANS/TAPS is expected to have significant positive economic impacts compared to the no-action alternative. ROW renewal provides additional revenues to federal, state, and local governments, and employment and income for U.S. workers in Alaska and elsewhere, and supports government policy objectives ranging from the National Energy Strategy to maritime policy (the Jones Act).

Equally important, continued operation of ANS/TAPS provides additional time for Alaska's economy to become more diversified and gradually adjust to reduced dependence on oil. As other countries dependent on a single industry have learned, such transitions are often painful, particularly if abrupt (Amuzegar, 1999). The more gradual the transition, the more time is available to develop other industries and government policies to cushion the impact of change.

Finally, renewal of the ROW preserves the pipeline and thus increases the possibilities for development of additional oil fields and/or commercialization of natural gas resources.

National Impacts. In a national context, the economic benefits provided by ROW renewal are projected to be smaller than in the past as production decreases, but very significant nonetheless. National impacts associated with continued TAPS operation include increased domestic crude-oil production, an improved balance of trade in crude oil, increased federal revenues, construction of additional double-hull tankers to serve the ANS trade, and increased employment for workers in U.S. shipyards and for U.S. seafarers. These impacts are summarized as follows:

- **Increased Domestic Crude Production:** Continued operation of the ANS oil fields will increase domestic crude production by an aggregate amount of approximately 7 billion bbl over the ROW renewal period. Figure 4.3-19 shows ANS production as percentages of estimated domestic crude production and demand. ANS production accounts for a declining but substantial percentage of estimated (EIA, 1998) domestic crude production through the year 2020. Key components of the National Energy Strategy are increased energy conservation and increased domestic production. Continued operation of ANS/TAPS serves the latter policy objective of ensuring against energy disruptions and of increasing domestic energy production in an environmentally responsible manner (USDOE, 1998).
- **Improved Balance of Trade:** The availability of ANS crude oil reduces the amount of crude that must be imported to meet estimated domestic demand and thus improves the balance of trade, which for petroleum has been negative for some years. Domestic petroleum demand is projected to increase and domestic crude production to decrease even if ANS production continues. Therefore, the trade deficit in petroleum will grow worse whether or not the ROW is renewed. However, the projected deficit will be smaller if ANS production continues. If the ROW is renewed, the cumulative value of ANS production is projected to be approximately $112 billion (1998 dollars), assuming a world oil price of $16/bbl or $150 billion (1998 dollars), based on world oil price forecasts made by the U.S. Department of Energy[2], and the trade deficit would be reduced by this same amount.
- **Increased Federal Revenues:** ANS production generates federal revenues from federal income taxes and lease royalties. From 2004 to 2034, continued operation of the ANS fields and TAPS is estimated to yield



Note: The apparent increase in ANS share of domestic production after 2020 is an artifact of the assumption that the baseline ANS throughput remains constant while U.S. production continues to decline between 2020 and 2034; see Appendix A)

Figure 4.3-19. *ANS output as percent of domestic crude production or consumption under the proposed action.*

[2]Cumulative ANS production value is calculated from throughput assumptions (Appendix A) and the 2000 EIA World Oil Price Forecast (EIA, 1999e).

approximately $10.8 billion in 1998 dollars (ECA, 1999b).

- **Tankers and Related**: Under OPA 90, existing single-hull tankers must be phased out over time and new double-hull tankers constructed to transport ANS crude from Valdez to destination ports. Based on the published phase-out schedule for the present ANS fleet and projected ANS output, it is estimated that nine 125,000-deadweight-ton tankers will have to be constructed at approximately $166 million (1998 dollars) each (ECA, 1999a). Thus, approximately $1.5 billion will be spent at U.S. shipyards for these tankers. Since approximately 1,000 shipyard jobs are generated for the 18 months that it takes to construct a tanker, nine tankers will support 162,000 worker-months of employment in these yards. Periodic tanker inspection and maintenance will provide additional jobs for workers in U.S. shipyards. Employment for U.S. seafarers will gradually decrease as the number of tankers required to carry ANS output decreases. At the beginning of the ROW renewal period, ANS tankers will employ approximately 1,330 U.S. seafarers. This number will decrease to approximately 530 over the renewal period. Indirect (multiplier) effects would add to the total economic activity associated with construction and operation of these tankers.

State Impacts Modeling. State impacts were calculated using a model developed by the Institute of Social and Economic Research (ISER) of the University of Alaska Anchorage (UAA) (Goldsmith, 1999b). Following is a brief description of the econometric methodology.

The projections of Alaska state and regional economic and demographic variables in both the proposed action and the no-action alternative were generated using the Man in the Arctic Program (MAP) Economic Modeling System of UAA. The MAP system was developed at ISER in the early 1970s to demonstrate the economic, demographic, and fiscal impacts on Alaska of different schedules of federally imposed petroleum-development scenarios (Kresge and Seiver, 1978; Kresge et al., 1984). It has since been used for a variety of purposes including analyzing the economic and fiscal effects of specific private-sector development projects (Goldsmith et al., 1976), analyzing the cumulative impacts of energy development (Huskey, 1979), and projecting likely economic futures for the state for transportation planning purposes (Goldsmith and Hill, 1997).

A set of statewide and regional economic and demographic projections has been produced using MAP nearly every year since 1990. The most recent set of projections, *Economic Projections for Alaska and the Southern Railbelt: 1999-2025*, prepared in July 1999, assumed the continued operation of the oil pipeline through 2025 (Goldsmith, 1999b). Those projections form the basis for the employment, income, gross state product, and population estimates for the proposed action.

To develop the economic and demographic estimates for the no-action alternative (Section 4.4.3), a different set of assumptions was developed and run through the models. These assumptions described the direct employment effect of shutting down the pipeline and North Slope operations — including DR&R — as well as the direct revenue effect on state and local governments. The models were run to estimate state and regional economic activity, state and regional fiscal activity, and state and regional demographic activity for the no-action alternative. Comparison of these results with the output from *Economic Projections for Alaska and the Southern Railbelt: 1999-2025* (including some variables not included in the earlier written report) produced estimates of the impact of the no-action alternative compared to the proposed action.

The MAP Economic Modeling System consists of both statewide and regional models. The statewide model has three modules: economic, fiscal, and demographic, while the regional model includes census-division-level simplified economic and demographic elements which can be aggregated into larger regions.

In the economic module of the state model, the level of economic activity is a function of production for export as well as production for local consumption. The output of the export sectors is determined exogenously, while that of the support sectors is a function of local demand reflected by disposable personal income and wealth. Production from both sectors generates wages and salaries which form the major portion of disposable personal income after personal taxes. Thus, demand and supply are simultaneously determined in this module. Time-series econometric equations underestimate most of the relationships in the model.

The economic module is linked to both the fiscal and demographic modules and depends as well on national economic activity measured by movements in the price level, wage rates, per-capita income, and other variables. Output of the public sector is an important element of total production, and government tax and expenditure policies directly affect the level of aggregate and per-capita disposable income. Population also influences both production, via local demand for goods and services, and personal income, via transfers and other payments related to the size of the population.

In the fiscal module, state and aggregate local government revenues and expenditures are determined. Since

most state revenues are from oil production and financial asset earnings, and expenditure patterns have changed with variations in the availability of revenues, this part of the module is a combination of econometric equations and accounting relationships. A particularly challenging part of any projection is developing a set of assumptions (a fiscal policy package) for dealing with the projected continued decline of state revenues. Local revenues and expenditures are represented by time-series econometric equations with revenues determining the level of expenditures.

The fiscal module is linked to the demographic module in that population is a determinant of the level of some revenues as well as some categories of expenditures. The level of economic production is also a factor in determining revenues, but there is no direct link between economic production and public spending.

In the demographic module, age and sex projections for Alaska Natives, non-Native civilians, and active-duty military are generated using a cohort survival methodology. There is a strong link with the economic module because the determinants of net migration (an important component of the change in population over time) include Alaska wage rates and unemployment rates relative to the rest of the national economy. Migration is also influenced by tax and expenditure policies reflected in the fiscal module.

The regional model consists of procedures that allocate Alaska employment, personal income, and population categories among the census areas of the state. Total employment estimates take into account the concentration of purchasing power and thus support employment in regional centers and away from outlying areas. Resident employment estimates account for the large number of workers in some census areas who reside elsewhere in the state or outside Alaska. Population estimates account for the movement of Alaskans toward those census areas where employment opportunities are increasing relatively faster. The relationships in this model are based on a variety of primarily cross-sectional data sources such as the U.S. Department of Commerce, Bureau of the Census, and point-in-time surveys. This model does not produce as much employment and demographic detail as the state model, and there are no local government fiscal modules for individual communities.

The model structures have evolved over time, primarily in response to changes in the structure of the economy of Alaska but also in response to the needs of users and to computer capabilities. It is standard practice to review and revise, as appropriate, model structures, input assumptions, initial values, and coefficient and parameter values each time the models are used.

State Impacts. Renewal of the TAPS ROW will provide substantial benefits to the State of Alaska and its residents. Continued operation of the pipeline and of North Slope oil- and gas-related activity generates a large and stable level of basic sector employment (Table 4.3-17) that contributes to the economic base of communities throughout the state. Since these jobs are among the highest paid in the state, each job makes a large contribution to the economy. Many jobs linked to oil field operations, particularly in refining, module construction, air cargo, and government oversight, are located outside the pipeline corridor. In addition, most North Slope oil and gas workers live in other parts of Alaska (ADOL, 2000).

Cumulative North Slope oil production during the ROW renewal period will be approximately 7 billion barrels. Total state petroleum revenues from North Slope oil production and pipeline operations are projected to be $14.2 billion (1998 dollars) between 2004 and 2033 (Figure 4.3-20). Revenues from ANS production represent 95 percent of all statewide petroleum revenues and 65 percent of total state General Fund revenues in 2004. The North Slope oil share of General Fund revenues from current sources falls to 36 percent in 2010 and 18 percent in 2025.

Projected North Slope oil revenues are based on a constant real price for North Slope crude of $16 (1998 dollars) and a production decline rate of 4.1 percent through 2020, with production constant thereafter (Appendix A). The North Slope share of state oil and gas royalties is 92 percent in 2004, falling to 80 percent in 2025. The North Slope share of state severance taxes is 96 percent in 2004, falling to 75 percent in 2025.

Revenues from the property tax on North Slope oil-production-related facilities and TAPS continue to be an important source of local government revenues (Figure 4.3-21). The North Slope Borough receives $1.896 billion (1998 dollars) in revenues from this source between 2004 and 2033, while the City of Valdez receives $126 million over the same period. Anchorage and Fairbanks receive smaller amounts.

Other local-property and state-income tax revenues associated with refining, module construction, and air cargo are the direct result of ROW renewal.

The Joint Pipeline Office (JPO), staffed by federal and state employees, provides regulation and oversight of the pipeline. Alyeska funds its TAPS-related activities. Other government agencies not part of the JPO also have oversight and regulatory authority over the pipeline. Various offices of state and federal government are involved with the regulation of North Slope oil activity and the management of state leases on the North Slope. State government

Table 4.3-17. *Direct full-time employment from pipeline and North Slope-related activity associated with the proposed action.*

Year	Total	Pipeline Subtotal	Pipeline Operations	Pipeline Oversight	North Slope Oil Field Subtotal	North Slope Oil Field Operations	North Slope Oil Field Oversight	Module Construction	Refining	Air Cargo
2000	11,601	2,638	2,538	100	8,963	5,823	325	500	215	2,100
2001	11,244	2,307	2,207	100	8,937	5,747	325	500	215	2,150
2002	11,062	1,998	1,898	100	9,063	5,823	325	500	215	2,200
2003	11,176	1,987	1,887	100	9,190	5,899	325	500	215	2,250
2004	11,320	1,928	1,828	100	9,392	6,052	325	500	215	2,300
2005	11,437	1,843	1,743	100	9,594	6,204	325	500	215	2,350
2006	11,630	1,834	1,734	100	9,796	6,356	325	500	215	2,400
2007	11,671	1,825	1,725	100	9,846	6,356	325	500	215	2,450
2008	11,712	1,816	1,716	100	9,896	6,356	325	500	215	2,500
2009	11,762	1,816	1,716	100	9,946	6,356	325	500	215	2,550
2010	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2011	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2012	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2013	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2014	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
2015	11,812	1,816	1,716	100	9,996	6,356	325	500	215	2,600
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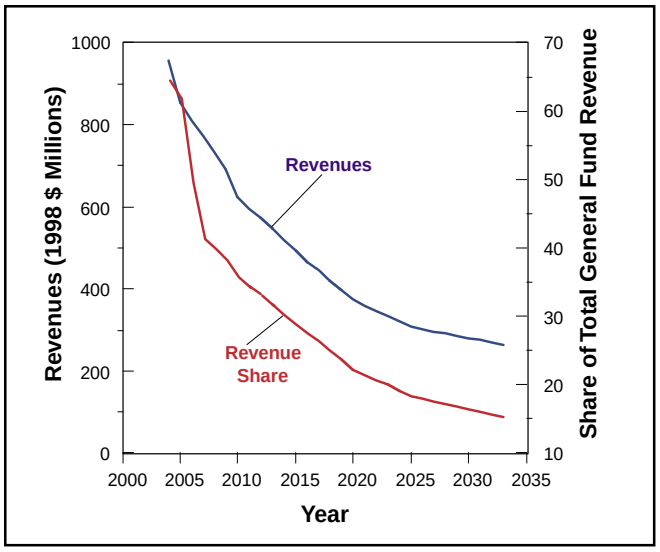


Figure 4.3-20. *Proposed action, state oil revenues and share of total General Fund revenues, 2004 to 2033.*

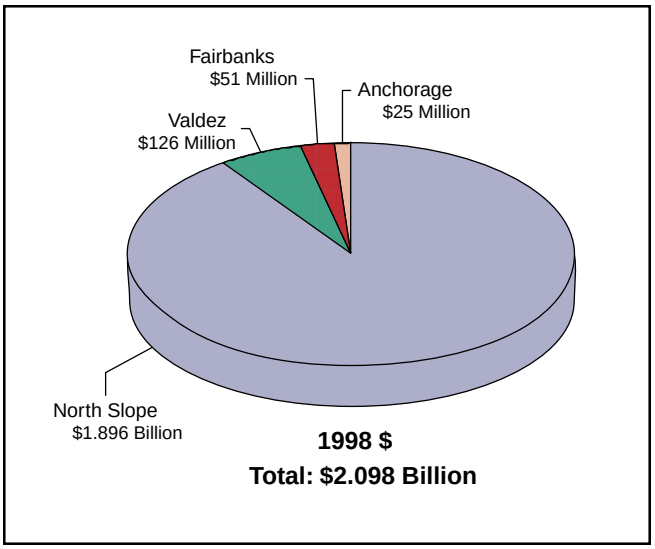


Figure 4.3-21. *Property tax revenues for proposed action for several communities, 2004 to 2033 (1998 $).*

spends $44 million annually on various oil- and gas-related activities (Gladziszewski, 1996).

The continuation of the direct jobs, business opportunities, income, and state and local government revenues in the proposed action has a multiplier effect on the economy resulting in the maintenance of additional jobs and income throughout the state. This following discussion examines the direct and indirect economic impacts of the proposed action.

Wage and salary employment grows 1.1 percent annually from 2000 to 2010, 1.4 percent from 2010 to 2025, and 1.0 percent thereafter (Table 4.3-18). This is slower than in the decades since statehood because the economy has matured and is shifting to reduced dependence on the petroleum industry. Because job growth is concentrated in support and infrastructure industries where the average wage is lower than in either basic industry or government, the average annual real civilian wage trends slowly down-

Table 4.3-18. *Annual average growth rates for economic indicators under the proposed action.*

History	Wage and Salary Employment	Total	Real Income Per Capita	Disposable Per Capita	Non-oil Gross State Product	Population
1961 - 1970	5.5%	8.1%	5.2%	4.9%	3.9%	3.0%
1970 - 1980	6.3%	5.9%	2.9%	2.8%	7.9%	3.1%
1980 - 1990	3.3%	4.2%	1.0%	1.1%	1.2%	2.8%
1990 - 1997	1.7%	1.0%	-0.4%	-0.6%	0.6%	1.4%
Projection						
2000 - 2010	1.1%	1.4%	-0.0%	-0.3%	1.0%	1.5%
2010 - 2025	1.4%	1.9%	0.3%	0.2%	1.4%	1.6%
2025 - 2034	1.0%	1.4%	0.2%	0.1%	1.0%	1.2%

ward. This slows the growth in real personal income, and real per-capita personal income remains virtually unchanged between 2000 and 2010 before resuming very slow growth.

Declining petroleum revenues for state government leads to reintroduction of a state personal-income tax and reduction in the PFD. These measures reduce disposable personal income and slow growth in private support jobs, particularly in trade and services, but help maintain state public services.

Non-oil gross state product (GSP) grows 1 percent annually through 2010 and 1.4 percent annually from 2010 to 2025. This slow growth reflects the drag on the economy produced by the slow decline in oil production and the movement to marginal and frontier fields with higher production costs.

Even though growth in employment opportunities slows, population growth continues at about the same rate as in the 1990s. Growth comes from natural increase, which occurs faster for the Alaska Native population than for the non-Native population, and from some migration of non-Natives in response to job opportunities. Some of the increase comes from the continued rapid growth of the over-65 population.

The continued operation of TAPS and production of North Slope oil facilitate gradual transition of the economy away from high dependence on one basic industry. The slower the decline in North Slope oil production, employment, and public revenues, the more time that is available for the growth of other basic sectors of the economy and the easier the transition. The replacement of North Slope oil activity with growth in other basic sectors is slow because of the small employment and gross product contribution of many of these other basic sectors and their modest rates of growth. Growth of the natural-resource-dependent industries, particularly seafood and timber, is also constrained by the size of the resource base.

North Slope oil activity increases the stability of the economy and reduces its seasonality. Since the Alaska economy is heavily dependent on natural resource production, it is particularly susceptible to economic “boom and bust” cycles (Rogers, 1999). The stability and diversification of the economy provided by North Slope oil production reduce the frequency of economic cycles, and the state revenues from North Slope production give the state the ability to reduce those cycles that do occur, particularly in regions that depend on resources such as fishing and timber. Furthermore, the seasonality of pipeline operations and North Slope oil activity is low compared to fishing, timber, tourism, and mining. This leads to increased stability of employment and income over the year, which in turn contributes to a larger support economy.

The continued operation of the pipeline and production of North Slope oil also increase the options for the eventual production of the large crude oil reserves on the North Slope that currently are not technically feasible to produce. The existing North Slope infrastructure and the transportation link provided by the pipeline lower the cost of applying any new technology to these reserves.

Continued TAPS operation and North Slope oil production also increase the options for eventually bringing North Slope natural gas to market. First, in fields containing both crude oil and natural gas, sharing the production costs between oil and gas in general reduces the unit production cost of both. Second, the most cost-effective method of transporting North Slope natural gas to market may entail converting the gas to a liquid on the North Slope and transporting the liquid. Without a liquids pipeline in place, that option becomes much more expensive, reducing the likelihood of marketing the gas.

Maintaining TAPS and ANS production extends the transition period for the Alaska economy away from its dependence on petroleum. The additional employment and public revenues provided by developing oil reserves that currently are not feasible to produce and by marketing ANS natural gas allow more time for alternative basic industries to expand.

Regional Effects along Pipeline Corridor. Regional economic impacts of the proposed action are estimated below for the North Slope Borough, Yukon-Koyukuk Census Area, Fairbanks North Star Borough, the Southeast Fairbanks Census Area, and the Valdez-Cordova Census Area (Tables 4.3-19 through 4.3-22, and Figure 4.3-21).

- **North Slope Borough:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in the borough. Property tax revenues of $1.896 billion (1998 dollars) are collected by the borough between 2004 and 2033 from pipeline and North Slope oil facilities. The sharing of state rev-

Table 4.3-19. *Total wage and salary employment by region for the proposed action (thousands).*

Year	State	North Slope	Fairbanks	Anchorage	Kenai Peninsula	Valdez-Cordova	Rest of State*
2000	277.1	7.6	32.1	130.9	17.0	4.8	84.8
2001	282.5	7.7	32.8	133.2	17.3	4.9	86.7
2002	287.1	8.0	33.2	135.8	17.5	4.9	87.7
2003	292.0	8.1	33.6	138.3	18.1	5.0	88.9
2004	297.0	8.4	34.0	140.6	18.5	5.1	90.4
2005	300.7	8.7	34.4	142.5	18.5	5.1	91.6
2006	299.5	8.9	34.1	141.5	18.4	5.1	91.4
2007	301.0	8.9	34.2	142.2	18.5	5.2	92.0
2008	303.8	8.9	34.5	143.7	18.7	5.2	92.7
2009	306.1	8.9	34.7	145.1	18.9	5.2	93.3
2010	310.3	8.9	35.1	147.4	19.2	5.3	94.5
2012	314.7	9.0	35.5	149.7	19.4	5.4	95.7
2013	319.1	9.0	35.9	152.1	19.7	5.4	96.9
2014	324.5	9.1	36.4	155.0	20.1	5.5	98.4
2015	330.7	9.2	37.0	158.4	20.4	5.6	100.1

*Rest of the state includes Yukon-Koyukuk and Southeast Fairbanks census areas.

Table 4.3-20. *Total resident employment by region for the proposed action (thousands).*

Year	State	North Slope	Fairbanks	Anchorage	Kenai Peninsula	Valdez-Cordova	Rest of State*
2000	311.9	3.8	36.9	147.7	19.6	5.1	98.8
2001	317.3	3.8	37.4	150.3	19.9	5.1	100.8
2002	322.2	3.9	37.7	153.1	20.3	5.2	102.1
2003	327.3	3.9	38.1	155.7	20.9	5.3	103.4
2004	332.5	4.0	38.5	158.2	21.3	5.3	105.1
2005	336.4	4.1	38.7	160.3	21.4	5.4	106.5
2006	334.8	4.1	38.4	159.2	21.3	5.4	106.4
2007	336.3	4.1	38.5	159.8	21.4	5.5	107.0
2008	339.2	4.1	38.7	161.4	21.6	5.5	107.8
2009	341.5	4.1	38.8	162.8	21.8	5.5	108.5
2010	346.0	4.1	39.2	165.2	22.1	5.6	109.9
2012	350.7	4.2	39.6	167.8	22.4	5.6	111.2
2013	355.5	4.2	40.0	170.4	22.7	5.7	112.6
2014	361.3	4.3	40.5	173.6	23.0	5.8	114.2
2015	368.1	4.3	41.1	177.3	23.4	5.8	116.1

*Rest of the state includes Yukon-Koyukuk and Southeast Fairbanks census areas.

Table 4.3-21. *Real per-capita income by region for the proposed action (thousands).*

Year	State	North Slope	Fairbanks	Anchorage	Kenai Peninsula	Valdez-Cordova	Rest of State*
2000	$25,673	$20,135	$22,436	$30,569	$23,431	$25,318	$21,711
2001	$25,868	$20,516	$22,718	$30,738	$23,645	$25,552	$21,889
2002	$26,067	$20,907	$22,916	$30,908	$23,825	$25,764	$22,091
2003	$25,995	$20,934	$22,845	$30,835	$23,632	$25,679	$22,023
2004	$25,895	$20,955	$22,759	$30,721	$23,637	$25,567	$21,907
2005	$25,771	$20,949	$22,664	$30,562	$23,694	$25,439	$21,768
2006	$25,496	$20,749	$22,453	$30,315	$23,400	$25,125	$21,476
2007	$25,441	$20,625	$22,419	$30,263	$23,383	$25,098	$21,421
2008	$25,561	$20,714	$22,552	$30,370	$23,535	$25,265	$21,535
2009	$25,460	$20,561	$22,485	$30,265	$23,447	$25,157	$21,417
2010	$25,581	$20,612	$22,602	$30,381	$23,603	$25,303	$21,527
2012	$25,663	$20,617	$22,674	$30,442	$23,727	$25,418	$21,612
2013	$25,735	$20,600	$22,743	$30,497	$23,846	$25,520	$21,685
2014	$25,837	$20,608	$22,831	$30,580	$23,989	$25,656	$21,785
2015	$25,940	$20,618	$22,916	$30,664	$24,129	$25,799	$21,886

*Rest of the state includes Yukon-Koyukuk and Southeast Fairbanks census areas.

Table 4.3-22. *Population by region for the proposed action (thousands).*

Year	State	North Slope	Fairbanks	Anchorage	Kenai Peninsula	Valdez-Cordova	Rest of State*
2000	631.2	7.2	83.6	263.0	49.8	10.3	217.4
2001	641.4	7.3	84.5	267.4	50.5	10.4	221.5
2002	649.9	7.3	85.1	271.7	51.2	10.5	224.2
2003	663.2	7.4	86.3	277.7	52.9	10.6	228.2
2004	676.2	7.6	87.5	283.2	54.3	10.8	232.8
2005	688.5	7.7	88.6	288.5	54.9	11.1	237.7
2006	695.4	7.9	89.1	290.4	55.4	11.2	241.4
2007	701.3	8.0	89.5	292.4	55.9	11.3	244.1
2008	709.5	8.1	90.2	296.1	56.6	11.4	247.2
2009	718.6	8.2	90.9	300.1	57.3	11.6	250.5
2010	729.6	8.3	92.0	305.1	58.2	11.7	254.4
2012	742.1	8.4	93.2	310.9	59.1	11.9	258.6
2013	755.1	8.5	94.5	316.8	60.1	12.1	263.1
2014	769.0	8.7	95.9	323.3	61.2	12.2	267.7
2015	784.5	8.8	97.5	330.7	62.4	12.4	272.8

*Rest of the state includes Yukon-Koyukuk and Southeast Fairbanks census areas.

enues from pipeline operation and North Slope oil production contributes to a continuing high level of public services in borough communities. The option for additional jobs, income, and revenues from future activities not currently technically feasible is retained. Population continues to grow.

- **Yukon-Koyukuk Census Area:** The proposed action provides an opportunity for employment and income for local residents. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities in the region.
- **Fairbanks North Star Borough:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in the borough. Property tax rev-

enues of $51 million (1998 dollars) are collected by the borough between 2004 and 2033. Additional property taxes are produced by refinery operations in the borough. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in borough communities. The option for additional jobs, income, and revenues from future activities not currently technically feasible is retained. Population continues to grow.

- **Southeast Fairbanks Census Area:** The proposed action provides an opportunity for employment and income for local residents. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities in the region.
- **Valdez-Cordova Census Area**: The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in the census area. Property tax revenues of $126 million (1998 dollars) are collected by the City of Valdez from pipeline facilities between 2004 and 2033. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities in the borough. The option for additional jobs, income, and revenues from future activities not currently technically feasible is retained. Population continues to grow.

Regional Effects in Other Areas: Regional economic impacts of the proposed action are estimated below for Anchorage, Kenai Peninsula Borough, and the rest of the state (Tables 4.3-19 through 4.3-22, and Figure 4.3-21).

- **Anchorage:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in Anchorage. Property tax revenues on facilities associated with the pipeline and North Slope oil production activities are $25 million (1998 dollars) between 2004 and 2033. Additional property taxes are generated by international-air-cargo activity and by module construction for North Slope production facilities. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the municipality. The option for additional jobs, income, and revenues from future activities not currently technically feasible is retained. Population continues to grow.
- **Kenai Peninsula Borough:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in the Kenai Peninsula Borough. Property taxes are generated by module construction for North Slope production facilities. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities in the borough. The option for additional jobs, income, and revenues from further activities not currently technically feasible is retained. Population continues to grow.
- **Rest of the State:** The proposed action contributes to continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in every other part of the state. Jobs and income earned by oil workers on the North Slope affect all parts of the state because these workers live in all parts of Alaska. They provide a stable and nonseasonal source of employment and income to the communities in which they live. The sharing of state revenues from pipeline operation and North Slope oil production contributes to the maintenance of public services in the communities throughout the state. The option for additional jobs, income, and revenues from further activities not currently technically feasible is retained. Population continues to grow.

Impact on Alaska Natives. Estimated economic impacts of the proposed action on Natives include:

- **Employment:** Employment opportunities for Alaska Natives will continue to exist in pipeline and oil- and gas-related industries and will expand in other parts of the economy, particularly trade and services, as the total number of jobs in the economy expands.
- **Unemployment:** Unemployment among Alaska Natives will be lower with the proposed action compared to the no-action alternative because the number of job opportunities will be higher while the size of the Alaska Native population will be the same.
- **Population:** The size of the Alaska Native population is insensitive to whether the proposed action is selected because Alaska Native migration into and out of the state has been small (ADOL, 1998a) and is likely to remain so. The Alaska Native population is mobile within the state, and a portion of the population moves in response to both job opportunities and the availability of public and private services. The proposed action increases jobs in the larger urban areas and commuter jobs, particularly on the North Slope, that are filled by residents who live in other parts of the state. Public spending of pipeline and oil revenues will increase the availability of public ser-

vices throughout the state. The effect of the proposed action on the spatial distribution of the Alaska Native population is unpredictable.

- **Income:** The proposed action contributes to higher money income for Alaska Natives through the availability of high-wage jobs, the continuation of the PFD, and the public expenditures made possible through state and local revenues from pipeline operations and North Slope oil production.
- **Public Resources:** State revenues of $14.209 billion (1998 dollars) combined with local revenues of $2.098 billion (1998 dollars) — the local share of oil- and gas-related property taxes — allow state and local governments to fund a higher level of public services than would otherwise be possible. These public services are provided to all communities in the state.
- **Alaska Native Communities:** The viability of Alaska Native communities is enhanced because the additional personal income and public revenues increase Alaska Native personal income and the public services in communities where Alaska Natives live.
- **Pressure on Natural Resources**: The proposed action results in a higher non-Alaska-Native population than the no-action alternative. This may put more pressure on resources used in subsistence activities.

4.3.3.2 Sociocultural Systems

By M. Galginaitis, C. Gerlach, P. Bowers, and C. Wooley

Sociocultural systems for communities on the North Slope and along the pipeline and transportation route have adapted to the presence of the ANS fields and the pipeline and have become dependent on the resultant economic benefits. Initial predictions of the impact of TAPS on Alaska Native and non-Native communities recognized that Alaska was already undergoing cultural change and that oil revenues would accelerate existing patterns of change (Education Systems Resources Corporation, 1971). Most sociocultural effects of TAPS construction and initial operation were indirect and occurred in combination with the effects of other developments such as passage of the Alaska Native Claims Settlement Act (ANCSA); creation of the NSB (1972); establishment of rural school boards (1976); improvements in village health, utilities, and communications systems; and the sociocultural contributions of nonprofit Alaska Native regional corporations (Strong, 1977). Together, these developments have profoundly affected the lives of Alaska Natives and other rural Alaskans; however, TAPS construction and operation was one of the many causes of these changes.

Social interdependence has been the cultural norm in rural Alaska, particularly in locations with few wage-employment opportunities. Major factors affecting cultural change in rural Alaska include increased material wealth from increased employment opportunities and increased infrastructure from capital construction projects (both indirect results of state oil revenues or local government revenues from property taxes on petroleum facilities). These processes are expected to continue with ROW renewal.

As discussed in Section 4.3.3.1, economic benefits will be realized through continued oil-derived revenue streams to the state General Fund, which is subsequently distributed for the support and benefit of all Alaskan communities. Benefits also are derived from employment opportunities provided by the oil and gas industry. The renewal of the TAPS ROW is not expected to cause any incremental impacts to ongoing sociocultural dynamics in areas such as indigenous languages, social structure, and family. The availability of wage income in rural areas should continue to give rural residents more lifestyle choices. People may choose to remain in smaller communities and follow a mixed cash/subsistence lifestyle, which helps promote family and community ties. As noted above, impacts of the proposed action include those directly and indirectly associated with the operation of the pipeline and those associated with operation of the ANS fields and the marine transportation link. These latter impacts are discussed as cumulative effects.

The area is subdivided into the North Slope, the Central TAPS, and the Valdez/PWS study areas (Section 3.3.2). From a geographic perspective, the direct effects of the pipeline itself can be identified and isolated. These principally affect the Central TAPS study area, whereas indirect and cumulative effects of the ANS fields and the marine transportation link pertain to the North Slope and Valdez/PWS study areas, respectively. For this reason, sociocultural and subsistence impacts on the North Slope and Valdez/PWS study areas are addressed in the cumulative effects section (see Section 4.5). The focus of this section is the Central TAPS area.

The principal impacts of TAPS ROW renewal in the Central TAPS study area would be continued revenues earned by state and local governments (albeit at lower levels than in the past), and earnings derived from operating and maintenance contracts held by Alaskan-owned and non-Alaskan-owned businesses and by Alaska Native corporations. In the absence of any planned major new construction activities associated with TAPS, there will be no temporary or seasonal upward spikes in local employment. No growth in population of local communities, and no need

for additional government services (new housing, etc.) associated with such growth are anticipated. The main negative impacts will result from reduction of TAPS throughput and the consequent decline in tax and business revenues.

4.3.3.3 Subsistence

By M. Galginaitis, C. Gerlach, P. Bowers, C. Wooley, and D.L. Maxim

Subsistence is important to many communities in Alaska, both for economic and sociocultural reasons. As a result, any activities that could adversely affect subsistence resources, harvest levels, access, competition for these resources, and related variables are potentially of concern and warrant investigation. Possible subsistence impacts for the North Slope and Valdez/PWS study areas are included in the cumulative effects discussion. This section addresses only subsistence impacts in the Central TAPS study area.

The key potential subsistence-related concerns associated with continued operation of TAPS and applicable to the Central TAPS study area are: (1) direct impacts resulting from oil spills and (2) indirect effects related to access to, and competition for, subsistence resources.

Oil Spills

As noted in Section 4.3.2, there are no biological or subsistence-harvest data indicating that routine pipeline operations have adversely impacted the abundance of fish and wildlife over the operating history of the pipeline. In principle, a major oil spill and resulting cleanup activities could release pollutants into streams and watercourses and cause fish stocks, local resident wildlife populations, and watersheds and critical habitat to be directly and negatively impacted at least for a time. This possibility has been a concern historically for some residents who value subsistence activities (Coates, 1993).

Data presented in Section 4.1.2 and Appendix B indicate that from 1977 to 1999, most pipeline spills were relatively small. For example, 88.0 percent of crude spills and 96.3 percent of product spills were less than 2 bbl. Most small spills are contained on site. Even if not contained on site, small spills are relatively easy to clean up and are not likely to threaten the environment. Rather, it is the relatively infrequent large spill that is potentially of concern.

From 1977 to 1999, there were five “large” (>1,000 bbl) pipeline spills (Table 4.1-2 in Section 4.1.2). The calculated number of large spills/billion bbl throughput for the pipeline is 0.39 over this time period. At this rate and based on a total future throughput of 7.02 billion bbl, there would be an average of 2.75 large pipeline spills over the 30-year ROW-renewal period. However, all the large pipeline spills occurred during the first five years of operation of TAPS — none has occurred since 1981. In the EIS for NPR-A (BLM and MMS, 1998), only pipeline spills occurring after 1989 were used to compute the number of spills on the pipeline.

Based on the conservative assumption that volumetric spill rates have remained constant for the pipeline, the average annual spill volume is calculated to be 573 bbl. (As noted in Section 4.1.2., volumetric spill rates for the pipeline have decreased over the years and may be lower than this conservative projection in the future.)

Spills onto land — even large spills — are likely to be confined to a relatively small area by the topography. Even on the North Slope, where the tundra relief is low (BLM and MMS, 1998), conditions combine to limit the spread of spills. For example, during the summer, flat coastal tundra develops a dead-storage capacity averaging 0.5 to 2.3 inches, which could retain 300 to 1,500 bbl of oil per acre (BLM and MMS, 1998). For example, the largest pipeline spill (16,000 bbl at Steele Creek, MP 457.53) affected an area no larger than 2.1 acres (Holland, 2000, pers. comm.).

Section 4.3.2.5 concludes that land-based spills will not adversely affect terrestrial mammal populations through increased mortality in the vicinity of TAPS. Likewise, spills that remain on land do not adversely impact fish. Therefore, the effects on subsistence of a pipeline spill that remains on land are likely to be negligible.

Large pipeline spills that enter rivers, streams, or groundwater will not be so confined and could result in fish and bird mortality over a much larger area. Crude residues might persist in sediments and river banks for several years. Ultimately, the affected water body will recover, but the recovery time is not known with certainty. Reduction in fish populations could change location patterns of terrestrial species that feed on these fish. The severity of these effects depends on the quantity discharged, season, location, and other factors. The pipeline has 34 major and about 800 other river and stream crossings. A spill at these locations would have greater potential for adverse environmental impact than would spills that stay on land.

None of the five largest pipeline spills to date has resulted in more than localized and temporary impacts. Four of these five spill sites are shown as special areas on the *Environmental Atlas of the Trans Alaska Pipeline System* (APSC, 1993; Maps 2, 5, 6, and 15). All five sites have been the subject of long-term monitoring, and there is no evidence of any lasting adverse environmental impact.

Any large spill that reduced fish populations materially could significantly and adversely effect subsistence harvests, because fish are an important part of the overall sub-

sistence harvest, particularly for communities in the Central TAPS study area. The severity of the subsistence impact depends on the amount of oil entering the water, season, effectiveness of cleanup activities, recovery time for the fish population, and the extent to which the contaminated stream/river were used by local residents.

Access Competition

Access issues are complex and are not under the direct control of the ROW applicants. Changes in access to subsistence resources (e.g., increased competition from new users, decreased or more difficult access for current users) potentially arising from the renewal of the ROW are likely to be the primary impacts on federally qualified subsistence users in the Central TAPS study area. Most concerns raised by rural Interior residents are related to difficult access and to the increased number of nonlocal hunters from urban Alaskan communities and from outside the state. The direct impact of more nonlocal hunters or more difficult access for local hunters is a real and/or perceived threat of an increase in hunting pressure and consequent reduction in harvest by local residents. These issues are commonly confounded with the indirect and cumulative effects from the Dalton Highway (now under state management), other state highways, and development activities not directly related to TAPS.

Construction and operation of the Dalton Highway provided improved access to subsistence harvest areas near the pipeline. If improvements to this highway are made which either permit or encourage greater access by recreationists, tourists, sports hunters and fishers, then adverse impacts on traditional subsistence users may result. It is important to note, however, that federal regulations will continue to grant priority to subsistence uses on federal lands in times of scarcity of individual subsistence species. Game management regulations enforced by ADF&G and federal land management agencies (including the BLM, U.S. Fish and Wildlife Service, and National Park Service) are expected to continue. Use of firearms in the DHCMA is authorized only for the residents of Alatna, Allakaket, Anaktuvuk Pass, Bettles, Evansville, and Stevens Village, and Alaska residents who live in the DHCMA (FSB, 2000).

The proposed action does not require any new access routes to subsistence harvest areas to be built along TAPS from the Yukon River south to Valdez. This entire route is currently served by the Alaska highway system. ADF&G and federal game management regulations govern use based on access from this existing road system. The TAPS ROW renewal would not affect these access points and would not affect subsistence use.

4.3.3.4 Cultural Resources

By C. Gerlach, P. Bowers, and C. Wooley

Renewal of the TAPS ROW has the potential to impact cultural resources. Although the construction phase was completed many years ago, ongoing activities (e.g., corrosion digs, slope/workpad maintenance, pipeline reroutes, below ground valve inspections, repairs of washouts and river training structures) have the potential to damage cultural resources. Oil spills could also result in adverse impacts, depending on factors such as the spill size, location, season, etc. This section addresses possible impacts of the proposed action alternative on cultural resources

Cultural resources can be impacted in various ways. Adverse impacts include removal of surface artifacts, surface disturbance resulting in artifact and feature dislocations, subsurface disturbance, and site contamination (36 CFR 800). Historically, the major sources of potential direct impact on cultural resources in the TAPS area included construction and maintenance of the pipeline; construction of access roads (including the Haul Road, now the Dalton Highway), material sites, disposal sites, and storage sites; and similar activities. Major direct impacts to TAPS-related historic properties were avoided or minimized during and after construction by following the Federal Grant stipulations and the Section 106 process (e.g., Cook, 1970, 1971, and 1977). During construction, Alyeska was in overall compliance with Stipulations 1.9.1 and 1.9.2, which provide for archaeological survey and mitigation (Campbell, 1973; Ecology and Environment, Inc., 1977). However, at least 145 known sites (15 percent) have been disturbed, and 229 have been archaeologically tested or excavated. Post-European-contact sites do not appear to have been included systematically — there were cases such as the Fort Liscum site at the VMT where historic sites were present but not inventoried or assessed before construction (Wooley, 1994).

The major indirect impacts can be divided into three categories: access-related impacts, ground-impacting activities, and oil spills.

Access-Related Impacts

Construction of the Haul Road (Dalton Highway) led to increased recreational traffic (especially since unlimited public access was granted), increased all-terrain-vehicle use near the highway, increased wilderness recreation activities such as hunting and hiking, increased scientific investigations, and ultimately increased visitation of archaeological sites by the public. Ongoing erosion has affected several surface sites, and several instances of accelerated erosion were caused by lack of backfilling during Alyeska-spon-

sored archaeological clearances (e.g., LIV-030, 041, 043, 046, 047). Sites near the Dalton Highway are more likely to suffer adverse impacts, since recreational use is inversely proportional to the distance from the highway. The impacts of TAPS on sites near other highways such as the Elliot and Richardson Highways cannot be estimated because these are confounded with the impacts of other development (mining, military, etc.). Some prehistoric sites are located in the same places where Alyeska and ADOT mine gravel, and any increase in material site use could result in cultural resource impacts (e.g., archaeological site identification, evaluation, or damage).

Ground-Impacting Activities

Ground-impacting activities associated with TAPS renewal include below-ground pipeline corrosion investigations, slope/workpad maintenance, potential reroutes, mainline valve inspections, river crossing repairs, fuel gas line maintenance and repair, and development of new material sites/rock quarries (Section 4.1.1).

- Alyeska has performed a large number of digs to address potential corrosion problems. Technological improvements have reduced the number of digs substantially (Section 4.1.1). Digs can disturb cultural sites; however, Alyeska minimizes disturbance by digging relatively small holes (generally 50 feet wide by 150 feet long) near the buried pipeline. Using this method, no new sites are disturbed because the excavated material was disturbed when the pipeline was originally buried.
- Slope/workpad maintenance may result in small areas of ground disturbance (typically less than 5 acres) that have not been evaluated archaeologically. Activities in such areas would be coordinated with the Authorized Officer and a qualified archaeologist to verify what historic sites, if any, are present and whether or not site evaluation is required.
- Potential pipeline reroutes constitute the greatest potential impact to cultural resources with TAPS ROW renewal. Impacts from reroutes are larger than for normal maintenance and approach original construction impacts in localized areas. Only three pipeline reroutes have been made: Dietrich River (1985), Atigun Pass (1987), and Atigun River (1991). The latter reroute involved a cultural resource survey of 8 miles (Gerlach, 1990). Future reroutes would have to follow the Stipulations and the Section 106 process.
- Below-ground valve inspections would occur in areas that have already been cleared archaeologically and would require no further mitigation.
- Repairs of washouts and river training structures would most likely not require use of, or damage to, archaeologically sensitive areas. Construction activities in active stream channels would not require consultation and/or mitigation. However, at least 355 sites (37 percent of total) are near rivers and streams; therefore, the State Historic Preservation Office would have to be consulted to verify site locations and the need for Section 106 actions. Several areas of the pipeline, such as the stretch along the Atigun River, lie in river drainages with high site concentrations.
- Maintenance and repair of the fuel gas line may result in ground disturbance in areas that have not been evaluated archaeologically. Activities in such areas would be coordinated with the Authorized Officer to verify what sites are present, if any, and whether or not site evaluation is required.
- Development of new material sites/rock quarries could adversely impact cultural resources. Many known cultural sites, especially in tundra areas, occur on topographic features that also are favored gravel sources. Material sources present a potential cultural-resource issue. Problems have occurred in cases where an archaeological site was investigated, provisional or limited construction clearance was issued, and later expansion of the material source damaged the site. By following the Section 106 process, historic properties can be identified and evaluated, and if the project will impact sites, mitigation measures can be implemented. Should cultural sites be located during ground-disturbing activities, mitigation measures will be undertaken as appropriate.

Oil Spills

Potential oil spills could impact cultural resource sites in the TAPS study area, including Prince William Sound, the Copper River delta, and the Yukon River. Contamination from crude oil is a direct impact, and various cleanup-related impacts could also harm sites if not mitigated. Federal and state agencies, in cooperation with the oil and gas industry, have taken steps to ensure that known cultural resource sites are identified and protected during emergency oil-spill-response operations. The Programmatic Agreement (1997) among federal and state agencies specifies when the Federal On-Scene Coordinator is advised to take action to protect sites, what type of expertise is required for site protection, and what process is needed whereby cleanup operations can proceed while considering the impact of the action on sites.

Efficient site protection during a spill response along the pipeline poses difficulties because reliable site locations are known for only 38 percent (364) of sites. However, 65 to 80 percent of spills reported to date occurred on gravel workpads and involved only small discharges. These spills are categorically excluded from cultural resource considerations (Programmatic Agreement, 1997).

In an effort to quantify the potential effect of crude oil spills on cultural resources along the pipeline, known cultural sites have been plotted by river drainage and pipeline segment as shown in Alyeska's oil spill contingency plan (APSC, 1999f). The number of sites is aggregated by drainage, the length of each pipeline-affected drainage is determined, and the site density is calculated given a standardized project width of 10 miles. The Arctic Foothills drainage (Itkillik River, Galbraith Lake, and Atigun River) has the highest site density and hence the highest potential for spill-related damage. Moving south along the pipeline, areas high in potential sensitivity are the South Fork Koyukuk River, Jim River, Bonanza Creek, Kanuti River, Tolovana River, Goldstream Creek, Moose/French creeks, Jarvis Creek, Phelan Creek, Tazlina River, Klutina River, and Little Tonsina River. Two of the largest rivers, the Yukon and Copper, while critical areas in many respects, are traversed by relatively short pipeline segments (7.1 mi. and 6.4 mi., respectively) and have few recorded sites on either side of the crossing (2 and 1, respectively). Site densities for stream crossings beyond the 10-mile width of the study area were not calculated; however, downstream sites would require identification and protection during a response in accordance with the Programmatic Agreement.

To help mitigate the potential impact of spills on cultural resource sites in Prince William Sound, Alyeska added cultural resource data to the Graphical Resource Database (GRD) for Prince William Sound and adjoining areas (Wooley et al., 1997). The GRD is part of the *Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan* and consists of digital data layers of sensitive environmental areas. The known cultural-resource-site data for Prince William Sound and the Copper River area are digitized and included in a confidential layer of the GRD to assist the Federal On-Scene Coordinator with protection of cultural resource sites during a spill response.

4.3.3.5 Land Ownership

By ClearWater Environmental, Inc. staff

In the TAPS ROW renewal, no lands other than those already lying within the TAPS easement will be required. There are no outstanding land ownership issues directly associated with the existing ROW; however, continuing land-use issues have been raised by at least two villages with lands in the ROW. These aside, no present or reasonably foreseeable land-ownership impacts are associated with TAPS ROW renewal.

4.3.3.6 Land Use

By ClearWater Environmental, Inc. staff

The most clearly observable impact on federal, state, and private land uses resulted from the construction of the 400-mile Dalton Highway. The highway and other roads and airstrips built to service TAPS and ANS oil development provide greater access to recreation-seekers, sports hunters and fishers, tourists, and subsistence users. These areas previously were accessible only over trails and from remote landing sites.

While no spur roads have been built that give direct vehicular access to lands outside the TAPS ROW, the Dalton Highway and associated airstrips make access to such lands much easier. If the highway were improved to meet state and federal highway construction standards and if tourist and vehicle services presently available only at Coldfoot were expanded, increases in visitor use can be expected beyond those seen since the opening of the entire highway to public access in 1994. Native landowners and land managers have noted that improved access for nonresident hunters, fishers, and recreation-seekers has created use conflicts even though federal and state land managers make every effort to alert visitors to private landowners' rights (Dalton Highway Advisory and Planning Board, 1998).

Such use conflicts also occur along the road system from the Yukon River to Valdez, but these access-related conflicts and land use impacts are not directly related to TAPS.

4.3.3.7 Coastal Management

By ClearWater Environmental, Inc. staff

Two segments of the TAPS ROW fall within approved coastal zone management districts: the North Slope Borough from Pump Station 1 south to Atigun Pass, and the Valdez city limits which include the shorelines and waters of Prince William Sound from Keystone Canyon to Tongue Point and Jack Bay just beyond the Valdez Narrows. In addition, the City of Cordova, Orca Inlet, and the Copper River Delta and flats facing the northern Gulf of Alaska lie in a coastal district defined in a coastal management plan. Plans for these three coastal districts all provide for the presence and use of the TAPS, the Valdez terminal, and shipping of North Slope crude oil by tanker.

All Alaska coastal zone management plans undergo periodic review and possible revision. None of the reviews for the NSB, Valdez, and Cordova district plans presently targets TAPS and its associated facilities and shipping activities for revision. Each requires acceptable oil spill response plans. The recently updated Prince William Sound Subarea Plan (APSC, 1999f) includes many features involving the Valdez terminal, and tanker loading and traffic created since OPA 90 and the *Exxon Valdez* oil spill cleanup and restoration (Section 4.1.2). No other impacts from TAPS and associated activities are likely to be addressed in the coastal zone management plans during the 30-year period of TAPS ROW renewal.

4.3.3.8 Recreation

By ClearWater Environmental, Inc. staff

Selection of the proposed alternative could result in direct, indirect, and cumulative effects on recreation. For the proposed action, the pipeline will continue operations, and the recreational benefits (see Section 3.3.6) afforded by scenic overlooks and visitor centers will continue throughout the duration of the ROW renewal period. Continued operation of the pipeline entails the risk of pipeline oil spills, which could affect recreational resources. As with other segments of the TAPS, most pipeline spills are relatively small. From 1977 to 1999, there were five large oil spills greater than 1,000 bbl along the pipeline. All resulted in minor, localized, and temporary effects.

Effects also include oil spills at ANS or marine transportation facilities and effects associated with improved access to lands adjacent to the Dalton Highway. These cumulative effects are addressed in Section 4.5.

4.3.3.9 Visual Resources

By ClearWater Environmental, Inc. staff

The above-ground segments of TAPS account for slightly more than one-half of its entire 800-mile length. These segments are clearly visible from the air, and the majority can also be seen from adjacent public roads. There are various designated viewing locations (Pump Station 1, Yukon River bridge, near Fox north of Fairbanks, near Copper Center, and elsewhere). Some of the pump stations are also clearly visible. Temporary visual air impacts (i.e., opacity) have occurred during tank-vent flaring at Pump Station 1. These opacity incidents have been few in recent years, and air emissions are stringently regulated by ADEC. Since no new TAPS infrastructure construction is planned during the TAPS ROW renewal period, no incremental visual impacts would occur.

4.3.3.10 Wilderness

By ClearWater Environmental, Inc. staff

Enhanced access to both federal wilderness areas and other state, federal (e.g., wildlife refuges), and certain private lands from the Dalton Highway are not related to TAPS renewal, but are made possible by the existence of the Dalton Highway. TAPS ROW renewal will have no direct impacts on wilderness or on primitive or undeveloped lands in any portion of the TAPS ROW. No parts of the ROW would be reclassified under wilderness designation.

4.3.3.11 Transportation

By ClearWater Environmental, Inc. staff

The TAPS ROW renewal would have no direct impact on existing transportation systems, which adequately serve the operation and maintenance requirements of TAPS. The following conditions for the various transportation modes are expected for the term of the renewal:

- All public road systems along TAPS are currently, and would continue to be, maintained by the State of Alaska. No new roads should be required to serve TAPS operation through 2034.
- Marine transportation facilities are in place to meet the anticipated demands of TAPS throughput through 2034. New double-hull tankers will be built to meet the requirements of OPA 90.
- Inland waterways are currently used to supply and maintain spill response equipment. This would continue as the only use of inland waterways to support TAPS and requires no additional improvements.
- TAPS would continue to exist with minimal expansions. Additional gathering or common carrier lines may be constructed on the North Slope to supply oil for transportation through TAPS. If TAPS did not exist, these additional pipelines would not be constructed. This is a cumulative effect discussed in Section 4.5.
- Renewal of the ROW will result in continued operation of passenger and cargo flights to North Slope oilfield facilities at or beneath present levels.
- No new aviation support facilities would be constructed as a result of TAPS ROW renewal, and no impact to the air support industry would occur.

4.4 Impacts of No-Action Alternative

Section 4.4 discusses the impacts of the non-action alternative, i.e., expiration of the TAPS Federal Grant and State Lease and DR&R of the system (see Section 2.2 of this Environmental Report for a description of DR&R). Cumulative effects are discussed in Section 4.5.

This section is divided into three main subsections:

- Physical Characteristics
- Biological Resources
- Social Systems

4.4.1 Physical Characteristics

This subsection covers the direct and indirect impacts of the no-action alternative on the physical characteristics of the TAPS region, including the terrestrial environment, water resources, and the atmospheric environment.

4.4.1.1 Terrestrial Environment

By R. Dugan

If operation of the pipeline is terminated, potential short-term impacts to the terrestrial environment may be caused by construction associated with DR&R, by those items left in place, or by modifications to the terrain that occurred during original construction and continue to have an effect. For DR&R, as defined by the state/federal grant and lease agreement, the pipeline system must be removed, but many elements would remain, such as buried pipe that is not adjacent to river training structures, the embedded portion of VSMs, and other buried facilities deeper than 1 foot below grade. All above ground facilities would be removed and the surface stabilized to minimize erosion.

Geology and Physiography

The impacts of TAPS removal to geology and physiography are expected to be localized to the work pad, access roads, and their immediate margins. The impacts will likely be limited to temporary soil erosion and drainage modification during DR&R due to construction equipment activity on the surface and numerous excavations to remove culverts, bridges, and other buried or embedded elements. There is essentially no direct impact to the bedrock or topography except for final grading of reclaimed surfaces.

Over the long term, river channel migration may locally erode the workpad and cause downstream sedimentation once river-bank protection is no longer maintained. Figure 4.4-1 shows a typical example of changes over a 10-year period along a protected stream bank. Impacts from modifications to stream channels and the permafrost regime are addressed later.

Paleontological Resources

DR&R of TAPS would likely have no impact on paleontological resources. If vertebrate fossils are present, they could be damaged during reclamation of material sites or by spills of hydrocarbons that could possibly occur during purging of the pipe.

Soils and Permafrost

Potential DR&R impacts to the soils and permafrost are generally related to modifications of the thermal regime. South of Fairbanks, where the permafrost is discontinuous and relatively warm, the permafrost table under the ROW has not reached equilibrium and will likely continue to be lowered because of the unavoidable damage to the insulating vegetative cover that occurred during construction. The rate of lowering will decrease with time because the increasing thickness of the overlying thawed soil will help insulate the deeper frozen soils. In addition, periodic brushing of the workpad and access roads by maintenance crews will be stopped and revegetation enhanced. The increased vegetation will provide more shading and a superficial organic layer to reduce absorption of radiant heat into the subsurface. Figure 4.4-2 shows an example of a revegetated embankment.

Settlement caused by the continued thawing of excess ice in the soils may locally cause depressions and some alteration of surface drainage. This is expected to be very minor since the permafrost soils that will thaw under the embankments in the future are relatively deep and generally have significantly less excess ice than soils near the surface.

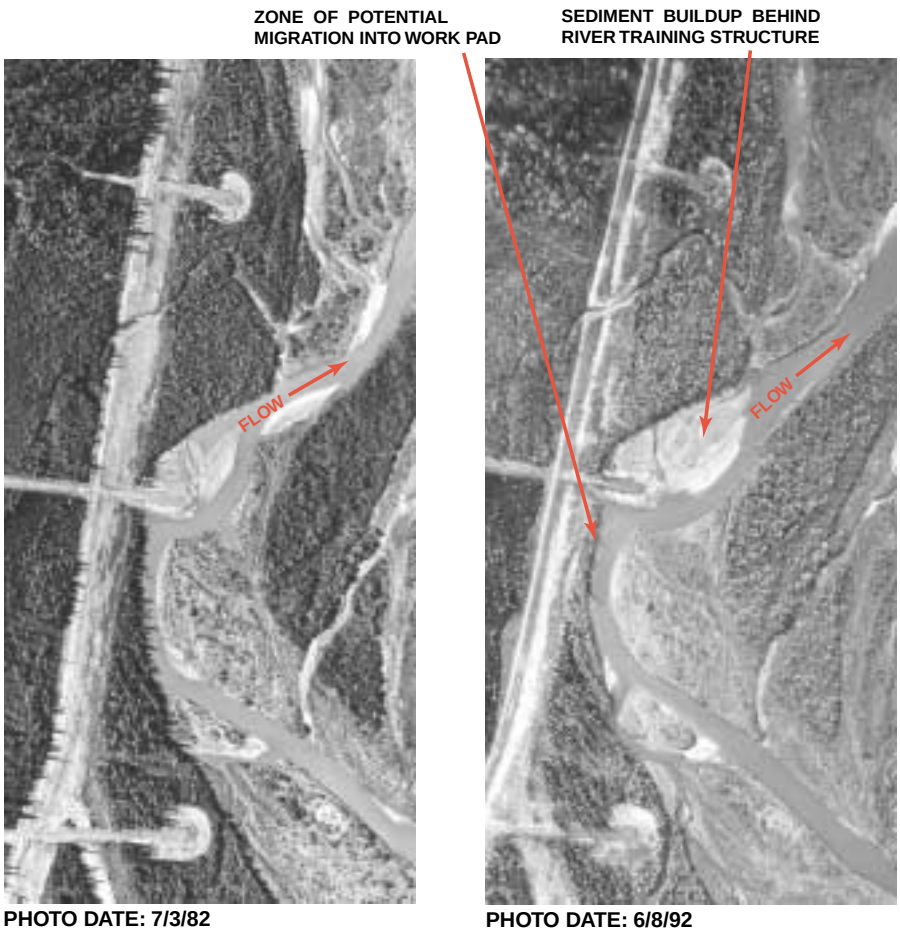


Figure 4.4-1. *Channel migration along workpad (photos by AeroMap U.S.).*

Sand, Gravel and Rock

Some sand, gravel, and quarry rock will likely be needed during DR&R. These materials will generally be used to provide a minimum of 2 feet of cover over abandoned facilities, to construct low-water crossings where culverts are removed, to cover fine-grained soils to prevent erosion, to fill depressions, and to create berms to block access to abandoned facilities. The materials can likely be obtained from existing stockpiles in Alyeska's permitted material sites and from the embankments being abandoned. There will likely be little or no additional extraction of these resources from undisturbed areas.

River and Floodplain

By W. Veldman

As a result of DR&R, the impacts on the behavior of the river and floodplain segments will be as follows, assuming the buried line is left in place. The impact on the rivers is expected to be minimal.

- The existing river training structures, bank protection works, guidebanks or revetments will remain as is. The continuing impact on the behavior of the rivers will be comparable to the impact to date (Section 4.3.1). If any structures require breaching to remove any facilities, they will be restored to a pre-DR&R condition as a partial breach could result in local rivers changes.
- Upon completion of DR&R, maintenance of the river training structures will cease. Thus, any erosion of the structures would not be mitigated. Structures integral to the Dalton Highway (e.g., guidebanks upstream of the road bridges) would be maintained by ADOT or other stakeholders, as necessary. If structures are believed to potentially have a long-term detrimental effects on adjacent stakeholders (e.g., a spur, deflecting flow), they will be removed.
- Workpads adjacent to or in the river crossings and floodplains would be removed, if necessary, to reduce sediment impacts into the river. Therefore, a pad con-

structed of natural river gravel would not be removed if the adjacent stream had comparable materials, whereas fine-grained material in a pad adjacent to a stream would be removed if erosion of the pad material would lead to significant sediment concerns.

Seismicity

By D. Nyman

If DR&R occurs, the seismic hazards relating to an operating pipeline system would be eliminated. For a relatively brief time after shutdown, the pipeline would be exposed to seismic hazards while containing crude oil or cleaning solvents. However, since the pipeline would be under low pressure, failure due to a seismic event would be even less likely than during normal operations. Furthermore, if a breach in the pressure boundary did occur, the spill volume should be much less than for an operating condition. Therefore, the pipeline seismic risk is minimal during dismantling.

As with any construction project, there is small risk of a seismic event occurring while a structure is partially complete, or in the case of DR&R, in a partial state of demolition. This poses some risk to personnel safety, but it is a level of risk commonplace in the industry.

4.4.1.2 Water Resources

By B. Jokela

Water Use and Discharges for Operations

Cessation of operation of TAPS will require continued use of water resources along the ROW to support DR&R. Wastewaters will be produced at accelerated rates by virtue of the intensive labor effort involved. Freshwater receiving environments will have increased potential for adverse impacts from the large camp populations and extensive earth moving activities involved in DR&R.

Injection of wastewater plant effluents into stacks at Pump Stations 1, 3, and 4 requires sufficient stack temperatures to ensure vaporization, volatilization, and disinfection. Elimination of turbine-powered crude-oil pumping systems will preclude the use of pump engine exhaust stacks for wastewater disposal, necessitating alternative means for wastewater disposal during DR&R.

Secondary biological sewage treatment and effluent disposal to tundra wetlands is expected to continue for the MCCFs and Pump Stations 5 and 6. Discharges are expected to increase at each site to the design capacity (up to 14,000 gallons per day, depending on the specific facility) during periods of extensive DR&R field effort. These discharges are expected to be assimilated by local water re-

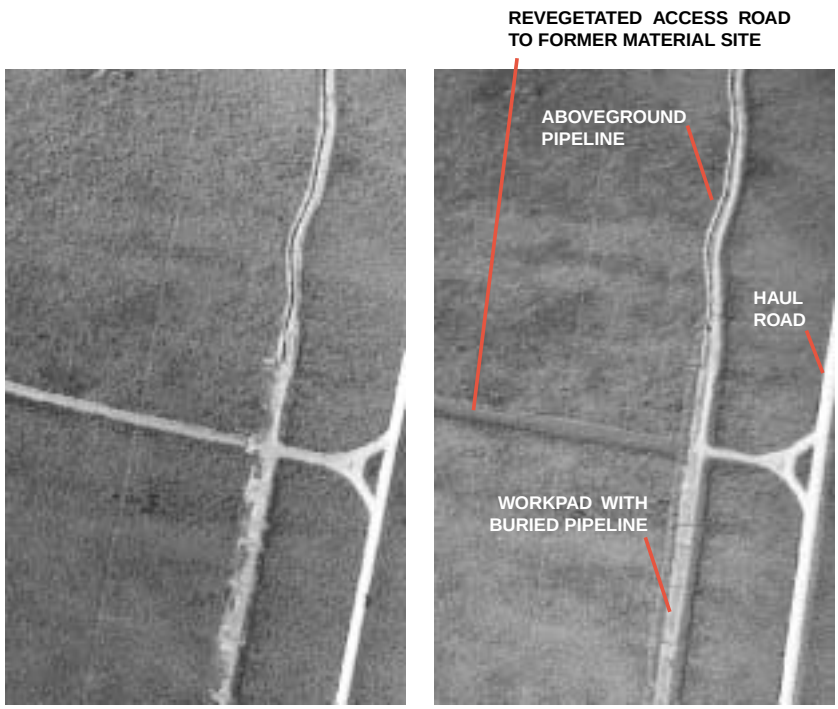


Figure 4.4-2. *Revegetation example of abandoned access road.*

sources with no significant effect on productivity or viability of aquatic ecosystems.

Enhancement of existing sanitary treatment facilities at the VMT may be needed to accommodate increased staffing and facility use during DR&R. Leachfield replacement or use of package sewage treatment plants may be necessary to accommodate DR&R labor crews.

Water Use and Discharges to Support Maintenance Activities

In addition to pump station and camp domestic water supply needs, water will continue to be used for a variety of industrial activities. Discharges will continue from dewatering of excavations, particularly in capping and decommissioning of buried pipe.

Excavations typically take place in winter to minimize the potential for groundwater handling. To the extent practicable, dewatering discharges will be to vegetated areas or dry channel beds to avoid impacts to surface water bodies. The effects of discharge on nearby surface waters depend on the rate and temperature of the discharge; slope and roughness of the receiving surface; permeability, temperature, and moisture content of the receiving surface; and presence of ice and snow. Water discharged onto a snowy surface in winter will freeze readily if atomized as in a snow-making operation or if allowed to spread out over a broad area. Assuming that water is allowed to freeze as a sheet of ice one inch thick over existing frozen ground, one million gallons of water will cover approximately 40 acres.

Currently only 11 of the many material sites identified along TAPS are subject to coverage under the MSGP for industrial stormwater discharge. New sites or expansions of existing sites may be located and/or developed in response to particular DR&R project needs. Mining or quarrying of new material during DR&R is likely to be minimal. No major new earthfill is envisioned in removing existing facilities. Designing a mining or quarrying plan for each site will require submittal of a stormwater pollution prevention plan to EPA and will entail development only in conjunction with implementation of best management practices for stormwater pollution prevention. Effects of stormwater runoff into waters along the TAPS route will not be significant.

Discharges to Port Valdez

Marine waters of Port Valdez will continue to be used to assimilate discharges from the VMT during DR&R. Although ballast water will cease to be collected, treated, and discharged from the tankers, sanitary wastewater from administrative facilities at the VMT will be generated, as well as industrial wastewater from operations of the VMT during shutdown. The BWTF will be used to treat oily seawater used to rinse the pipeline prior to dismantling. Up to 400 million gallons (the volume capacity of the 800-mile long pipeline) will be delivered to the BWTF for treatment and discharge to Port Valdez during the cleaning operation.

When oil shipments stop, no tanker ballast water is expected to be delivered to the BWTF. The BWTF would be grossly oversized and inefficient to handle the discharges provided only by the VMT Industrial Wastewater Sewer System. The plant may require adjustment to provide for treatment of pipeline cleaning flows and VMT industrial discharges during DR&R.

4.4.1.3 Atmospheric Environment

By E. Haas

After DR&R, all TAPS-related air emissions would cease. For most facilities, the direct ambient impact levels would revert to pre-construction levels.

Impacts on Ambient Air Quality

Ambient monitoring data collected at Prudhoe Bay monitoring sites show statistically no degradation of the ambient air quality over a 10+ year period. The levels are significantly below the limits set by the Alaska Ambient Air Quality Standards. However, the question arises as to how low the monitored data actually would be if all TAPS operations and emission sources ceased. In the North Slope oil fields, elimination of Pump Station 1 alone would not likely make a significant difference for the existing monitoring stations.

No monitoring data prior to 1986 are available for the pipeline route or the North Slope. Natural background data can be estimated by selecting the lowest values from the monitoring stations with the least impacts and wind directions indicate air flow from non-impacted areas. Summaries of estimated background values are shown in Table 4.4-1 for Prudhoe Bay and Table 4.4-2 for Valdez. The natural background levels should not be confused with the regulatory background levels, which are discrete ambient values on the specific date the baseline was set for each air quality control region (18 AAC 55, Table 2, Baseline Dates). The tables show that the current impact levels are substantially lower than the ambient standards and not much above the natural background values. A substantial change in existing air quality impacts would not result if TAPS operations cease.

Table 4.4-1. *Prudhoe Bay area annual background levels (ug/m³).*

Pollutant	Background	Impact	NAAQS
NO_2	2	19	100
SO_2	< ND	4	80
CO	115	950 (a)	10,000
Ozone	44	~ 50 –100 (b)	235 (c)
PM10	< 5	6 - 12	50

(a) 8-hour value
(b) High variability depending on atmospheric conditions
(c) 1-hour standard

Table 4.4-2. *Valdez area background levels (ug/m³) (a).*

Pollutant	Background	Impact	NAAQS
NO_2	5.7	17	100
SO_2	3.2	10	80
CO	-	1,100 (b)	10,000
Ozone	20-88	112	235 (c)
PM10	6.6	15	50

(a) Fluor and TRC (1995). Values are based on highest observed background concentrations.
(b) 8-hour value
(c) 1-hour standard

Fugitive Emission Impacts

During DR&R, fugitive dust emissions may substantially increase due to increased traffic on the Dalton Highway and use of heavy equipment. The additional impacts of dust on vegetation, of higher engine emissions, and of increased noise levels would temporarily raise the stress on wildlife beyond levels discussed in Section 3.1.3. Some open burning of construction and demolition materials may temporarily raise ambient particulate levels locally. Open burning is controlled by ADEC regulations. Any crude or chemical spills may need to be in-situ burned, which would add to the ambient particulate levels. After completion of DR&R, the level of fugitive dust emissions from the Dalton Highway should be significantly reduced beyond current levels since traffic related to TAPS and oil and gas activity will cease on the highway. Only occasional recreational traffic will remain.

4.4.1.4 Global Climate Change

DR&R of TAPS will have no adverse effect on global warming. However, the increase of air temperature associated with global warming will have an impact on soil temperatures and thus may effect soils in permafrost terrain disturbed by TAPS as discussed in Section 4.4.1.1.

4.4.2 Biological Resources

As in the proposed action, the effects of the no-action alternative on fish and wildlife were grouped into five general categories: (1) obstructions to movement, (2) disturbance and/or displacement, (3) habitat alteration or enhancement, (4) mortality, and (5) harvest- and recreation-related effects. The following assumptions apply to the discussion of potential impacts on fish and wildlife:

- Removal of the above-ground sections of pipeline likely would be scheduled in winter to reduce impacts to the ground surface from heavy machinery.
- Many workers would be housed initially at pump stations to reduce the need for, or size of, field camps;
- Removal of pipelines, dismantling of facilities, and backhauling of scrap would take 3 years.
- Gravel pads and access roads would be revegetated following removal of facilities, and revegetation efforts may require several years before acceptable standards are met for approval by the Authorized Officer and State Pipeline Coordinator.
- After the pipeline and facilities have been removed and restoration undertaken, vehicular traffic on the Dalton Highway would decline, particularly in winter when the State of Alaska may not maintain the road north of Atigun Pass.

Section 2.3 describes the activities anticipated for the no-action alternative. DR&R would greatly increase the number of people working along the TAPS ROW during the 3 years of activity. The magnitude of impacts may approach the level of TAPS construction. In particular, harvest pressure on game and fish resources along the ROW could increase substantially during DR&R if workers are hunting and fishing.

4.4.2.1 Special Areas and Special Management Zones, and Zones of Restricted Activity

By H. Whitlaw, R. Ritchie, and J. McKendrick

Evaluation of environmental consequences associated with the no-action alternative in special areas and special SASMZs was based principally on an understanding of the historical impacts of TAPS construction, operation, and maintenance on fish and wildlife resources. Impact evaluation was also based on a review of state and federal mitigation and environmental compliance regulations that apply to activities in SASMZs.

SASMZs near the pipeline include (APSC, 1993):

- *Zones of restricted activity* created and implemented

under Stipulation 2.5.3.1 in the Federal Grant, and restrict activities during all fish and falcon breeding, nesting, spawning, and migration periods.

- *Areas of critical ecological concern (ACEC)* proposed in BLM (1989) and established with BLM (1991), and pertain to critical and sensitive terrestrial mammal and falcon habitats.
- *Long-term vegetation monitoring and restoration sites* established for monitoring willows, revegetation efforts, and vegetation response to oil spills.

ZRAs are currently based on TAPS operating stipulations in the Federal Grant. Implementation of the no-action alternative would presumably eliminate these areas.

Vegetation

Ground-impacting activities would take place in the vicinity of vegetation SASMZs. These areas may be adversely affected; however, compliance with current restrictions (APSC, 1993) would likely reduce impacts. After completion of DR&R activities, continued opportunities to monitor revegetation efforts and vegetation response to disturbance in long-term SASMZs may be reduced. Implementation of the no-action alternative would have minimal impact in vegetation SASMZs.

Fish

DR&R activities would take place in watersheds, wetlands, riparian areas, and streams. These activities may obstruct fish movement, alter habitat, and/or increase mortality. Work in ZRAs (i.e., all fish-bearing streams crossed by the pipeline and its facilities) is currently restricted during all breeding, spawning, and migration periods. The no-action alternative would presumably eliminate these areas; however, compliance with current ZRA restrictions during active DR&R would likely reduce impacts.

In addition to restrictions imposed by ZRA stipulations, activities that may impact fish resources are reviewed under the ADF&G Title 16 and Fish Habitat permit processes, and the U.S. Army Corps of Engineers Section 404 (Clean Water Act) permit process for jurisdictional waters (SPCO, 1993, 1995). After active DR&R, state and federal permit review processes would continue to be applicable. Assuming compliance with ZRA stipulations and with state and federal regulatory permits, the no-action alternative will likely have minimal impacts on fish resources.

Terrestrial Mammals

During active DR&R, ground-impacting activities would occur within, and in the vicinity of, BLM-designated ACECs (APSC, 1993; BLM, 1989). ACEC restrictions are not related to Federal Grant stipulations and would presumably remain in effect both during and after active DR&R. In these special management areas, activities are restricted to meet designated sensitive-habitat and management objectives (BLM, 1989, 1991). ACECs primarily contain Dall sheep lambing areas and mineral licks near the Brooks Range. Through the continued and effective protection provided to terrestrial mammal habitats through ACEC activity restrictions, the no-action alternative would likely have minimal impacts on these resources.

Threatened and Endangered Species

Two species listed as threatened under the federal Endangered Species Act (Spectacled Eider and Steller's Eider), and two delisted subspecies of Peregrine Falcon (the *tundrius* and *anatum* races) would potentially be affected by activities associated with the no-action alternative. Occupied Peregrine Falcon nests, as designated by the FWS through the Authorized Officer, constitute a ZRA. The no-action alternative would presumably eliminate these areas; however, compliance with current ZRA restrictions during active DR&R would likely reduce impacts. Activities in ZRAs are now restricted during breeding and nesting periods. In addition, FWS Section 7 permits under the Endangered Species Act are required for some activities that may affect threatened and endangered species. After active DR&R, federal permit review processes would continue to be applicable. Assuming compliance with ZRA stipulations and federal regulatory permits, implementation of the no-action alternative would likely have minimal impacts on threatened and endangered species.

4.4.2.2 Vegetation and Wetlands

By J. McKendrick, D. Funk, T. Jorgenson, and J. Kidd

Habitat Loss, Alteration, and Enhancement

Wetlands. Impact to wetlands from DR&R should be minimal, although impoundments associated with workpads are likely to persist unless efforts to breach them are made. Since culverts will be converted to low-water crossings, any sedimentation or erosion should be minimized. It is possible that permafrost areas covered with fine-grained soils could be restored to wetlands over the long term through thermokarst, but the process would likely take several decades.

Dust. Relatively large amounts of dust from increased traffic along the ROW would be expected during DR&R. These impacts would be short-term, and vegetation along the ROW would probably recover quickly. Access roads and the pipeline route would no longer be regularly traveled

for ROW surveillance and maintenance. Public access probably would be limited because river crossings would be decommissioned and access roads not maintained.

Off-Road Use. The removal of above-ground structures is likely to increase ORV use of the ROW, but the impacts probably will not be much greater than those described for ROW renewal. Damage to plant communities adjacent to the ROW actually may be lessened as ORV users restrict more of their travel to the ROW.

Drainage and Water Flow Issues

Drainage and water flow impacts associated with DR&R would be similar to those described for ROW renewal with a few minor differences. Because the workpad would remain in place, impacts associated with adjacent impoundments would persist, particularly on the Arctic Coastal Plain. Establishing breaches or low-water crossings in impoundment areas could minimize this impact. Conversion of culverts to low-water crossings would greatly reduce erosion and scouring associated with cross-drainage. Elimination of culverts would greatly reduce icing problems. Because river-training structures will remain in place, sedimentation in slackwater areas behind dikes would continue and would provide habitat for riverine willows and other early successional species. Erosion of the unmaintained structures is also likely, but its limited extent and the low failure frequency of the structures would make this a minor impact.

Thermokarst

Thermokarst associated with leaving the workpad in place would have little additional effect on adjacent areas. Thermokarst from impoundments would persist and continue developing in place. Thermokarst underneath the workpad would continue and probably become widespread, but ecological effects on adjacent vegetation would be negligible. Thermokarst of the workpad probably would enhance revegetation because it would increase soil moisture and create a diversity of microsites (Jorgenson and Joyce, 1994; Kidd and Rossow, 1998; Bishop et al., 1999).

Oil, Fuel, and Chemical Spills

Oil spills will not be of consequence following DR&R, but crude oil spills and fuel spills can occur during active DR&R. Impacts from spills were discussed in detail for the proposed action. Revegetation of spill-affected areas will not be an issue for the no-action alternative, except for spills that occur during removal of the pipe. Revegetation of spill-affected areas was also discussed previously in sections dealing with the proposed action.

Revegetation

If grass seed and fertilizers are used to artificially revegetate the ROW, temporary attractive grazing areas will be created in the northern Brooks Range for Dall sheep and caribou, and for geese north of the Brooks Range. In 5 to 10 years, palatability of seeded grasses will diminish. In the boreal zone, browse development can be thwarted for 20 or more years if grasses are successfully established as revegetation.

Adding seed and fertilizer will increase risk of introducing weeds. During TAPS construction, most inadvertently introduced broad-leaved weeds (except for *Trifolium hybridum* and *Taraxacum officinale*) failed to persist throughout much of the route. In contrast, several seeded grass species have remained in all regions of the route.

Leaving the workpad in place after facilities are removed will temporarily increase vegetation for wildlife. Browse, which is currently mowed on the workpad, will be released and produce a temporary increase in habitat for moose and hare. Removing the workpad will expose vegetated soils to erosion and temporarily decrease wildlife habitat and aesthetics along the ROW.

4.4.2.3 Fish

By R. Fechhlem and L. Moulton

DR&R of TAPS has the potential to impact fish populations and habitats in a manner similar to that documented for TAPS construction. Removal of the pipeline will be a major construction action, with substantial vehicle movement along the workpad. Culverts, pipes in road casings, and buried pipe adjacent to river training structures will be removed, thus creating the potential for increased sediment load, habitat alteration, and migration blockage.

Obstructions to Movement

Barriers to fish movement may be caused by increased traffic across low-water crossings and during removal of culverts and road casings. Increased traffic can lead to severe rutting that can create ridges and spread flow, thus creating barriers to fish movement at low flows. Low-water crossings will need more frequent maintenance during the removal period to ensure that fish passage is maintained. Removal of culverts and road casings will need to be planned and monitored to ensure proper erosion control methods are used and the final streambed is consistent with the natural configuration. Impacts can be mitigated by not

scheduling DR&R activities during sensitive times for fish.

Habitat Alteration or Loss

Construction activities in the active floodplain can alter habitat through removal of cover or increased sedimentation and erosion. Removal of cover can substantially reduce the carrying capacity of the altered stream reach by making the area unsuitable for refuge from predators (Woodward-Clyde Consultants, 1980). South of the Brooks Range, large woody debris in streams provides important cover for many fish species. Cut banks and boulders provide additional cover. North of the Brooks Range, large woody debris is scarce, and cover is provided primarily by cut banks and boulders. Activities in and around the active channel should avoid loss of these cover features.

Mortality

As with maintenance activities, pipeline removal operations need to avoid disturbing, dewatering, or degrading overwintering areas. The potential for increased fish mortality would be high during DR&R operations. The potential for fuel and crude oil spills during DR&R activity would also increase substantially from that of normal pipeline operations. However, these impacts would be relatively brief, and fish populations would be expected to recover from impacts once DR&R was completed.

Overharvest

Overharvest is not likely to be a concern since active DR&R will have a relatively short duration and will not create new access, although localized fishing by DR&R workers during the 3 years of activity may be heavy in some areas. After TAPS operations cease and DR&R is complete, a potentially important impact on fish is increased harvests from a variety of sources (i.e., legal, illegal, sport, subsistence, and commercial). The end of operations of the oil industry in the ANS oil fields, TAPS, and the VMT will be accompanied by significant reductions in statewide employment and incomes. This may increase pressure on fish (e.g., sport, commercial, and subsistence fishing) if residents use wild foods to compensate for the loss of income. If decreased state revenue results in less enforcement of fish regulations, this impact could be intensified. However, it is also possible that the human population (and fish harvests) will decrease in response to the economic decline. In addition, removal of some bridges and water crossings will probably reduce access through time, thereby reducing harvest of fish in some areas. The reduction in access may allow some populations to recover from excessive harvest pressure. Regulation and monitoring by the appropriate agencies will be needed to manage this potential impact.

4.4.2.4 Birds

By B. Anderson, R. Day, S. Johnson, R. Ritchie, and D. Troy

Obstructions to Movements

DR&R activities at TAPS facilities would probably increase disturbance and limit movements of birds in the immediate vicinity during periods of high activity. However, the flight capability of birds substantially reduces the possible obstructions to movements by activities along the TAPS ROW. During their flightless molting and brood-rearing periods, birds (primarily waterfowl) are more likely to have their movements affected by human disturbance and facilities. Temporary DR&R camps would present local barriers to movements of brood-rearing/molting waterfowl. This effect could be mitigated by siting camps away from important brood-rearing areas and scheduling decommissioning activities in important bird areas to occur in winter or other times outside the breeding season.

The greater amounts of traffic on the Dalton Highway during the initial phases of DR&R would limit the ability of some brood-rearing waterfowl to cross the road. High traffic levels (usually >10 vehicles/hr) and the presence of larger, heavier, and unusual-profile vehicles such as boom cranes resulted in greater disturbance to brood-rearing waterfowl in the oil fields than did less traffic and light-vehicle traffic (Burgess and Ritchie, 1987, 1990, 1991; Murphy and Anderson, 1993). Removal of elevated pipelines during winter would have little effect on movements of birds because fewer bird species are present. Once pipelines and facilities are removed, bird movements along TAPS would no longer be affected.

Disturbance and Displacement

Equipment noise, vehicles, pedestrians, aircraft operations, and other activities associated with DR&R would cause increased disturbance of birds near facilities and activities such as pipe removal. Scheduling of pipeline removal during winter would minimize disturbance and mitigate most impacts on birds. Most bird species are not residents along the ROW and are not present in winter. Exceptions include resident Gyrfalcons near traditional nesting sites.

Disturbance caused by dismantling pump stations would probably be greater than the disturbance effects noted for birds during oil field operations. Oil field impacts are well documented (Woodward-Clyde Consultants, 1985; Hampton and Joyce, 1985; Anderson et al., 1992; Burgess and

Rose, 1993; Murphy and Anderson, 1993; Troy, 1993; TERA, 1993b). The most comparable studies are those conducted during major oil-field construction activities (Endicott Development Project: Burgess and Ritchie, 1987, 1990, 1991; Lisburne Development: Murphy and Anderson, 1993; GHX expansion: Anderson et al., 1992). During those studies, greater disturbance to birds occurred during the initial construction period than after operations began. Disturbance of birds would be greater during the 3-year DR&R along TAPS than during normal operation. Disturbance would be reduced below operational levels after all facilities were removed and restoration underway.

As described for the proposed action, the relative severity of disturbance to birds varies with the human activity. Humans on foot and natural predators (foxes or gulls) cause stronger reactions than vehicular activity (Ritchie, 1987; Murphy and Anderson, 1993). The numbers of humans on foot around pump stations would be greater during DR&R than during normal operations. Restricting foot traffic to gravel pads could mitigate impacts caused by humans on foot. This restriction would provide a buffer for birds using adjacent tundra habitats. For vehicular traffic, the level of disturbance to waterfowl generally increases as traffic rate and the number of large, noisy vehicles increases, and as the distance to disturbance such as the Dalton Highway and pump stations decreases (<500 to 700 ft [150 to 210 m]) (Murphy and Anderson, 1993). Scheduling major activities requiring large, noisy trucks during periods when birds are not flightless would reduce disturbance impacts.

Some level of aircraft activity would be associated with DR&R. Most studies of aircraft disturbance in the Arctic have focused on low-flying helicopters (LGL, 1974; Barry and Spencer, 1976; Simpson et al., 1982; Ritchie, 1987; Derksen et al., 1992). Some waterfowl species, such as Brant and Snow Geese, appear to be more sensitive to disturbance by helicopters, particularly at flight elevations below 800 ft (240 m), than are other geese (Canada and Greater White-fronted Geese) and other birds species groups (LGL, 1974; Derksen et al., 1992; Murphy and Anderson, 1993; Ward et al., 1994). Raptors may be most sensitive during arrival, courtship, laying and incubation, and early nestling periods of their breeding (Roseneau et al., 1981). However, all species continue to nest in close proximity to air traffic routes associated with TAPS. Visual and auditory impacts of helicopter overflights on birds inhabiting the forested portions of the TAPS ROW are probably mitigated by the visual and sound barrier provided by surrounding vegetation. In general, flight restrictions to limit low-flying aircraft during the more sensitive periods for birds (nesting, brood-rearing) during DR&R could mitigate the magnitude of these impacts on birds. In the long term, after closure of the pipeline and pump stations and elimination of surveillance flights along TAPS, disturbance to birds would be greatly reduced.

The indirect effects of disturbance associated with DR&R would cause the habitats adjacent to facilities such as the pump stations to become temporarily less attractive to birds. Because facilities along TAPS have operated for over 20 years, it is likely that birds have become habituated to some extent to the constant sources of noise, but the activities associated with DR&R would increase noise levels. However, unlike the proposed action, where facility noise could cause long-term reduction of bird use in areas experiencing constant disturbance, the displacement associated with DR&R would be relatively short term (3 years or less for the entire pipeline removal), and noise sources would be eliminated once facilities were removed.

Habitat Loss, Alteration, or Enhancement

DR&R activities along TAPS would result in either permanent (revegetation) or temporary (initial alterations with pipeline removal) changes in bird habitats. Habitat along the ROW and work pad would be disturbed during removal of above-ground sections of the pipeline, and effects of long-standing habitat modification would continue until revegetation and restoration were successfully accomplished. Gravel fill has a relatively small but notable impact on wildlife habitats in the Arctic because the disturbance may be long term and vegetation recovery may be slow (Johnson, L., 1987; Walker, Webber et al., 1987; Jorgenson and Cater, 1991).

Although revegetation efforts in the oil fields have been moderately successful at restoring gravel pads or disturbed tundra, only a few studies have evaluated the use of these disturbed habitats by wildlife (Troy, 1991; Rodrigues, 1992; Truett et al., 1994). The magnitude of use of restored sites by birds depends on the nature of the site after reclamation. Areas with gravel-based (old exploration pads; Rodrigues, 1992) or disturbed-tundra (“peat roads”; Troy, 1991) substrates receive considerable bird use — often more use than undisturbed tundra. Nest densities are lower on gravel-rich sites than undisturbed tundra, but higher on peat substrates. The nature and magnitude of bird use appear to be a function of the degree of local (microsite) heterogeneity and the presence of ponding in addition to the establishment of vegetation. In more southerly sections of the ROW, revegetation and restoration efforts at facilities would likely be more successful at restoring natural vegetation, and bird use of these sites would increase over time as the habitat progresses through a mosaic of grassland, then

shrubs, and eventually forested lands on reclaimed facility sites.

Along the northern end of TAPS, bird use of habitats adjacent to the Dalton Highway and pump stations has been affected by habitat alteration from dust fallout, gravel spray, persistent snowdrifts, impoundments, thermokarst, contaminants, and water withdrawal. With completion of DR&R, some of these impacts would be greatly reduced or eliminated. Following DR&R, traffic levels on the Dalton Highway likely would decline substantially, particularly during winter months (depending on the level of road maintenance), reducing dust fallout and the correspondingly advanced snowmelt (up to two weeks early) in the dust shadow adjacent to roads and pads. The loss of the spring dust shadow and its associated open water and tundra would affect the distribution and movements of birds along the road. Without the dust shadow and its snow-free habitats, the movements of birds northward along TAPS in spring would be restricted to naturally occurring snow-free zones along the Sagavanirktok River and Franklin Bluffs. This change would cause short-term detrimental effects on species that forage in snow-free areas.

Water impounded by gravel roads and pads along the northern end of TAPS both displaces and attracts birds, depending on the species (Kertell and Howard, 1992; Kertell, 1993, 1994; Troy, 1993; Noel et al., 1996). Impoundments can be temporary, disappearing by mid-June, or can persist through the summer. Temporary impoundments preclude nesting (Walker, Webber et al., 1987) but also attract some birds. The effect of DR&R on the occurrence of impoundments is difficult to predict. If maintenance of the Dalton Highway were reduced and maintenance of the TAPS workpad ceased, culvert efficiency could decrease forming more impoundments. Gravel pads would remain in place and cause some snowdrifting and water impoundment along the workpad. Persistent snow drifts or impoundments would reduce habitat availability during early summer and probably reduce breeding near roads and pads. Planned removal of culverts along access roads would help restore natural cross-drainage.

For several bird species, the TAPS ROW and associated facilities enhanced habitat by providing structures for nests, perching, and resting sites. With the removal of the above-ground sections of the pipeline and dismantling of facilities during DR&R, those artificial nesting structures would be eliminated, reducing nesting opportunities for some species (Gyrfalcons, Common Ravens, swallows, Snow Buntings). Cessation of brush removal along the TAPS ROW would allow natural succession and an eventual return to the vegetation found in surrounding areas. These changes in vegetation would affect the bird community using the ROW, but the changes would be long-term and would resemble the normal changes encountered by these species when habitats are naturally disturbed by such events as fires.

Mortality

With the removal of the above-ground sections of the pipeline and pump station facilities, the potential for bird collisions with these structures would be eliminated. The largest identified source of indirect bird mortality associated with the TAPS route — road kills along the Dalton Highway — would increase during DR&R because of higher traffic levels during this action, particularly during late spring when most birds are attracted to the dust shadow along the road. Ptarmigan, grouse, and passerines are the primary species groups killed by vehicle collisions. Raptors have infrequently been identified as collision victims along the Dalton Highway, especially in the northern portion. Species that hunt along the road and its dust shadow, including Rough-legged Hawks, Northern Harriers, and Short-eared Owls, would be most susceptible to collision with vehicles. Following DR&R, vehicle-associated mortality in the northern section of the ROW would decline due to decreased traffic volume and the corresponding reduction in the dust shadow along the Dalton Highway.

Mortality due to early fledging of young raptors or increased predation due to human disturbance of raptor nests has not been reported along TAPS. Careful scheduling of the removal of above-ground pipeline sections in winter would minimize disturbance and potential mortalities. However, recreational parties associated with the Sagavanirktok River may interrupt some nesting raptors and may cause abandonment or premature fledging or attract predators. These types of activities would likely increase after DR&R is completed if the ROW were completely opened to recreational use.

During DR&R, small oil spills and contaminant releases are likely to occur, causing minor mortality of birds. The relative impact should be reduced by rapid cleanup response. Small spills that affect habitats, particularly tundra habitats, may have short-term effects, such as reduced breeding in the summer after cleanup, even after cleanup has been completed (Burgess, Cater et al., 1995; Burgess, Jorgenson et al., 1995). Exposure to and ingestion of contaminants (including minor incidents of fouling and oiling) in the North Slope oil fields occasionally have caused injury and mortality to small numbers of animals (Amstrup et al., 1989; ABR, Inc., unpubl. data).

Increased predation on birds from increases in predator

populations caused by artificial food sources has been documented as an impact in existing North Slope oil fields (Day, 1998). Levels of impact are inferred from the higher number of foxes and increased density of fox dens (Eberhardt et al., 1982; Burgess and Banyas, 1993; Burgess, Rose et al., 1993) and higher numbers of bears (Shideler and Hechtel, 1995), gulls (Murphy et al., 1987), and ravens in the oil fields compared to undeveloped areas. Gulls and ravens prey on bird eggs and young, foxes prey on birds and small mammals, and bears prey on caribou, muskoxen, ground squirrels, and some birds, primarily waterfowl.

During DR&R when work camps are established at various locations along the TAPS ROW, the potential for temporarily increasing predator populations through artificial feeding is high. This possibility could be mitigated by adherence to proper garbage handling and strict enforcement of existing prohibitions on feeding of wildlife, which would limit the attraction of predators to DR&R work zones and activities. Following removal of the pump stations and pipeline, predator populations would stabilize or decline as human sources of garbage were eliminated, although some garbage dumping or feeding by recreational users would be likely if recreational use of the TAPS route increased after DR&R were completed.

Harvest and Recreational Effects of Humans

Changes in harvest of game bird species associated with the TAPS ROW have not been well-documented, but access by hunters has increased along the route since construction. With the opening of the entire ROW following DR&R, the level of harvest would be expected to increase further, particularly by hunters previously deterred by Alyeska's requirements for accessing the ROW. After TAPS operations cease and DR&R is complete, a potentially important impact on birds is increased harvests from a variety of sources (i.e., legal, illegal, sport, and subsistence). The end of operations of the oil industry in the ANS oil fields, TAPS, and the VMT will be accompanied by significant reductions in statewide employment and incomes. This may increase pressure on birds (e.g., sport and subsistence hunting) if residents use wild foods to compensate for the loss of income. If decreased state revenue results in less enforcement of game regulations, this impact could be intensified. However, it is also possible that the human population (and bird harvests) will decrease in response to the economic decline. Regulation and monitoring by the appropriate agencies will be needed to manage this potential impact.

The primary species likely to be affected by increased hunting effort would be Spruce, Ruffed, and Sharp-tailed grouse and Willow, Rock, and White-tailed ptarmigan. Increased access would also affect sport harvest of waterfowl, particularly between Fairbanks and Thompson Pass, where the route crosses waterfowl habitats. Although the northern end of TAPS crosses waterfowl habitat, birds leave the area relatively early for fall migration, thus limiting the potential for increased harvest by humans.

Increased recreational use of the areas along the TAPS ROW has occurred, particularly since the opening of the Dalton Highway to the public. The level of use likely would increase after opening of the TAPS ROW following DR&R. To variable extents, wildlife tours, birding groups, and individual recreationists all use the Dalton Highway to access habitats adjacent to the TAPS ROW. Although these activities are considered non-consumptive, they are not entirely benign in their impacts on the animal resources. For most bird species, the impacts of recreational activities are probably minor, but for rare birds, such as the Bluethroat, increased access to their nesting habitats near Pump Station 2 may have detrimental effects, although the magnitude is unknown. Falconry permits from the State of Alaska allow for the taking of Arctic Peregrine Falcons and Gyrfalcons along TAPS. Gyrfalcons, although nesting close to the ROW north of the Brooks Range and along the Sagavanirktok River, have not been taken in this region (Wright, 1999, pers. comm.).

4.4.2.5 Terrestrial Mammals

By W. Ballard, H. Whitlaw, B. Burgess, and M. Cronin

Issues and potential environmental consequences of the no-action alternative on terrestrial mammals were identified from review of the original TAPS EIS (BLM, 1972) and of scientific literature and unpublished reports. Much progress has been made in understanding the effects of human activities on wildlife populations and in mitigating potential adverse effects. Although it is unlikely that impacts related to TAPS construction will be duplicated with DR&R, the following evaluation was based in part on the reported impacts of TAPS construction.

Environmental consequences of the no-action alternative were evaluated at the population level. Although impacts to individuals were also considered, management is generally conducted at the population level and therefore evaluations are also at this level (Cronin et al., 1997; Cronin, Ballard et al., 1998).

Obstructions to Movements

Pipeline. Elevated pipeline sections were predicted to

create barriers or obstructions to movements, restricting free passage of terrestrial mammals (BLM, 1972). Available evidence suggests that TAPS has not been a barrier to movements of terrestrial mammals (Ballard et al., 1987; Carruthers and Jakimchuk, 1987; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Gasaway et al., 1983; Kiker and Fielder, 1980; Van Ballenberghe, 1978).

Caribou, moose, muskoxen, and bison encounter the TAPS pipeline during seasonal migrations and as components of their annual home range. During TAPS construction, elevated sections of pipe were built as designated big-game crossings along sections of the TAPS pipeline to ensure free passage and movement of big game animals (JSFFWAT, 1977). They were located at sites "known to be regularly used by bison, moose and/or caribou as well as those sites with a high probability of utilization based on tradition or habitat characteristics" (JSFFWAT, 1977, p. 1). In addition, buried sections (i.e., sagbend crossings) were built to accommodate caribou movement. Research on designated big-game crossings in the Copper River Basin and Interior Alaska indicated that they were not selectively used by moose or caribou; pipeline crossing locations were primarily dependent on traditional use, topography, terrain, and vegetation (Carruthers and Jakimchuk, 1987; Eide et al., 1986; Sopuck and Vernam, 1986a, b; Van Ballenberghe, 1978).

The no-action alternative would result in removal of all above-ground pipe and VSMs, while buried sections would remain in place. Although available research does not support the prediction of obstructed movements due to the pipeline, removal of above-ground sections of pipe would ensure free passage of terrestrial mammals after completion of DR&R. While dismantling above-ground sections, care should be take to avoid piling pipes on the ground in areas known to be regularly used for movement of terrestrial mammals. Morgantini (1985) reported that pipe — either lying on the ground or welded and lying on skids — acted as a visual and physical barrier to the free movement of moose and deer.

Roads and Traffic. Roads and associated traffic were predicted to create barriers or obstructions to movements of terrestrial mammals (BLM, 1972). In the vicinity of the TAPS ROW, caribou, moose, bison, muskoxen, Dall sheep, mountain goats, bears, and wolves encounter roadways (i.e., Dalton and Richardson Highways, rural two-lane roads, and pipeline access roads) during seasonal migrations and as components of their annual home range.

Road crossing success along TAPS is primarily a factor of traffic volume (Lawhead, 1997; Cronin et al., 1994), and environmental factors such as insect harassment, predation threat, disturbances, and snow depth. Cameron et al. (1985) reported that crossings of the Dalton Highway by CAH caribou were predominately by bulls, with calves composing only 3 percent of the caribou in crossing groups during spring and summer 1977-82. They concluded that maternal cows were sensitive to human activities. In contrast, Jakimchuk et al. (1987) proposed that cows with calves avoided riparian habitats, not TAPS, as a predator avoidance strategy.

The no-action alternative would result in contouring and hydroseeding of TAPS access roads, and the Dalton Highway would remain in place. During the 3 years of active DR&R, traffic volumes along the Dalton Highway would likely be greater than those currently experienced. During the calving season, this increase may affect the movement of maternal cow and calf caribou across the highway. Traffic volumes could be restricted during calving as mitigation. It is presumed that traffic along the Dalton Highway would be reduced from current levels after completion of DR&R, although public use for recreation and tourism would likely increase (BLM, 1998; Jeffrey, 1993). Adverse effects of traffic along the Dalton Highway on terrestrial mammals movements are expected to be minimal.

Disturbance and Displacement

Aircraft and Vehicle. Terrestrial mammals would encounter various types and levels of disturbance during active DR&R. Aircraft disturbance would include helicopter and light fixed-wing aircraft flights at presumably irregular intervals along various sections of the route. Disturbances would also include use of light-aircraft landing strips, and the use of airports at Deadhorse and Prudhoe Bay by helicopters and commercial and light fixed-wing aircraft. Vehicle disturbances would likely include heavy machinery, passenger vehicles, foot-traffic, and perhaps snowmobiles and off-road vehicles. These disturbances would occur along the Dalton and Richardson Highways, and TAPS access roads and work pads.

After DR&R, aircraft and vehicle disturbance would probably be reduced. Aircraft flights and vehicle traffic on the Dalton Highway would likely be recreational and therefore not regulated by current TAPS-related mitigation measures. These mitigation measures include temporal and spatial specifications for aircraft disturbance, with respect to work within the ROW.

The effects of aircraft overflights on wildlife vary among species, populations, environmental variables, levels of habituation, and habitat type (McKechnie and Gladwin, 1993; Miller, F.L., and Gunn, 1984). In addition, aircraft disturbance responses depend on aircraft type and flight al-

titude, with helicopters and low-flying military jet aircraft being generally more disturbing to terrestrial mammals than light fixed-wing aircraft (Maier et al., 1998; Côte, 1996; Bleich et al., 1994; McKechnie and Gladwin, 1993; Davis et al., 1984; Valkenburg and Davis, 1984; Fancy, 1982.). Animals that range near airports or other continuous sources of aircraft disturbance may be exceptions to this pattern and appear to become habituated to them (Maier et al., 1998; McKechnie and Gladwin, 1993; Davis et al., 1984; Valkenburg and Davis, 1984).

Aircraft disturbance associated with the no-action alternative would not likely affect terrestrial mammal populations in the vicinity of the TAPS ROW, assuming that flights are in compliance with lease stipulations. Short-term aircraft disturbance to individuals may occur. Short-term disturbances from vehicles may adversely affect individuals in the vicinity of the ROW. These impacts are likely to result from the operation of heavy equipment and from increased traffic volumes. However, these impacts could be mitigated through compliance with lease stipulations in sensitive areas (APSC, 1993). In addition, disturbance is probable as the work force during DR&R increases; wildlife in the vicinity of the active DR&R areas could be harassed or hazed by humans. These impacts could also be mitigated by compliance with lease stipulations.

Animal Feeding. The intentional feeding of wildlife and/or the use and habituation of some species to anthropogenic food sources such as garbage were common problems during TAPS construction, particularly in camps and at pump stations (Schmidt, 1999, pers comm.; Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.; Follmann and Hechtel, 1990; Milke, 1977). During this time, active feeding of animals such as bears, wolves, foxes, squirrels, gulls, and ravens by pipeline workers, in addition to improper garbage handling and disposal, resulted in “large numbers” of animals being attracted to camps and areas of human activity (Milke, 1977, p. 1). Milke (1977) reported that animal feeding problems continued during the operation phase of TAPS, although the frequency and magnitude had decreased. Current Alyeska policy mandates that employees be disciplined and/or fired for intentionally feeding wildlife. Nuisance animals are hazed by trained Alyeska personnel, and may be translocated or killed if problems persist. There is general consensus among state and Alyeska biologists and environmental personnel that animal feeding by Alyeska personnel is no longer a problem along TAPS (Stephenson, 1999, pers. comm.; Schmidt, 1999, pers. comm.). However, animal-feeding problems associated with public and commercial use of the Dalton Highway may still occur (Brown, D., 1999, pers. comm.).

During active DR&R, the potential exists that animal feeding and nuisance animal issues may again be problematic because of increased numbers of workers who may have less training in environmental aspects of the project, and have a shorter-term view of the consequences of their actions. However, continued enforcement of Alyeska policy on garbage management and intentional animal feeding, in addition to education of DR&R workers regarding the adverse effects of feeding wildlife, should reduce impacts. After DR&R, animal-feeding problems associated with public use of the Dalton Highway may occur. Public awareness and education programs could be implemented for hunters, tourists, and recreationists using the Dalton Highway corridor.

Displacement. BLM (1972) predicted that terrestrial mammals would be displaced as a result of activities associated with TAPS construction. The no-action alternative in the short term could displace animals as a result of disturbances and/or habitat change. Potential effects of displacement could be realized at the individual and/or population levels and may include displacement to adjacent habitats, increased mortality, increased activity budgets, and/or changes in group composition.

Roby (1978) and Cameron et al. (1979, 1985) reported that caribou groups with calves during summer were sensitive to activities and traffic along the Dalton Highway north of Pump Station 4. They suggested that this was a group response to vehicular traffic and construction activity. In contrast, Carruthers et al. (1984) investigated factors besides human activity which may affect the distribution of cows and calves adjacent to TAPS. Their 1981-83 survey results indicated that cows with calves avoided river valleys and riparian habitats (whereas bulls preferred riparian habitats), and that the habitats preferred by females were not associated with the TAPS ROW. They concluded that variables such as habitat and sexual segregation influenced the distribution of caribou adjacent to the TAPS ROW. Jakimchuk et al. (1987) further proposed that cows with calves avoided riparian habitats, not TAPS, as a predator avoidance strategy.

There is no evidence that other caribou herds in the vicinity of the ROW (i.e., NCH, DCH) were displaced as a result of TAPS construction (Valkenburg, 1999; Carruthers and Jakimchuk, 1987; Eide et al., 1986; Gasaway et al., 1983). Caribou south of the Brooks Range have maintained traditional migratory routes and in some cases have expanded their ranges to now encounter TAPS.

There is no evidence that populations of Dall sheep, muskoxen, bison, or moose were displaced as a result of TAPS construction (DuBois and Rogers, 1999; Reynolds,

P., 1998; Eide et al., 1986; Jakimchuk et al., 1987). Aircraft and vehicle disturbances have been reported to elicit behavioral and physiological responses in individual ungulates, but they are generally short-term and are not reflected at the population level.

Brown bears have been locally displaced from roads in British Columbia, Montana, Alaska, and Yellowstone National Park, Wyoming (McLellan and Shackleton, 1989; Mattson, 1988; McLellan, 1988; Archibald et al., 1987; Harting, 1987 and references therein; Miller, S., and Ballard, 1982). In most cases, individual bears avoided areas within 1 km of roads, but no population-level effects were reported. McLellan and Shackleton (1989) reported that predictable human activities might displace bears; strongest responses were to the presence of humans on foot in open areas of low human use. S. Miller and Ballard (1982) reported that following translocation, three sows with cubs were delayed or deflected by the Glenn Highway.

During active DR&R, traffic volumes along the Dalton Highway would likely be greater than those currently experienced. This relatively short-term disturbance may affect movements of caribou cows and calves across the highway during the calving season. Traffic volumes could be restricted during the caribou calving period as mitigation for potential displacement effects.

Traffic along the Dalton Highway would probably be reduced following DR&R, although public use for recreation and tourism would likely increase (BLM, 1998; Jeffrey, 1993). Public awareness and education programs could be implemented to reduce the likelihood of displacing terrestrial mammals from the Dalton Highway corridor. Adverse effects of traffic along the Dalton Highway on terrestrial mammals movements should be minimal.

Habitat Loss, Alteration, or Enhancement

Impacts of the no-action alternative on terrestrial mammal habitat will likely be similar to those that occurred during construction, although much progress has been made in understanding of the effects of human activities on wildlife populations and in mitigating potential adverse effects. Habitat alteration and loss issues associated with the no-action alternative are related to wetlands and riparian areas, oil spills, fire suppression, habitat loss and reclamation, and species-specific sensitive areas (McKendrick, 1999a, b; Cronin and Bickham, 1998; Bridges et al., 1997; Dominske, 1997; Doucet and Garant, 1997; Hurst, 1997; Macks et al., 1997; Duffy et al., 1996; Cameron et al., 1995; Armentrout and Boyd, 1994; Jorgenson and Joyce, 1994; Truett et al., 1994; Garant and Doucet, 1993; Maki, 1992; Walker and Walker, 1991; Gasaway et al., 1989; Senner, 1989; MacCallum, 1988; Morgantini and Bruns, 1988; Morgantini and Worbets, 1988; Walker, Cate et al., 1987; Gasaway and DuBois, 1985; Hartley et al., 1984; BLM, 1981; Kavanagh and Townsend, 1977; BLM, 1972).

Wetlands and Riparian Areas. Wetlands, especially riparian areas, provide habitat in the form of food, travel corridors, cover, and shelter for many terrestrial mammal species (Senner, 1989). Concern has been expressed over the role of wetlands in limiting wildlife, primarily in arctic regions (Senner, 1989). The TAPS ROW and the Dalton Highway accounts for an estimated 69 percent of wetland losses related to petroleum development in Alaska — an estimated 0.02 percent of Alaska's wetlands (Pamplin, 1979).

During active DR&R, work in wetlands and riparian areas would be monitored through state and federal regulations designed to reduce impacts to fish and wildlife habitat. Assuming compliance with these regulations, active DR&R would not adversely affect terrestrial mammal habitats associated with wetlands and riparian areas. Following completion of DR&R, there would be minimal disturbance in wetlands and riparian areas in the vicinity of TAPS, except for use by recreationists, hunters, and fishermen.

Oil Spills. Oil spills were common during TAPS construction (Kavanagh and Townsend, 1977). Since then, spill contingency plans have been prepared for the pipeline, spill reporting and consistency have improved, employee training and education have been enhanced, and spill regulations are strictly enforced.

Crude oil spills will not occur under the no-action alternative. During DR&R, some fuel spills could occur, but these would generally be confined to gravel roads and facilities. The probability of exposure of terrestrial mammals to spills is small and would be limited to a few individuals. Minimal impacts to terrestrial mammals are likely to occur from oil spills.

Wildfire. Wildfire is a natural occurrence in Alaskan ecosystems and is a primary agent of change in the boreal forest. Periodic fire creates or improves habitat for browsing and grazing species such as moose and bison (BLM, 1981). Moose populations may increase following fire due to increased browse production, unless they are limited by factors other than habitat — i.e., predation, hunting. This is the case for many of the moose populations in the vicinity of the TAPS ROW, although seasonal and opportunistic use of burned areas may increase (Gasaway et al., 1989; Gasaway and DuBois, 1985). Wildfires are also beneficial to bison because fire stimulates new growth of grasses and forbs (DuBois and Rogers, 1999; BLM, 1981). Caribou may be adversely affected by fire in the short-term; how-

ever, long-term benefits include rejuvenation of stands of lichen with declining production (BLM, 1981).

During active DR&R, fire suppression efforts would likely be maintained at the current levels. After completion of DR&R, protection would likely be decreased in areas where fire would not threaten human life or infrastructure (ADNR, 1999b). Levels of fire suppression associated with the no-action alternative would not adversely affect terrestrial mammal populations and may benefit those that are limited by food availability.

Habitat Loss and Reclamation. Some terrestrial mammal habitat was directly lost as a result of TAPS construction (Jorgenson and Joyce, 1994; Truett et al., 1994; Pamplin, 1979). Many disturbed areas have since been revegetated to restore wildlife habitat and are used by a variety of species (McKendrick, 1999b; Jorgenson and Joyce, 1994; Senner, 1989; MacCallum, 1988; Morgantini and Bruns, 1988; BLM and USACE, 1988; Jorgenson and Joyce, 1994). Habitat loss from active DR&R would likely be less than that realized during TAPS construction. Because buried pipe would remain in place, direct ground disturbance would be reduced. Also, gravel pads and access roads would be hydroseeded, potentially improving available forage (Kraeger, 1976). Habitat loss and alteration would be negligible after active DR&R. Presuming the end of ROW maintenance, native patterns and processes would likely be restored in the long term.

Species-Specific Sensitive Habitats. Losses or alteration of species-specific sensitive habitats are potential impacts associated with DR&R. Calving areas and mineral licks have been identified as critical areas for caribou, moose, and bison along the ROW. Many of these sensitive habitats have been protected through the implementation of BLM-designated ACECs (BLM, 1989). Activities in all identified sensitive habitats for terrestrial mammals in the vicinity of TAPS are regulated by federal and state mitigation stipulations, which are in place to minimize adverse impacts on wildlife. Assuming that all stipulations and mitigation measures currently in place will continue during active DR&R, the no-action alternative would not adversely impact sensitive species-specific habitats.

Mortality

Terrestrial mammal mortality was predicted to be a potential consequence of TAPS construction (BLM, 1972). TAPS-related mortalities during construction included vehicle collisions, increased non-hunting kills (i.e., defense of life and property, and nuisance animals) (Follmann and Hechtel, 1990), and mortality from oil spills.

Vehicle Collisions. Vehicle collisions with terrestrial mammals, particularly moose, are an issue of public safety, as well as a notable source of wildlife mortality. In 1996, the ADOT identified rural two-lane highway segments with the highest moose-vehicle accident reports (ADOT, 1996) and concluded that most accidents occurred on rural highways surrounding major cities and towns. None of the identified segments was on the Richardson or Dalton Highways (ADOT, 1996). Mitigation measures employed by ADOT to reduce moose-vehicle collisions on high-accident segments include moose fencing and underpasses, one-way gates, continuous illumination, and increased public awareness (ADOT, 1996; Del Frate and Spraker, 1991; McDonald, 1991).

In Alaska, moose/vehicle collisions averaged 630 per year between 1995 and 1997 (ADOT, 1997). In comparison, a minimum of 1,200 moose — a number that is approximately 10 percent of the annual allowable harvest — are killed each year on highways and railways in British Columbia (Child et al., 1991). In GMU 13, which is bisected by the TAPS ROW and the Glenn Highway, approximately 50 moose are killed a year (1994-98) from collisions with motor vehicles (Sinnott, 1999, pers. comm.). A small proportion of the annual number of moose killed in collisions annually occurs in the vicinity of the TAPS ROW (Sinnott, 1999, pers. comm.; Martin, P., 1999, pers. comm.; Billbe, 1999, pers. comm.). Vehicles kill fewer than 10 Delta bison annually (Kiker and Fielder, 1980). Numbers of other terrestrial mammals killed in vehicle collisions are unknown. Whitten (1999, pers. comm.) indicated that vehicle collisions with wildlife are rare. None of the terrestrial mammal populations examined in this review is limited by vehicle collision mortality. Numbers are dictated primarily by predation, severe weather, and hunting; and population management objectives are being met.

Wildlife-vehicle collision rates increase as a result of increased traffic volumes and the proximity of wildlife to roadways. Attraction to roadways occurs as a result of roadside maintenance procedures, road-salt accumulation creating man-made mineral licks, and the presence of roads in concentration areas and travel corridors. The above-mentioned mitigation measures are designed to reduce the number of collisions based on these wildlife attractants. However, increased traffic volumes are a result of increased human population numbers and improved access. As the Dalton Highway increases in recreational value and its use is advertised and encouraged (BLM, 1998), traffic levels may increase.

It is probable that increased human activity during active DR&R could result in increased wildlife/vehicle collisions. It is not likely that these mortalities would adversely affect

terrestrial mammal populations. After DR&R, recreational use of the Dalton Highway could increase (BLM, 1998), but industrial traffic would decline dramatically.

Mortality — Non-Sport. Several wildlife species such as brown and black bears and wolves may become habituated or attracted to human activities, often leading to conflicts with people (Whittaker and Knight, 1998; McCarthy and Seavoy, 1994; Mattson et al., 1992; Follmann and Hechtel, 1990; Follmann, 1989; McLellan, 1989; Miller, S., and Chihuly, 1987). During TAPS construction, the intentional feeding of wildlife was a major concern (Follmann and Hechtel, 1990; Kavanagh and Townsend, 1977).

Follmann and Hechtel (1990) reviewed the history of nuisance bear problems and TAPS between 1971 and 1979. They reported that 71 percent of problems with bears occurred north of the Yukon River, where inadequate garbage disposal and widespread animal feeding created dangerous situations. Of the 192 officially reported bear problems associated with TAPS, 65 percent involved the presence of bears in camps or dumps, while remaining problems were associated with the feeding of bears on garbage or handouts (13 percent), property damage or economic loss (10 percent), bears in and under buildings (7 percent), and charges by bears (5 percent). Control measures for nuisance bears included hazing, relocations, and/or shooting; 25 black bears and 13 brown bears were shot between 1971 and 1979 (Follmann and Hechtel, 1990).

S. Miller and Chihuly (1987) examined the circumstances during which non-hunting (i.e., other than sport or subsistence hunting) brown bear deaths occurred in Alaska between 1970 and 1985. They reported that of 224 persons who reported killing bears, 72 percent of the bears were shot to avoid perceived danger, 21 percent to protect property, and 7 percent to eliminate nuisances. Non-hunting bear kills increased during the study period, with 40 percent being reported from coastal areas near Juneau, Kodiak Island, and the Alaska Peninsula. S. Miller and Chihuly (1987) concluded that non-hunting kills were most prevalent when humans were in bear habitat (i.e., hunting and fishing) and that areas with highest human densities (Anchorage, Kenai Peninsula, Matanuska Valley) had the highest ratio of non-hunting to sport harvests. Human activities associated with TAPS operation and maintenance were not addressed in S. Miller and Chihuly (1987).

It is probable that increased human activity during active DR&R could result in increased mortality of nuisance wildlife. However, it is unlikely to be the major problem documented during TAPS construction. Alyeska policy prohibits intentional feeding of wildlife, improvements in garbage management have been implemented, and public awareness has been increased on the danger of animal feeding. Presuming compliance with all garbage-handling regulations by all DR&R workers, it is expected that increases in nuisance wildlife mortality would be minimal during active DR&R. It is not likely that these non-hunting mortalities of individuals would adversely affect populations.

After completion of active DR&R, it is expected that increased recreational use of the TAPS ROW could occur (BLM, 1998), and it is likely that non-hunting mortalities of brown bears may increase. Public awareness and education programs could be implemented to reduce the likelihood of increased non-hunting mortality of nuisance animals within the TAPS ROW. Implementation of the no-action alternative may adversely affect some individuals, but population-level effects are unlikely.

Oil Spills. The effects of land-based oil spills on terrestrial wildlife populations have not been thoroughly investigated. No reported terrestrial-mammal mortalities due to land-based oil spills were identified, and available evidence does not indicate that this is a major source of mortality at the population level (Stephenson, 1999, pers. comm.; Hunter, 1999, pers. comm.). Deer, mountain goats, and brown bears in the vicinity of Prince William Sound were potentially exposed to the *Exxon Valdez* oil spill; an unknown level of deer mortality occurred (Nowlin, 1993a, b, 1994, 1995a, b). Based on available evidence, there were no population-level impacts on terrestrial mammals as a result of the *Exxon Valdez* oil spill.

During active DR&R, there is a risk of land-based oil spills. It is possible that exposed terrestrial mammals would be adversely affected, including the likelihood of mortality. It is presumed that oil spill prevention and response measures will be in place and complied with during active DR&R. However, the effects of a land-based spill on mortality of terrestrial mammals depends on spill type, size, location, season, and response effectiveness.

Harvest by Humans

Concerns have been raised about potential impacts of harvest by humans on terrestrial mammals related to impacts in previously undisturbed wilderness areas that are now accessed by the Dalton Highway. Issues are related to management and population objectives (i.e., harvest numbers, hunting pressure, animal wounding), compliance with regulations (i.e., Dalton Highway Corridor Management Area, firearms, monitoring and enforcement effort), and access. These issues are not unique to the TAPS ROW, and have been addressed in other areas of North America (James and Stuart-Smith, 2000; Hay and Mohrman, 1993; Ricard and Doucet, 1993). Section 3.2.5 contains back-

ground information and data on particular species, as well as population and harvest trends and status.

South of the Yukon River, relatively few concerns have been identified with respect to the TAPS ROW and harvest by humans. The Richardson Highway was in place before construction of the pipeline and ROW, and therefore the issue of access into a previously undisturbed large area is not relevant. However, public access has been created with trespass permission on Alyeska property (Schmidt, 1999, pers. comm.; Lawlor, 1999, pers. comm.; Shoulders, 1999, pers. comm.). In these cases, although hunting is not allowed from or within the ROW, the hunting and recreating public may travel within and across the ROW to previously isolated areas.

North of the Yukon River, the Dalton Highway has provided access into a previously remote and isolated area. There is concern that this increased access has adversely affected moose, caribou, wolf, and bear populations as a result of increased harvests (Yokel, 1999, pers. comm.) and the wounding of animals. However, Smith (1999) concluded that although use of the DHC has increased since 1991, populations of moose, caribou, brown bears and wolves have not been adversely impacted. Monitoring and enforcement of regulations along the Dalton Highway have been variable (Smith, W., 1999).

Beginning in 1980, summer traffic on the Dalton Highway was allowed as far north as Dietrich Camp, and starting in 1984 year-round access was permitted. Travel was restricted to commercial vehicles north of Dietrich Camp (Smith, W., 1999). In 1991, the Dalton Highway was opened to public traffic along its entire length, but shortly thereafter was officially closed north of Dietrich Camp as a result of court challenges. The highway's entire length was reopened by administrative order in December, 1994 (Smith, W., 1999). According to W. Smith (1999, p. 1), "Although the northern section of the Dalton Highway was officially closed (between 1991 and 1994), the prohibition was largely ignored, and there was extensive hunting from the road. State policy dictated that the closure was not enforced as a primary statute, but was placed on a secondary status, similar to Alaska's seatbelt law. This meant violations of the road permit regulation were only cited in association with other violations."

Current hunting regulations north of the Yukon River include the DHCMA in addition to regulations for each GMU. DHCMA boundaries extend 8 km (5 miles) from each side of the Dalton Highway, including the highway's drivable surface, from the Yukon River to the Prudhoe Bay Closed Area. Management objectives of the DHCMA were developed to discourage behavioral reinforcement of summer avoidance of facilities by caribou cows with calves (Whitten, 1999, pers. comm.). Restrictions in the DHCMA include the following:

- The DHCMA is closed to hunting with firearms, but big game may be taken by bow and arrow;
- No motorized vehicles, except aircraft, boats, and licensed highway vehicles, may be used to transport game or hunters within the DHCMA; and
- Any hunter traveling on the Dalton Highway must stop at any check station operated by ADF&G in the DHCMA (ADF&G, 1999g).

ADF&G has maintained a hunter check station on the Dalton Highway since 1991 to monitor hunting pressure, and to provide information to hunters within the DHC and in GMUs adjacent to the road (Smith, 1999). More than half of all hunters registering at the check station are making their first trip up the Dalton Highway. Most (75 percent) hunters are Alaskan residents, 69 percent of whom reported home addresses in the areas of Fairbanks, northern Interior, Anchorage, Chugiak or Eagle River. Approximately one-fourth of hunters using the DHC are on active military duty (Smith, W., 1999).

W. Smith (1999) reported that in any year, several factors combine to influence the number of hunters using the DHC. Factors that encourage hunter use of the corridor include good weather, good road conditions, early (early August) influx of caribou near the road in GMU 26B, reduced availability of Tier 1 permits for the Nelchina caribou herd, lowered bag limits for other registration hunts, and State promotion of tourism to Alaska. The State does not specifically promote use of DHC (unlike BLM-Dalton Unit, see BLM, 1998); however, promotion of tourism is likely to increase use of the DHC (Smith, W., 1999). Factors that discourage hunter use of the DHC include the 5-mile walk for rifle hunters, closure of moose and nonresident brown bear hunts in GMU 26B, reduced numbers of caribou near the road after August 15, lack of facilities between Coldfoot and Prudhoe Bay, and lack of paving (Smith, W., 1999).

The following is a excerpt from W. Smith (1999, pp. 7-8) regarding harvests of these populations:

> "The number of hunters for the 4 major big game species increased substantially in 1998, but harvest remained similar to previous years. As in the past few years, most caribou were taken in August near Toolik Lake, probably from eastward excursions of the large Western Arctic Herd (ca. 460,000) to the Dalton Highway. Consequently, the resident Central Arctic Herd in Unit 26B remains lightly harvested and, with current firearms restrictions with the DHC, should not

be much affected by increased hunting pressure. Since the closure of Unit 26 to moose hunting, hunters using boats for access have shifted to waterways south of the Brooks Range such as the Koyukuk River and Bonanza Creek. This, along with increasing number of hunters using the road for access, resulted in the highest take of moose in Units 20F and 24 since 1991. Although hunting pressure has been localized along the road and the few navigable waterways off the Dalton Highway, moose harvest should be monitored in these units. Sheep brought through the check station represent only a small proportion of sheep harvested in units adjacent to the Dalton Highway. Since most successful sheep hunters use aircraft, increased hunting pressure from the road and by boat will have only minimal effects on sheep harvest. Changing the Unit 26B brown bear regulations caused a significant decrease in brown bear harvest to below the harvest quota. The increased harvest in Unit 24 was not caused by incidental take by higher numbers of hunters using the road or boats, but by an increased take by hunters using aircraft. However, similar to moose, brown bear harvest in Unit 24 should continue to be monitored carefully for increased incidental harvest."

The increase in Alaska's human population since TAPS construction has undoubtedly increased the hunting pressure on the state's wildlife. ADF&G has responded to this pressure where necessary by restricting seasons and bag limits. Many moose and caribou populations in the state are limited by predation, and ADF&G has implemented predator-control programs to increase the number of ungulates available to hunt. Although these programs have been controversial at times, ADF&G management objectives include direction to provide recreational harvest opportunities, which requires management for productive moose and caribou populations.

In addition, changes in land ownership and land uses (i.e., access for hunting and fishing) in the early 1980s redistributed hunting pressure in the entire state. Areas that had previously been available for hunting were restricted due to federal land use regulations for National Park Service lands (e.g., Wrangell-St. Elias National Park and Preserve, Gates of the Arctic National Park) (Mumford, 1999, pers comm.; Heimer, 1980). Thus, hunting pressure in those areas not taken over by the federal government increased concurrently with TAPS-related increases in population.

Hunting pressure and harvests have increased for most wildlife species. However, ADF&G management objectives are being met for most wildlife populations. Bag limits and seasons have been adjusted to allow for maximum sport-hunting opportunities without adversely impacting the population. Many populations are successfully managed (i.e., numbers regulated) through hunting. Increases in harvest and hunting pressure have not produced adverse population-level effects. The increased workforce associated with active DR&R may increase hunting pressure on terrestrial mammals in the vicinity of the ROW and across the state.

After TAPS operations cease and DR&R is complete, a potentially important impact on terrestrial wildlife is increased harvests from a variety of sources (i.e., legal, illegal, sport, and subsistence). The end of operations of the oil industry in the ANS oil fields, TAPS, and the VMT will be accompanied by significant reductions in statewide employment and incomes. This may increase pressure on wildlife (e.g., sport and subsistence hunting) if residents use wild foods to compensate for the loss of income. If decreased state revenue results in less enforcement of game regulations, this impact could be intensified. However, it is also possible that the human population (and wildlife harvests) will decrease in response to the economic decline. Regulation and monitoring by the appropriate agencies will be needed to manage this potential impact.

Furbearers and Small Mammals

Obstructions to Movements. Localized obstruction to movement of furbearers and small mammals would occur in areas of heavy activity during DR&R as elevated pipe, culverts, and pump stations were being removed. Heavy equipment operations and high levels of human activity would create localized barrier effects for furbearers and small mammals. Such effects would last less than 3 years over approximately half of the TAPS route.

Disturbance and Displacement. The human presence and activities associated with DR&R activities would disturb individual animals that reside in areas where such activities or human presence has been uncommon. Such disturbance would be substantially greater than under normal operation and maintenance, although the effects generally would be localized and temporary, and thus unlikely to have significant consequences for the disturbed animals, except in the case of denning foxes, coyotes, river otter, wolverine, or lynx. Animals habituated to human presence or regularly subject to human disturbance unrelated to TAPS activities, such as near population centers or areas of major activity, would be less affected by DR&R activities.

Small accidental spills could occur during DR&R, although large spills would presumably be much less likely than during operation of the pipeline. Spill cleanup activi-

ties could disturb small numbers of resident furbearers and small mammals. It is unlikely that disturbance associated with spill response would have population-level impacts on furbearers or small mammals.

Deliberate displacement of problem animals in protection of life and property, either through hazing or live-trapping and releasing, could increase during DR&R. The creation of problem animals through garbage mishandling or deliberate feeding could increase during DR&R (as it did during TAPS construction) due to the large numbers of workers operating in remote locations where food-handling regulations and animal feeding prohibitions are more difficult to enforce. Beavers could continue to cause flooding near camps and work sites and would need to be displaced as long as drainage patterns through culverts were maintained. Although nuisance animals would be a threat to human health, it is unlikely that deliberate displacement of problem animals would have population-level consequences for furbearers or small mammals.

After abandonment, former access roads and pads would provide attractive campsites for tourists, hunters, and other recreationists, which would disturb and possibly displace furbearers. Additionally, the use of those sites and of the TAPS ROW as a travel corridors for snowmachines and ATVs could increase substantially after abandonment and the termination of access restrictions. All species would be affected by increased human use, particularly by vehicle disturbance, but the consequences of such disturbance would likely be minor for most furbearer species, except foxes, coyotes, lynx, river otter, and wolverine, which actively avoid humans and are susceptible to disturbance during denning (Olliff et al., 1999).

Habitat Alteration/Enhancement. During DR&R, habitat alteration would result from (1) ground disturbance, such as VSM and pipe removal and other earthwork during DR&R, (2) dust fallout from increased traffic associated with DR&R activities along unpaved portions of the highway (particularly the Elliot and Dalton Highways north of Fairbanks), and (3) waste discharges and accidental spills. Following DR&R, habitat alteration would result from regrowth of shrubs and trees in the ROW. Cessation of vegetation management along TAPS would result in decreases of early successional (grassland) habitats and small mammals relying on such habitats, and an increase in late successional (shrub and forest) habitats and associated species of furbearers and small mammals (e.g., red squirrels, red-backed voles, and marten). The net effect eventually would be to return about half of the TAPS ROW to a state more comparable to that existing before construction, depending on the success of revegetation on the gravel workpad, pump station pads, and access roads.

Ground disturbance and to a lesser extent, waste discharges and spills, would affect relatively large areas of the TAPS ROW during DR&R, but would likely affect only those small mammals (voles, lemmings, and squirrels) resident in the immediate vicinity. Early thaw and green-up from dust fallout along unpaved roads would attract many herbivorous animals and, consequently, their predators (Thompson, 1999, pers. comm.; Shoulders, 1999, pers. comm.; Martin, P., 1999, pers. comm.; Bright, 1999, pers. comm.; McIntosh, 1999, pers. comm.). The magnitude of dust fallout would increase during DR&R because of the higher traffic volume. Such effects would continue after DR&R due to tourist and other traffic, but would not be direct impacts of the project.

Another form of habitat alteration would be the attraction of predators and scavengers by food and garbage scent or by handouts in areas of human activity. DR&R would mimic the impacts that occurred during TAPS construction (Milke, 1977; Follmann et al., 1980), although improvements in garbage management practices, worker education, state law, and stricter enforcement since the construction period would help to minimize such problems. However, incidents of property damage, inadvertent or deliberate feeding, and animal control measures, including shooting offending animals, have continued at low levels during operation. The large increase in number of people working in remote areas during DR&R would undoubtedly result in an increase in animal feeding problems. Of the furbearers and small mammals, the species most likely to become nuisance animals due to the availability of human foods are arctic and red foxes, coyotes, wolverines, and red and ground squirrels. Although nuisance animals would be a threat to human health, the effects during DR&R would be temporary, and significant population-level consequences would be unlikely.

Mortality. Increased traffic levels during DR&R would result in increased roadkills, especially in the northern portion of the ROW. As previously mentioned, concentrations of wildlife near unpaved highways occur during the period of spring snowmelt, and increased roadkills are observed during that period. All species of furbearer and small mammals would be affected, but arctic and red foxes, ground squirrels, and porcupines would be most susceptible. However, this mortality source probably would not cause significant population-level consequences for furbearers and small mammals.

Accidental oil or chemical spills and waste discharges would cause mortality in the spill areas, potentially affecting small numbers of all species present. Aquatic or semi-

aquatic mammals would be most vulnerable, including beaver, muskrat, mink, and river otter. Population-level effects for furbearers and small mammals are unlikely to result from small spills; the size of the spill and required response would determine the population consequences.

Mortality of furbearers or small mammals would result from deliberate action taken against problem animals (Brown, D., 1999, pers. comm.; Shoulders, 1999, pers. comm.; Preston, 1999, pers. comm.). As previously mentioned, the creation of nuisance animals would be likely to increase during DR&R. Foxes and other animals exhibiting symptoms of rabies are shot and their heads sent to the University of Alaska for testing (APSC, 1998e). Furbearers and small mammals that would most likely be killed to prevent disease transmission or property damage include arctic and red foxes, coyotes, ground squirrels, and voles and mice. Beavers would cause flooding near camps and work areas during DR&R and would need to be trapped, moved, or shot as long as culvert maintenance was important. Although problem animals would be a serious legal risk and threat to human health, it is unlikely that there would be population-level consequences by the killing of nuisance furbearers or small mammals.

Increased densities of predators/scavengers attracted to areas of human activity would result in increased predation pressure on prey populations. Although the attraction of predators and scavengers to DR&R camps and work sites would be greater than during operation (as described above), the overall effects would be temporary during DR&R and not chronic as during the operational phase. Long-term depression of prey populations would therefore be unlikely, and the impact would be minor.

Similarly, increased densities of predators and scavengers would increase the occurrence and rate of transmission of enzootic diseases, including rabies (Follmann et al., 1988). The primary reservoir of rabies in the arctic is arctic foxes, whereas south of the Brooks Range, red foxes and other carnivores are a greater concern (Winkler, 1975). Although the risk of transmission of rabies (and other diseases) to humans would increase, the effects on wildlife populations susceptible to rabies would be temporary and the impact would likely be minor.

Harvest by Humans. Improved access and campsites provided by the abandoned right-of-way, access roads, and pads would result in increased legal and illegal harvest of all furbearer species. It is unknown what regulations would be promulgated by the state, BLM, or ADF&G after abandonment of the right-of-way, particularly whether the state would continue to prohibit the use of firearms and motorized vehicles by hunters within the Dalton Highway corridor north of Livengood. Trapping and hunting regulations would be adjusted accordingly to protect and manage wildlife populations. It is unlikely, however, that illegal take would decrease or that monies for enforcement would increase after TAPS use were terminated. As with the proposed action, improved access provided by the TAPS ROW and access roads to hunters and trappers would likely be the greatest single impact on furbearers after DR&R.

4.4.2.6 Threatened and Endangered Species

By R. Ritchie, D. Troy, and J. Kidd

Birds

Two species listed as threatened under the federal Endangered Species Act (Spectacled Eider and Steller's Eider) and two delisted subspecies of Peregrine Falcon (the *tundrius* and *anatum* races) would potentially be affected by activities associated with the no-action alternative. The endangered Eskimo Curlew evidently no longer occurs in Alaska. No listed terrestrial mammals or plants occur within the ROW. Because of similarities among the remaining listed species, the discussions of environmental consequences have been combined for both eider species and for both peregrine subspecies.

Spectacled and Steller's Eiders

DR&R likely would have negligible effect on the two threatened species of eiders. No records of Steller's Eider within the TAPS ROW are known, indicating its rarity; thus, deleterious impacts are unlikely. Spectacled Eiders occur regularly in low numbers in the vicinity of the northern portion of TAPS; however, records near the area of operations or facilities are few. Compared to routine operations, human activity and the potential for disturbance will be higher during the process of dismantling the pipeline and Pump Station 1. Given the limited overlap among the distributions of these species and TAPS facilities, scheduling activities to occur outside the period when eiders are present on the tundra would effectively eliminate disturbance impacts. Summer activities along the TAPS ROW and at Pump Station 1 could probably occur with little or no disturbance of Spectacled Eiders; however, if the Deadhorse and northern Dalton Highway infrastructure were used to any great extent for storage, transport, and staging, incremental disturbance of eiders would likely occur. Following decommissioning of TAPS, overall disturbance would be reduced and some minor changes in habitat availability would ensue. Early melt zones along the Dalton Highway would diminish as traffic on the highway and workpad decreased, whereas persistent snowdrifts adjacent

to the above-ground pipeline would diminish.

Obstructions to Movements. Roads and pipelines do not appear to be major barriers to eider movements. The greatest potential for obstruction of movements would occur during the brood-rearing period of the nesting cycle, when flightless Spectacled Eider with broods cross roads in the Prudhoe Bay oil field (TERA, 1995, 1996b). Increased activity on the TAPS workpad and the Dalton Highway during DR&R would hinder attempts to cross either structure. Removal of the pipeline and TAPS facilities would eliminate them as a source of obstruction to eiders, and would lead to diminished traffic on the Dalton Highway.

Disturbance and Displacement. The evidence for sensitivity of Spectacled Eiders to disturbance is mixed, as was explained for the proposed action. DR&R initially would increase disturbance (for 1 to 3 years, unless scheduling permits all decommissioning to occur during the winter) but would decrease disturbance in the long-term following complete removal of facilities.

Habitat Alteration and Enhancement. Spectacled Eiders use roadside impoundments in the Prudhoe Bay and Kuparuk oil fields (Warnock and Troy, 1992; Anderson et al., 1996). Thus, the habitat modifications along the TAPS workpad and Dalton Highway may have enhanced these areas for Spectacled Eiders. Use of TAPS or Dalton Highway impoundments away from Deadhorse has not been documented. DR&R would not eliminate impoundments entirely, because the Dalton Highway and TAPS workpad would not be removed. Changes in snowmelt may alter the availability of these areas to Spectacled Eiders, however. Reduced traffic after DR&R would diminish the early melt zone along the Dalton Highway. The opposite effect of earlier melt would occur along the workpad after removal of the above-ground pipeline and attendant snow-fence effect.

Mortality. No mortality of Spectacled Eiders due to TAPS infrastructure has been documented. Use of roadside impoundments poses a limited risk for traffic-associated mortality, especially near Deadhorse, although no records of such mortality have been located. This risk would increase due to increased traffic during DR&R and then would decrease following removal. To the extent that predator populations may be augmented by TAPS activities, Spectacled Eider nest success could be depressed to a minor degree. After removal of TAPS, predator populations would be expected to decline. Oil spills would be a risk factor; however, the low use of areas adjacent to TAPS makes this a small risk. The process of dismantling the pipeline likely would increase the incidence of small spills.

Harvest by Humans. Hunting of Spectacled and Steller's eiders is prohibited throughout the state, and permits are not issued to collect any eider eggs in Alaska for captive propagation by private breeders. Thus, it is presumed that no harvest of these eiders occurs. DR&R would not be expected to affect the harvest of either species.

Peregrine Falcon

DR&R likely would have negligible long-term effects on both *anatum* and *tundrius* subspecies of Peregrine Falcon along TAPS. Temporary losses in productivity and displacement at some nesting areas might be increased by the greater levels of disturbance associated with DR&R activities. In addition, some man-modified habitats (e.g., VSM perches) would be removed, influencing some behaviors and habitat use by peregrines; survival would not be affected adversely by removal of facilities.

Obstructions to Movements. Activities associated with DR&R of TAPS would not be likely to pose obstructions of movements by Peregrine Falcons within the TAPS ROW.

Disturbance and Displacement. Potentially disturbing activities associated with DR&R would include increased helicopter and fixed-wing aircraft traffic near nesting areas, heavy-equipment operations and associated loud noise, and activity by ground parties. Impacts would include temporary disturbance and possibly avoidance of some nesting sites in high-activity areas. However, standard mitigation stipulations would reduce or eliminate those impacts.

Habitat Alteration and Enhancement. DR&R activities along TAPS would result in both permanent and temporary changes in nesting and foraging habitats of Peregrine Falcons. Most DR&R activities affecting habitats (e.g., gravel removal, reclamation of borrow sites) would occur at sites already heavily modified or altered; the emphasis of restoration would be to return habitats to as natural a state as possible. Therefore, traditional nesting and foraging habitats for Peregrine Falcons likely would not be impacted negatively by DR&R actions.

The removal of buildings and elevated portions of the pipeline would eliminate some artificial substrates used for resting and perching by peregrines. Their removal would not result in population-level impacts, but would simply cause the birds to shift to other perch locations.

Mortality. As described for the proposed action, direct or indirect mortality of Peregrine Falcons related to pipeline activities has been rare. White et al. (1977) concluded that no demonstrable negative impacts were attributable to TAPS construction activity. In at least one nesting area along TAPS (Sagwon Bluffs on the Sagavanirktok River), however, productivity was low to nil during the years of major TAPS construction (Roseneau et al., 1981). Although contamination with DDT is now generally considered to be

the major reason for low productivity in Alaska peregrines during that period, the possibility that some pipeline-related activities (e.g., Haul Road construction) affected productivity cannot be eliminated (Roseneau et al., 1981). Productivity on the Sagavanirktok River was lowest during pipeline and road construction years 1974-76 (Roseneau et al., 1981). Therefore, it is possible that pipeline removal operations would cause temporary, but important, disturbances that might temporarily reduce the productivity of the Sagavanirktok population by causing nest desertion and egg and nestling loss. Appropriate mitigation strategies, such as seasonal restrictions on activities near nest sites, would mitigate the negative impacts of DR&R activities.

Harvest by Humans. Falconry uses of Peregrine Falcons would be similar to those described for the proposed action. No other uses of the species would be affected by DR&R actions.

Plants

No threatened or endangered plants occur along the TAPS route. Therefore, no effects are discussed.

Terrestrial Mammals

No threatened or endangered terrestrial mammals occur in Alaska. Therefore, no effects are discussed.

4.4.3 Social Systems

4.4.3.1 Economy

By O.S. Goldsmith, L.D. Maxim, and R. Niebo

This section provides estimates of the combined direct, indirect, and cumulative economic effects of the no-action alternative for the pipeline, ANS oil fields, marine transportation link, and other industries in Alaska. (See also the cumulative effects discussion in Section 4.5.) The economic methodology used requires that these effects be considered together. Other social impacts of the no-action alternative could be separated largely based on geography, so that only direct impacts of the pipeline are addressed here. Cumulative social effects are included in Section 4.5.

The economic effects are significant, wide-ranging, and have not been addressed in any previous EIS or EA.[1] Brief summaries are included at various points in the text for the reader interested in an overview.

Since completion of the economic analysis summarized here, oil prices increased substantially above the $16 per bbl used in the model (>$30 per bbl in October 2000). It is not feasible to replicate this analysis in response to every crude-oil price movement. However, an upward shift in oil prices will magnify the economic impacts presented here. First-order impacts of this change include substantial (factor of two) increases in revenues to various levels of government. To the extent that higher prices persist, the economics of marginal fields and other oil and gas developments become more attractive. Development of these fields would increase future ANS production and pipeline throughput and, therefore, revenues. In turn, greater revenues result in “ripple” (multiplier) effects throughout the Alaskan economy. Although some effects would be adverse — such as higher prices for gasoline, diesel fuel, heating oil — most are beneficial for oil-producing regions. The differences between the impacts of the proposed and no-action alternatives are likewise affected. Therefore, the adverse economic impacts of the no-action alternative estimated here are understated at present crude oil prices.

Key Economic Assumptions: Pipeline Termination

- **Pipeline Operation:** The last crude oil flowing through TAPS arrives at Valdez at the beginning of 2004 (i.e., the production and throughput profile given in Appendix A drops to essentially zero).[2] All employment associated with pipeline operation, including contractor employment and special projects, terminates at the beginning of 2004. At shutdown, the full-time-equivalent (FTE) employment directly associated with the pipeline is 1,828 — 700 in operations, 800 working under contract, and 328 associated with special projects. Workers are concentrated in Fairbanks and Valdez, with a small number in Anchorage (Table 4.4-3).
- **Pipeline DR&R:** Activities related to DR&R will commence in 2002 and continue for six years, ending in 2007. Tasks in the two years before the pipeline is shut down include planning, mobilization, and preparatory construction. Actual DR&R (cleaning and purging the pipeline; dismantling the pipeline, pump stations, and VMT; and scrap disposals) start in 2004 and continues for three years. The final year consists of demobilization. The time required for DR&R is consistent with available information. The particular

[1]The no-action alternative is addressed in each of the North Slope EISs, but they do not discuss the total effects of a cessation of oil and gas operations on the ANS. Nearly all of the material contained in Section 4.4.3.1 is original. The source for all tables and figures in Section 4.4.3.1 is original analysis by section authors.

[2]Production from the Kenai Peninsula continues; however, this is small in comparison to ANS production.

schedule for DR&R is an assumption. In reality, it is unlikely that DR&R planning and mobilization would be initiated in 2002 while the ROW renewal process is underway. However, this assumption recognized the extensive planning efforts that will be required before actual on-ground DR&R begins. Overall impacts will be essentially the same if DR&R planning is postponed several years.

FTE employment associated with DR&R (Table 4.4-4) is estimated based on expenditures projected from existing studies of the cost of DR&R (Fluor, 1983). The 1983 Fluor study estimated the cost of DR&R in 1982 dollars to be $1.553 billion plus $159 million for post-commissioning facilities ($1.0125 billion in 1977 dollars). The cost converted to 2004 dollars using the Anchorage Consumer Price Index for Wage Earners is $2.6305 billion.

Work in the field is seasonal and requires remote camps for dismantling the above-ground portions of the pipeline and the pump stations. Pipe and other material from the northern part of the line are taken to the North Slope to be moved by sea lift for ultimate disposal. Fairbanks is the staging area for the central portion of the pipeline with material transported to Seward or Whittier by truck or train. Valdez is the staging area for the southern portion of the pipeline and the terminal. Because of the seasonality of work in the field, the peak summer employment exceeds the FTE annual employment level by about one-third. Because of the small size of the Alaska labor force [construction employment in 1997 was 13,134 (ADOL, 1988a)], a portion of the labor required for DR&R is provided by nonresidents who commute seasonally, as occurred during pipeline construction. Most of the equipment and supplies are also imported from outside the state due to the small relative size of Alaska's construction industry.

The nature and scope of this DR&R project are unique, and so estimates of employment are suggestive of the general level, timing, and composition of employment that would actually be required. Specific requirements and available technology will determine the actual level of effort.

- **Government and Other Oversight:** With cessation of pipeline operations, JPO activities associated with TAPS and the oil pipelines on the North Slope are no longer necessary. The Prince William Sound Regional Citizens' Advisory Council also ceases operation at the end of pipeline DR&R. Some state and federal workers not associated with these agencies are also no longer required for pipeline oversight. The annual employment associated with this activity is estimated to be 100, divided among federal and state government.
- **Pipeline Total:** Table 4.4-5 shows the total direct pipeline employment effect of the no-action alternative. The employment loss from terminating pipeline operations and government oversight and the employment gain from DR&R of the pipeline create a boom-and-bust pattern. In the main DR&R years of 2004 and 2005, employment jumps, primarily in construction and closely related industries. Subsequently, employment is lower by 1,816 compared to the proposed alternative, primarily due to loss of employment associated with pipeline operations. Because of the size of the Alaska economy, this employment cycle could be absorbed without significant negative consequences during either the boom or bust phases, particularly if a large share of the DR&R workers were not from Alaska. However, localized impacts, particularly at Valdez and Fairbanks, could be severe.

Table 4.4-3. *No-action alternative impact on direct annual average employment of pipeline operations including special projects.*

Year	Total	Fairbanks	Anchorage	Valdez/ Cordova
2004	(1,828)	(934)	(222)	(671)
2005	(1,743)	(858)	(204)	(681)
2006	(1,734)	(853)	(203)	(677)
2007	(1,725)	(848)	(202)	(674)
2008	(1,716)	(843)	(202)	(671)
2009	(1,716)	(843)	(202)	(671)
2010	(1,716)	(843)	(202)	(671)
CONSTANT AFTER 2010				

Table 4.4-4. *No-action alternative impact on direct annual average employment of pipeline DR&R.*

Year	Total	Construc-tion	Transporta-tion	Services
2002	232	116	0	116
2003	553	415	0	138
2004	5,219	3,653	783	783
2005	3,350	2,345	502	502
2006	1,922	1,345	288	288
2007	561	393	84	84
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0

Table 4.4-5. *No-action alternative impact on direct annual average employment of total pipeline-related activity.*

Year	Total	Pipeline Operations	Pipeline DR&R	Pipeline Oversight
2002	232	0	232	0
2003	553	0	553	0
2004	3,391	(1,828)	5,219	0
2005	1,606	(1,743)	3,350	0
2006	188	(1,734)	1,922	0
2007	(1,264)	(1,725)	561	(100)
2008	(1,816)	(1,716)	0	(100)
2009	(1,816)	(1,716)	0	(100)
2010	(1,816)	(1,716)	0	(100)
CONSTANT AFTER 2010				

Table 4.4-6. *No-action alternative impact on North Slope oil field construction and operations direct annual average employment.*

Year	Total	North Slope	Fairbanks	Anchorage
2004	(7,539)	(4,006)	(322)	(3,211)
2005	(7,728)	(4,107)	(330)	(3,291)
2006	(7,918)	(4,207)	(339)	(3,372)
2007	(7,918)	(4,207)	(339)	(3,372)
2008	(7,918)	(4,207)	(339)	(3,372)
2009	(7,918)	(4,207)	(339)	(3,372)
2010	(7,918)	(4,207)	(339)	(3,372)

Note: Does not include indirect job losses.

Key Economic Assumptions: Termination of North Slope Oil-Related Activity

- **North Slope Exploration and Development:** Without TAPS, North Slope oil production ceases since there would be no viable transportation alternative. A small amount of gas production continues for gas and electric utilities of some North Slope communities. Exploration for new resources also stops, as does development of discovered but not yet producing reserves. Petroleum activity in the Cook Inlet region in Southcentral Alaska is not affected by the shutdown of the pipeline.

  Oil company, oil field services, and construction employment on the North Slope, and in Anchorage and Fairbanks is eliminated by 2010 by termination of North Slope activities (Table 4.4-6). An unspecified number of jobs in business services, transportation, construction, and wholesale trade also terminate. Most of the workers on the North Slope commute from other locations. Many of these workers are not Alaska residents, but the majority live in Southcentral Alaska (including Anchorage, the Kenai Peninsula Borough, and the Matanuska-Susitna Borough) and in Fairbanks in the Interior.
- **North Slope DR&R:** The North Slope leases, most of which are on state land, require that production facilities be dismantled and removed and the land restored to the satisfaction of the lessor after operations cease. There is no history of North Slope oil field DR&R on which to base an estimate of the cost and manpower requirements for DR&R of the entire North Slope. DR&R of exploration activity on the National Petroleum Reserve 4, west of the present North Slope facilities, took place in the early 1990s, but the limited scope of this activity makes it inappropriate as a basis for estimating the cost of DR&R of the main North Slope facilities (BLM and USGS, 1992). Most of the current information on DR&R of oil and gas facilities concerns offshore oil and gas platforms, where most DR&R is occurring (Kemp and Stephan, 1997).

  The cumulative dollar value of capital investment in oil and gas facilities on the North Slope is about $20.6 billion in 1977 dollars (Deakin, 1989; BP Annual), or $53.6 billion estimated in 2004 dollars adjusted by the Anchorage Consumer Price Index for Wage Earners. The estimated cost of DR&R for the pipeline is about 11 percent of the original construction cost (estimated at $9 billion in 1977 dollars). The DR&R cost for the North Slope facilities will probably be a smaller percentage of the value of facilities in place because the facilities are geographically more concentrated so that logistics will be less challenging. Using an estimate of 5 percent of the value of North Slope facilities as the cost of DR&R yields an estimate of $2.681 billion, approximately equal to the cost of DR&R for the pipeline. Table 4.4-7 shows FTE employment for North Slope DR&R, based on the same distribution of effort by time and industry as the pipeline DR&R.
- **Module Construction:** Fabrication of the larger modules used at North Slope production facilities, originally done in the Lower 48, began in Alaska in the mid-1990s. Smaller-module construction, as well as fabrication of other components, has been occurring in-state for much longer. This construction activity is intermittent, dependent on the characteristics and timing of new field development. Annual average

construction employment in Anchorage, Fairbanks, and on the Kenai Peninsula is estimated at 500 jobs, which are eliminated with the termination of North Slope oil activity (Table 4.4-8).

- **Refining:** Two refineries at Fairbanks and one at Valdez have been built to take advantage of the availability of North Slope crude (ADNR, 1999c). The output of these refineries — primarily gasoline, diesel, and jet fuel — is marketed in Alaska. Upon termination of North Slope production, these refineries cease operations because they lose their crude supply. The next best alternative for them is to import crude from outside the state (Cook Inlet oil production is insufficient to supply these refineries). However, they are configured to use only the lighter portion of the crude they receive from the pipeline, returning the heavier components to the pipeline. They would incur large capital investments to be able to use the entire barrel. Employment at the refineries in Fairbanks is 160 and at Valdez 55, a total of 215 workers (Table 4.4-8).

  A refinery on the Kenai Peninsula predates construction of the pipeline and does not currently rely on North Slope crude for throughput. It continues to operate and serve the Railbelt markets using Cook Inlet and imported crude oil.
- **Air Cargo:** International air cargo activities — primarily at Anchorage International Airport with some activity at Fairbanks International Airport — are dependent on many factors, including competitively priced and locally produced jet fuel. Termination of North Slope production and the subsequent closure of the refineries in Fairbanks and Valdez make it more difficult to supply the airports with competitively priced jet fuel. As a consequence, the airports face greater competition for the international air cargo business from airports in other locations. International air cargo operations directly account for about 2,000 workers in Anchorage (Goldsmith, 1995a, 1998), and their numbers are growing rapidly. With termination of pipeline operations, that growth slows as the competitive position of Anchorage erodes (Table 4.4-8).
- **Other Industries:** High prices for petroleum products impact most Alaska industries and households. In particular, diesel fuel costs are important in the fishing industry. Most smaller Alaska communities without hydroelectric power or natural gas rely on diesel fuel for space heating and electricity. Closing the Fairbanks and Valdez refineries could result in higher petroleum product prices generally, but no analyses have documented either the likelihood of this occurring or its impacts.
- **Shipping:** Closing the Fairbanks and Valdez refiner-

Table 4.4-7. *No-action alternative impact on direct annual average employment of North Slope oil facilities.*

Year	Total	Construction	Transportation	Services
2002	236	118	0	118
2003	564	423	0	141
2004	5,320	3,724	798	798
2005	3,414	2,390	512	512
2006	1,959	1,371	294	294
2007	572	400	86	86
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0

Table 4.4-8. *No-action alternative impact on direct annual average employment of North Slope oil-related activity.*

Year	Total	North Slope Oil Field Operations	North Slope Oil Field Construction	Oil Field DR&R	Oil Field Oversight	Module Construction	Refining	Air Cargo
2002	236	0	0	236	0	0	0	0
2003	564	0	0	564	0	0	0	0
2004	(2,934)	(6,052)	(1,487)	5,320	0	(500)	(215)	0
2005	(5,230)	(6,204)	(1,525)	3,414	0	(500)	(215)	(200)
2006	(7,074)	(6,356)	(1,562)	1,959	0	(500)	(215)	(400)
2007	(8,986)	(6,356)	(1,562)	572	(325)	(500)	(215)	(600)
2008	(9,758)	(6,356)	(1,562)	0	(325)	(500)	(215)	(800)
2009	(9,958)	(6,356)	(1,562)	0	(325)	(500)	(215)	(1,000)
2010	(9,958)	(6,356)	(1,562)	0	(325)	(500)	(215)	(1,000)
CONSTANT AFTER 2010								

ies requires importation of petroleum products to replace a portion of the lost production, dependent on the change in demand for jet fuel for the international air cargo industry. This results in changes in the distribution pattern for petroleum products. Petroleum products moving into Southcentral Alaska by tanker would increase, and products would move north from Anchorage to Fairbanks by railroad. Currently, product moves south along the railroad from Fairbanks to Anchorage. This change could impact the Alaska Railroad. No specific estimates of the employment effect of these changes are available.

- **Government Oversight:** The annual cost to the State of Alaska for management, oversight, and regulation of the oil and gas industry is $44 million (Gladziszewski, 1996). A large portion of this expense would be unnecessary with the termination of oil-related activity on the North Slope. In addition, several federal government agencies devote resources to oversight of North Slope oil and gas activity. The annual employment associated with these activities is 325, mostly in state government (Table 4.4-8).
- **North Slope Oil Total:** A large reduction in employment occurs starting in 2004 because of the employment loss from terminating North Slope oil and gas production, government oversight, and module construction; from refinery closure; and from downsizing of the international air cargo industry with the employment increase from DR&R of the North Slope facilities. In the early years, the loss in the oil and gas industry is partially offset by the increase in construction and other sectors associated with DR&R. Because many of the workers who lose their jobs in the oil and gas sector will not be employed in DR&R, there will be a turnover of workers during this period that is not reflected in the net change in employment. Subsequent to DR&R, North Slope employment is lower by 9,958 compared to the proposed action, primarily due to loss of employment associated with oil activities (Table 4.4-8).

Figure 4.4-3 shows the combined (i.e., pipeline, ANS, oversight, module construction, refineries, DR&R, and air cargo) direct effects of employment gains and losses from 2002 to 2010. DR&R activities both for the pipeline and ANS fields offset other employment losses in the early years. However, losses in operations and construction (both for the pipeline and ANS fields), oversight, and other related industries (modules, refining, and air cargo) combine to create aggregate losses of nearly 12,000 jobs by the year 2009 — losses that are never recovered.

National and State Economic Effects

Compared to the proposed action, closure of the North Slope/TAPS is expected to have very substantial and adverse economic effects at the regional, state, and national levels. The overall level of economic activity drops, employment decreases in many industries as does personal income per capita, although DR&R activities create some short-lived employment opportunities. Federal, state, and local revenues also decrease sharply, which makes it difficult to maintain services and/or to cushion these adverse impacts. DR&R activities create some short-lived employment opportunities, one of the few positive elements in an otherwise bleak economic landscape. Domestic crude production decreases sharply, the trade deficit worsens, and U.S. shipyards lose business because double-hull tankers to serve the Alaskan trade are not required. An abrupt shutdown of nearly all of the Alaskan petroleum industry foreclosures opportunities for a smooth transition from a petroleum-based to a more diversified Alaskan economy. Closure and dismantling of TAPS and ANS production infrastructure increase the difficulty of commercializing ANS gas in the future because any such development must pay for developing the infrastructure and a new pipeline. Adverse impacts in a national context include an abrupt decrease in domestic crude production, an increased balance-of-trade deficit, and adverse impacts on domestic shipyards and employment opportunities for U.S. seafarers (Section 4.3.3.1).

Impacts on the State of Alaska are proportionately more significant, amounting to a severe and prolonged economic

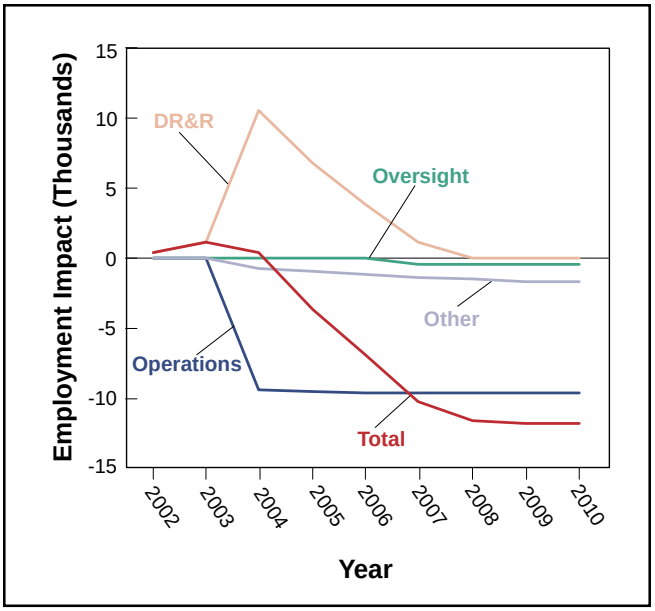


Figure 4.4-3. *Direct annual employment impact of the no-action alternative, 2002 to 2010.*

contraction. State impacts are calculated using a model developed by ISER and described in Section 4.3.3. This model integrates the economic effects of the entire production and transportation system, and thus includes direct, indirect, and cumulative effects.

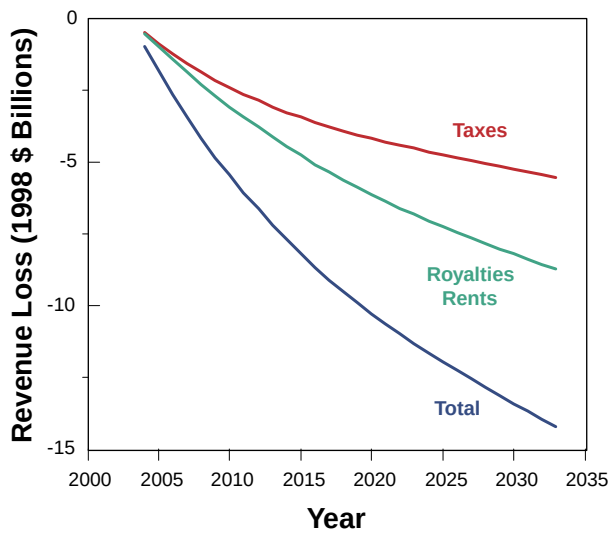
Direct Impacts to State Economy. The combined effect of terminating pipeline operations and North Slope oil production-related activities and start of DR&R is a slight initial increase in employment over the proposed action (peaking at 1,118 in 2003). Two years later, employment drops below projected employment for the proposed action by 3,623 in 2005, 6,886 in 2006, 10,250 in 2007, and 11,575 by 2008. By 2010, employment is projected to stabilize at 11,775 below the proposed action (Figure 4.4-3).

After 2010, no further increase appears in the difference between direct employment levels for the no-action alternative and the proposed action because of the uncertainty associated with projecting specific activities and levels beyond that point in time.

The intensity of the boom and bust associated with the no-action alternative depends on how long DR&R lasts and how abruptly employment associated with North Slope oil production is eliminated.

Although the direct employment loss of 11,775 is only about 3 percent of total wage and salary employment in the state in 2010 (314,000), the loss of economic activity represented by these job cuts is much more significant for several reasons. First, the wage rates in the impacted industries are the highest in the economy, and consequently the proportionate loss of wages is much greater than indicated by the number of jobs lost. High wage jobs are more likely to support a household and contribute more purchasing power to the economy, resulting in a high economic multiplier.

Second, the termination of pipeline and North Slope oil operations directly eliminates a large share of state revenues, as well as local taxes for the North Slope Borough, Fairbanks North Star Borough, the City of Valdez, and to a lesser extent, Anchorage. Based on a $16/bbl oil market price in 2004 (1998 dollars) and production declining at 4.1 percent per year through 2020 and remaining constant thereafter, the loss of revenue to the state from termination of the pipeline and North Slope operations compared to the proposed action would total $14.209 billion (1998 dollars) from 2004 to 2034 (Figure 4.4-4). This includes royalties ($8.402 billion), rents and bonuses ($310 million), severance tax ($3.394 billion), state property tax ($430 million), and corporate income tax ($1.673 billion, including corporate taxes on the pipeline paid by the owner companies). Most of this revenue goes into the state General Fund. In 2004, North Slope oil and pipeline revenues are estimated



Note: Taxes" include property tax, corporate income tax, and severance tax. "Royalties/Rents" include royalties, and rents and bonuses. "Total" includes all these elements.

Figure 4.4-4. *Cumulative lost revenues associated with the no-action alternative, 2004 to 2034.*

to account for 65 percent of state General Fund revenues. In addition, the portion of royalties paid to the Alaska Permanent Fund is eliminated.

This revenue loss is particularly significant because of the relatively larger size of the public sector in Alaska necessitated by the large area, dispersed population, and special needs of Alaska, such as a disproportionately large school-aged population. Public employment (state and local government combined) per capita is 41 percent above the national average, while state and local government spending, adjusted for the cost of living, is 87 percent above the national average (Goldsmith, 2000a). Replacing the lost public-sector purchasing power represented by this loss of tax revenue requires fiscal measures that adversely impact all sectors of the economy.

Several local governments depend on property taxes on North Slope oil production and pipeline facilities to support public services. The loss of revenues to local government from this source is $2.098 billion in 1998 dollars (Figure 4.4-5). The losses are greatest for the North Slope Borough ($1.896 billion) and much smaller (but still significant) for Valdez ($126 million), Fairbanks ($51 million), and Anchorage ($25 million).

Other tax revenues that are not directly identified with oil and gas production and transportation also will decline. Reductions will occur in general local property taxes and the state general corporate income tax as a result of the re-

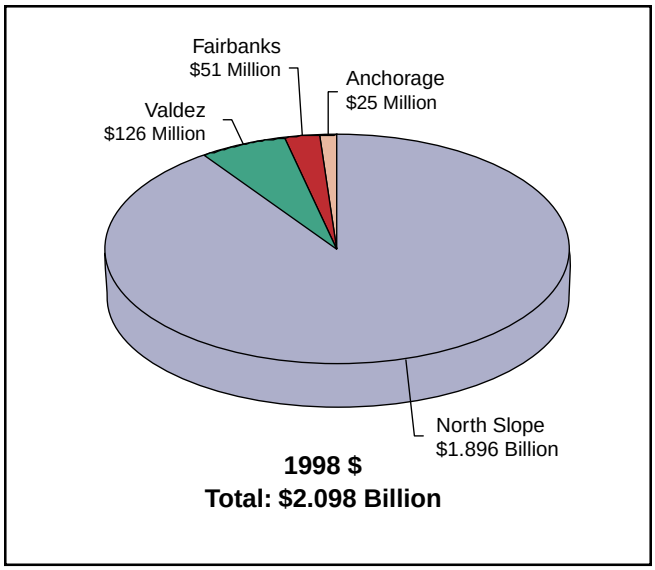


Figure 4.4-5. *Cumulative loss of property tax revenues (1998 $) for the no-action alternative, 2004 to 2033.*

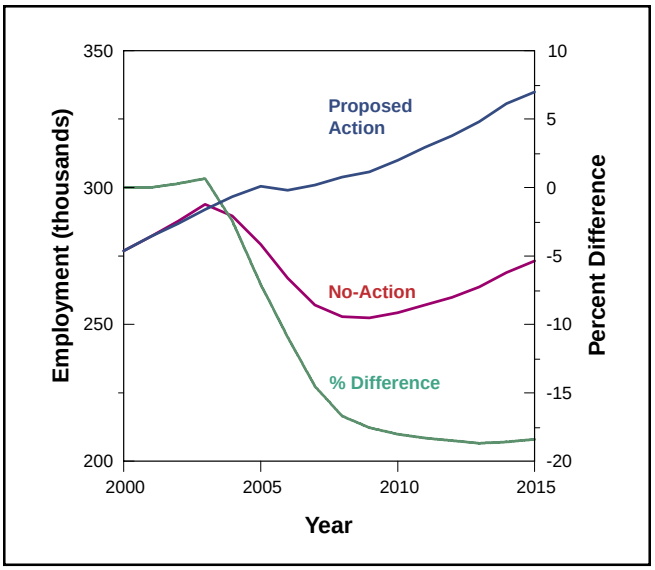


Figure 4.4-6. *Projected statewide employment (thousands) for proposed and no-action alternatives and percent difference, 2000 to 2015.*

finery closures, reduction in international air cargo activity, and the value of oil company headquarters property.

Gross State Product Changes. GSP measures the importance of different activities to the economy and includes not only wages paid to workers and taxes paid to government, but investment in new equipment and profits. Because of the level of investment in oil-related facilities and the profitability of oil, the share of GSP directly attributable to oil production, transportation, and processing is much larger than the oil industry's share of total employment. During the 1990s the share of GSP from oil varied from 46 percent to 19 percent, depending on the price of oil and production (Goldsmith, 1999a). With oil at $16/bbl (1998 dollars), GSP will directly fall by about 30 percent with the no-action alternative compared to the proposed action.

The importance of the oil industry to the Alaskan economy has been documented in a number of studies (Berman et al., 1992; Goldsmith, 1985; Huskey, 1995; Tussing, 1984; McDowell Group, 1999b, 2000). All recognize that its importance is inadequately represented by its share of total state employment. The elimination of oil industry activity puts many Alaska oil field service, environmental, engineering, transportation, construction, and wholesaling firms out of business.

Total (Direct and Indirect) Economic Impact. The direct job loss, wage and other income loss, and state and local government revenue loss will cause additional loss in jobs, income, business activity, population, and government revenues as the purchasing power associated with pipeline and North Slope oil production activity is lost to the economy. Taking into account the multiplier effect of the direct job loss and the loss in government revenues, the pattern of total job loss (wage and salary employment) compared to the proposed action is shown in Figure 4.4-6. Following a small increase in 2002 and 2003 due to DR&R, employment falls rapidly over the next five years to 56,000 (18 percent) below the proposed action by 2010. Unlike the proposed action in which employment increases from 297,000 to 310,000 between 2004 and 2010, employment in the no-action alternative falls to 253,000 in 2009. Although employment begins to rise in 2010, by 2015 it does not return to the level of jobs in 2001. The area between the proposed action and no-action curves in Figure 4.4-6 provides a measure of person-years of employment lost from 2004 to 2015.

The employment loss is shared among almost all sectors of the economy except seafood, timber, mining, and tourism. Trade, services, and finances are particularly heavily impacted — eventually about one in five jobs is lost compared to the proposed action.

The small increase in employment due to DR&R is moderated because some of these workers are not Alaska residents. Since these nonresidents do not live and spend their income in the state, the positive effect of DR&R on the economy is less than if residents worked all these jobs.

The job loss is magnified by the loss of purchasing power from the loss of high-wage jobs. The average annual civilian wage drops to 4 percent below the proposed action case (1998 dollars). Per-capita disposable personal income is further eroded by state government actions to maintain essential government services in spite of the loss of petroleum revenues. Most important is the elimination of the

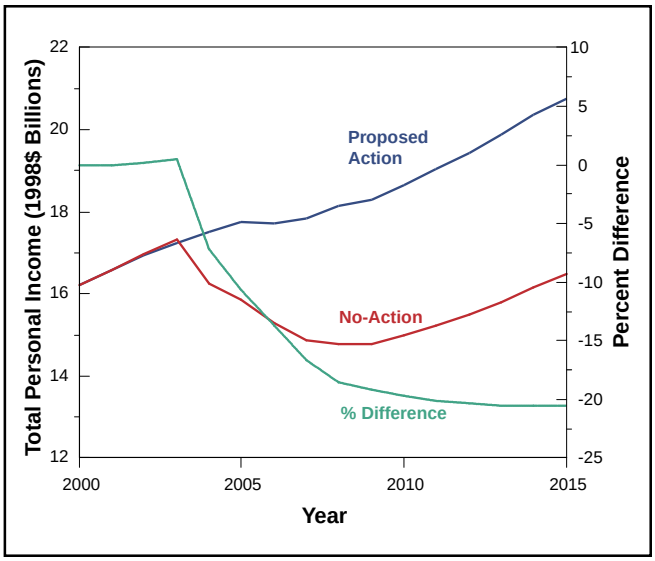


Figure 4.4-7. *Projected state total personal income for the proposed and no-action alternatives and percent difference, 2000 to 2015.*

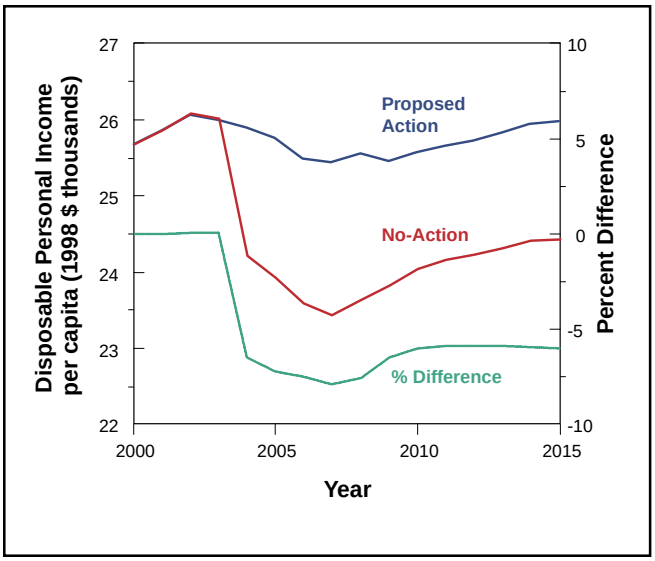


Figure 4.4-8. *Projected disposable personal income for the proposed and no-action alternatives and percent difference, 2000 to 2015.*

Permanent Fund Dividend. Although projected to gradually decline in the proposed action, in the no-action alternative it is immediately eliminated in 2004 in order to fund necessary public services. The loss of the dividend reduces the purchasing power of Alaska households throughout the state. Lower-income households are particularly adversely impacted, while the job loss is concentrated in the urban areas where most of the retail trade and service jobs are located. Total personal income falls below the proposed action by $1.258 billion in 2004 (1998 dollars) and by $3.680 billion (20 percent) in 2010 (Figure 4.4-7).

Disposable income per capita[3] is lower by 6.5 percent in 2004 and 6 percent in 2010 in the no-action alternative (Figure 4.4-8). This is due to the lower average annual wage rate, the early phase-out of the Permanent Fund Dividend, and the loss of nonwage income from the outmigration of higher-income households from the state. Estimates presented in Figure 4.4-8 are annual. Cumulative losses in disposable personal income are represented by the area between the proposed action and no-action curves in Figure 4.4-8.

Non-oil GSP, which is the best measure of the aggregate demand produced by the regional economy, falls below that associated with the proposed action by 16 percent in 2010 (Figure 4.4-9). This decline represents a reduction in the size of the market and with less competition and a loss of business leading to increased bankruptcies.

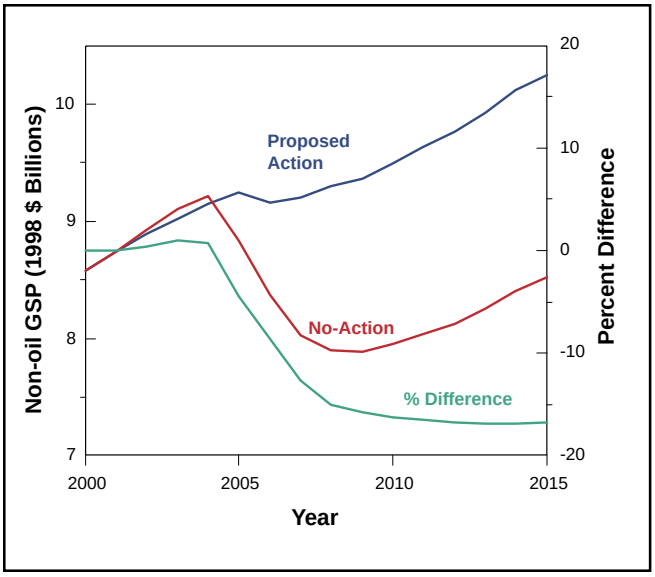


Figure 4.4-9. *Projected non-oil gross state product (GSP) for the proposed and no-action alternatives and percent difference, 2000 to 2015.*

The unemployment rate peaks at nearly 11 percent in 2006 and 2007 compared to 8 percent in the proposed action. This is due to two factors. First, the boom associated with DR&R of the pipeline and North Slope oil facilities draws more workers to Alaska from other states than are required to fill the available jobs. Subsequently, the drop in jobs outstrips the rate at which workers can adjust. Over several years, potential workers drop out of the job market or move to other states. Eventually, in 2014, the unemployment rate reverts to its level in the proposed action.

[3] Disposable income — the amount of current income households or individuals have to spend and/or save — is calculated as personal income minus personal income taxes. Disposable income/capita is disposable income divided by population; it represents the personal income available each person has to spend and/or save.

Net migration is the primary method by which the labor market clears in Alaska. The annual movement of people into and out of the state is large compared to the total population, and when fewer jobs are available in the state, the inflow slows at the same time that the outflow increases. Net in-migration increases slightly during the first stage of DR&R in the no-action alternative but turns negative in 2004. Net outmigration peaks at 20,000 in 2006, and population outmigration continues through 2010.

By 2010, net outmigration causes the population to fall to a level 15 percent below the proposed action. The loss is concentrated in the non-Alaska-Native population. A similar decline occurs in the number of households. The population falls absolutely from a level of 671,000 in 2004 to 621,000 in 2009 and regains the previous peak only in 2015 (Figure 4.4-10).

The decline in population and the number of households results in under-utilization of private and public fixed assets. In the private sector this is most evident in excess vacancy rates in the housing stock and in commercial real estate. Based on experience from four previous slumps in the Alaskan economy, the excess inventory of empty residential units and commercial buildings has four impacts (Goldsmith et al., 1988; ADOL, 1988a):

- The price of real estate falls below replacement cost, and so there is no new construction and the quality of the stock does not improve as it would with normal replacement.
- The fall in the price of the stock puts many property owners "under water" — i.e., the market price of their property is below the outstanding mortgage on the property. This creates an incentive to walk away from the mortgage and default on the loan. Defaults in turn put pressure on the banks.
- The large inventory of vacant real estate invites vandalism and adversely affects the perception, if not the reality, of the quality of life in the community.
- Property tax values and revenues decline.

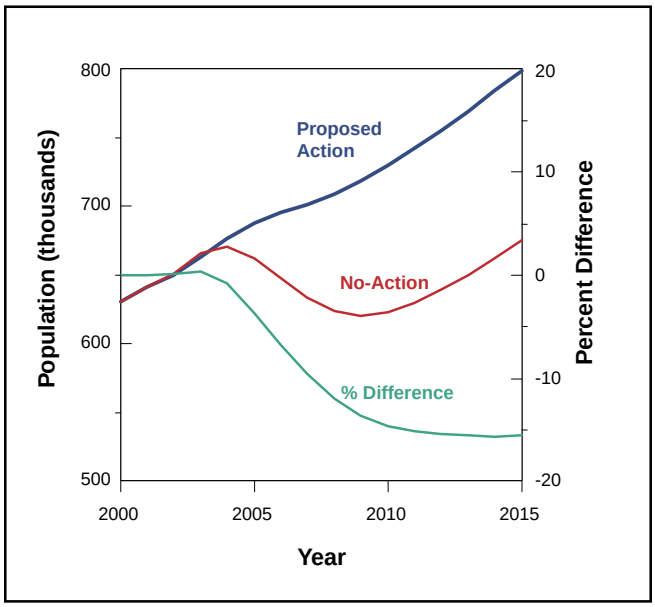


Figure 4.4-10. *Projected state population for the proposed and no-action alternatives and percent difference, 2000 to 2015.*

The population decline will have adverse impacts on other sectors of the economy, such as the utility and health care industries, that have high fixed costs. The unit cost of providing services in these sectors increases because the fixed costs are spread over a smaller number of customers. The same is true in the public sector, where operating and maintenance costs of the fixed stock of capital — schools, roads, office buildings — are shared by a smaller population than had been anticipated at the time it was built.

At the same time, the population decline relieves pressure on fixed assets and resources where congestion detracts from the quality of life. For example, the number of cars on the road decreases, and pressure from sport hunting and fishing demand decreases. Although these are arguably positive impacts, recession and outmigration are not appropriate means to reduce congestion.

The loss of pipeline and North Slope oil revenues sharply reduces the revenues realized by the state and the main communities along the pipeline. Other revenues also decline as the economy and population contract. The state can partially offset the loss in revenue by diverting Permanent Fund earnings from the dividend to the state budget, but the amount available from this source is less than the lost pipeline and oil-related revenues.

Figure 4.4-11 shows the impact of the no-action alternative on the amount and composition of state revenue by year from 2000 to 2015. Some care is necessary in interpreting this graph, which shows the differences in annual revenues for the no-action alternative relative to the proposed action, not absolute levels of revenues for either alternative. For example, oil revenues apparently plummet in 2004 because they go to zero in the no-action alternative when the ROW is terminated, whereas they are large and positive in the proposed action. Therefore, the difference in revenues is negative. In later years, the difference between the alternatives gradually decreases as throughput declines in the proposed action. The difference in Permanent Fund earnings between the two alternatives first increases — not because fund earnings would be higher in the no-action alternative but because the Permanent Fund Dividend is assumed to be eliminated and the funds are retained by the state. Figure 4.4-11 also shows the annual total from these

sources of revenues. This total is negative for each year, indicating that the no-action alternative provides less income to the state even after the Permanent Fund Dividend is eliminated. On a cumulative basis (i.e., summing the annual totals), the state is worse off by approximately $4.1 billion (1998 dollars) at the end of 2015.

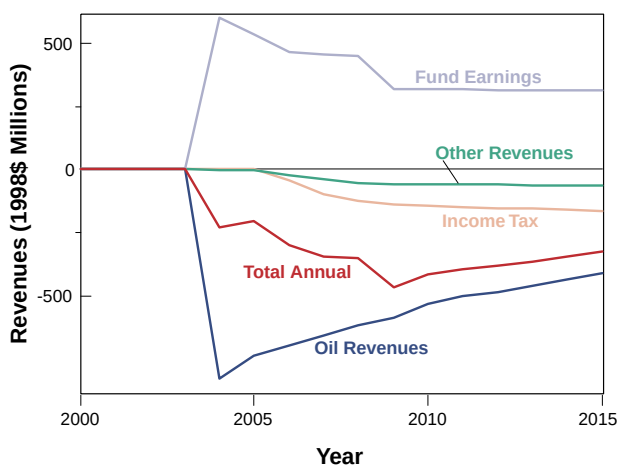
State expenditures per capita are constrained by available revenues and also fall 5 percent below the proposed action. Although terminating pipeline operation and North Slope oil activity reduces staffing needs in the state agencies overseeing those activities, several factors contribute to an increase in the average cost of public-service delivery:

- Outmigration is concentrated among urban workers, leaving a larger share of the population in rural Alaska, where both per-capita public service requirements and the costs of service delivery are higher.
- The dislocations associated with an increased incidence of job and income loss as well as bankruptcies place additional demands on the health and social service agencies.
- The fixed costs of government, such as the maintenance of schools and roads, are shared among a smaller population.

The balance in the Permanent Fund will be lower in the no-action alternative by a smaller percentage due to the termination of new deposits from North Slope oil revenues in 2004 — even though royalties from Cook Inlet oil and gas production continue to be deposited in the fund. The Alaska Constitution allows only the earnings of the fund to be used, and fund earnings are slightly less in the no-action alternative.

As with state government, local government's ability to pay is reduced in the no-action alternative by the loss of property taxes associated with oil production and transportation. Other revenues also decline as the size of the economy and population contract. Figure 4.4-12 shows that the decline in state government's ability to support local governments through transfers is the most important revenue loss to local governments. The decline in nonpetroleum property taxes, other types of taxes, and charges compound the loss. In total, revenues in 2010 fall 24 percent below the proposed action and exceed the percent drop in population, so that the ability of local government to pay for public services is also reduced. Cumulatively, from 2000 to 2015, local revenues are lower by over $6.5 billion (1998 dollars) in the no-action alternative — a very substantial adverse impact.

For a short period there is some upward pressure on the price level due to the demand for labor and equipment associated with DR&R. This quickly is more than offset by a drop in housing prices resulting from the high vacancy rates when population declines. Only after the excess housing stock has been reabsorbed does the price of housing return to the level reflecting its replacement cost. Two other factors will tend to elevate the price level. First is the fixed cost burden shared among a smaller population. Second is the



Note: Graph shows the differences in annual revenues for the no-action alternative relative to the proposed action, not absolute levels of revenues for either alternative.

Figure 4.4-11. *No-action alternative impact on composition of state revenues, 2000 to 2015.*

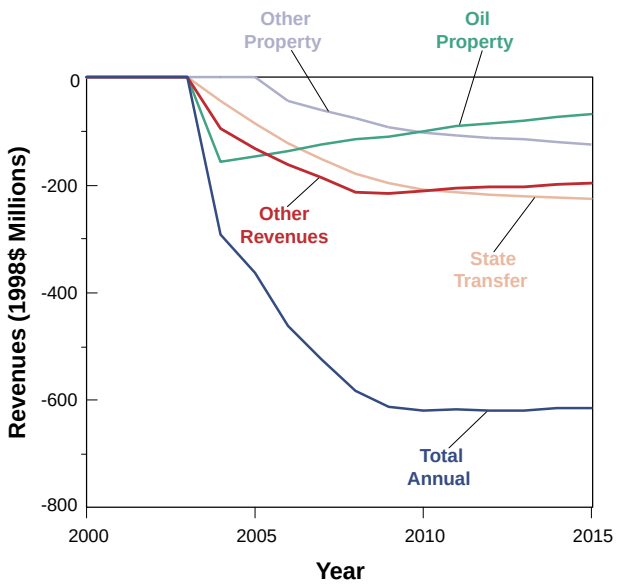


Figure 4.4-12. *No-action alternative impact on composition of local revenues, 2000 to 2015.*

loss of some economies of scale and competitive pressure on prices which are the result of the smaller economy.

Figure 4.4-13 shows the per-capita change from the no-action alternative for several variables. Both private and public income decline.

As indicated by prior Alaska recessions, the long decline in employment and subsequent slow recovery in the no-action alternative undermine consumer and investor confidence in the future of the economy (Foster et al., 1988). This results in reduced consumer spending, less new business activity, and the likelihood of additional outmigration, particularly of those individuals able to take advantage of economic opportunities elsewhere.

The recession that occurred in Alaska from 1986 to 1988 and the earlier slowdown between 1977 and 1979 after construction of the pipeline provide some indication of what economic conditions would be like in Alaska in the no-action alternative. Both of these economic downturns were much less severe than would be the downturn from removing the oil pipeline and North Slope oil activity. The more recent downturn did not involve elimination of a basic industry in the economy, and the earlier one was cushioned by positive expectations and growth from pent-up demand factors. In contrast, the no-action alternative downturn is the result of eliminating an important basic industry in the state, combined with a long period of extremely low consumer and business confidence. Figure 4.4-14 contrasts the projected drop in state employment and the time required to regain the former job level in the no-action alternative with the actual drop and recovery time for the recessions of the 1980s and 1970s. The recession from the no-action alternative is both much deeper and much longer.

The recession of 1986 to 1988 was the result of runaway government spending quickly brought down to earth by a drop in the price of oil in early 1986, combined with a private-sector expectation that the boom had no end. The loss of jobs and income was concentrated in the urban centers and the construction, trade, and finance industries. When the excess capacity in these industries had been shaken out, the economy began to recover because the strength of the basic sectors of the economy was not adversely impacted. By 1989, the economy had bottomed out and was starting its recovery, although not all sectors recovered at the same rate (Goldsmith, 1991).

Anchorage, as the trade and service center of the state, was the hardest hit. Seasonally adjusted wage and salary employment in Anchorage fell 11 percent between July 1985 and March 1988, leading to outmigration of more than 21,000 in 1986. This, in turn, resulted in a vacancy rate for apartments of 25 percent in 1986. The excess capacity resulted in a drop in the number of new housing units authorized from a peak of 9,082 in 1983 to 183 in 1987. New housing only hit the 1980 level of 1,071 again in 1993. No multifamily units were built for three years. Sales and prices of housing fell, contributing to a jump in the number of bankruptcies from 228 in 1983 to 1,094 in 1987. State-

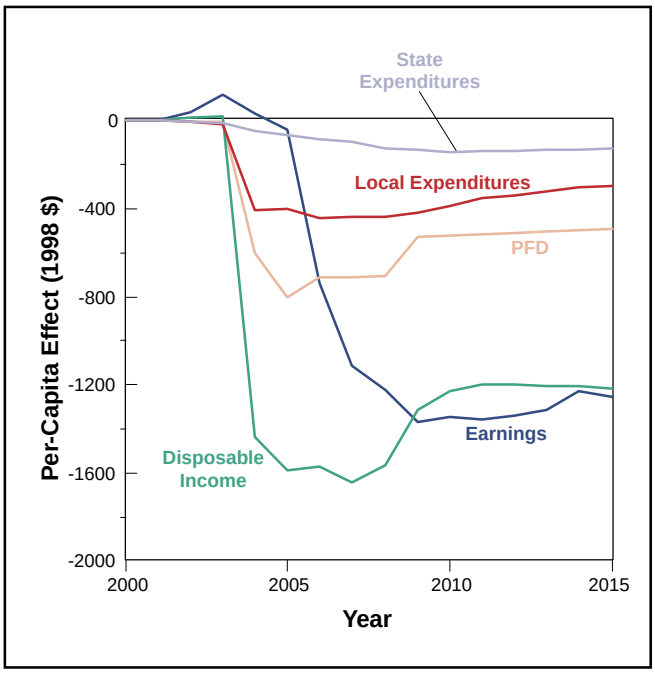


Figure 4.4-13. *Per-capita impact of the no-action alternative, 2000 to 2015.*

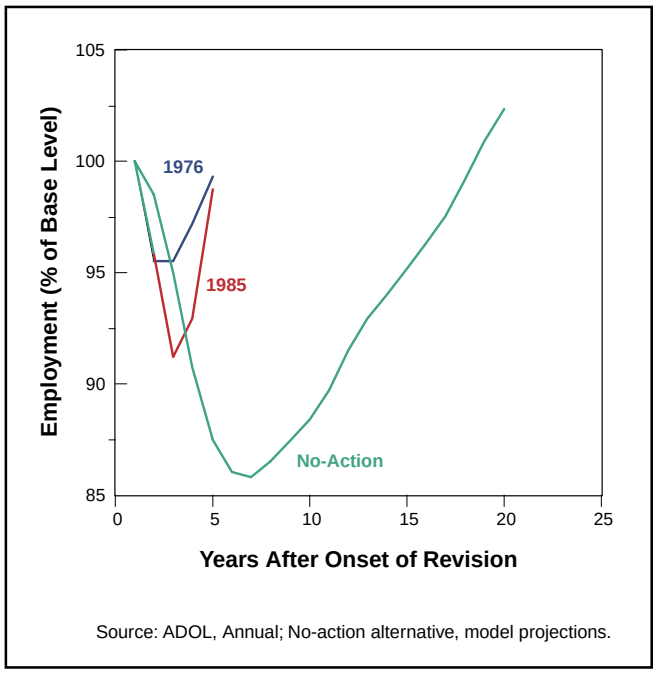


Figure 4.4-14. *Employment projections for the no-action alternative compared with the recessions of 1976 and 1985.*

wide, the number of banks and credit unions fell from 17 in 1983 to eight in 1989. School enrollments in Anchorage fell by 2,106 between 1984 and 1988. The assessed value of property in Anchorage fell from $15.011 billion in 1986 to $8.324 billion in 1989 (Municipality of Anchorage, 1997).

The economic slowdown after construction of the pipeline was less than anticipated for several reasons (Section 3.3.1) (ADCED, 1978):

- A large percentage of pipeline construction workers were not Alaska residents. The impact of these transients on the economy during the construction of the pipeline was modest.
- Construction of a gas pipeline from the North Slope was expected to begin within a year or two of completion of the oil pipeline. This moderated the outmigration of construction workers who had moved to the state during the oil-pipeline construction years. It also created an environment of consumer and business confidence conducive to spending and investment.
- A large amount of household and business income earned during pipeline construction was available, and spending of this income augmented the normal consumer spending and investment.
- Oil revenues collected after the pipeline began operation were used to expand state and local government expenditures.

None of these factors would apply if the no-action alternative were implemented.

Removal of the pipeline and the oil-related facilities on the North Slope will reduce the options for subsequent economic development employing the oil and gas resources there. The impacts of the no-action alternative are measured against a relatively conservative projection of oil and gas activity on the North Slope in the proposed alternative. The level of oil and gas activity on the North Slope would likely exceed this level if the pipeline remained operational and the facilities on the North Slope were not removed. Removal of the pipeline and ANS production infrastructure would essentially preclude a gas commercialization project in the foreseeable future. Likewise, oil exploration and development activities would cease.

Removal of the pipeline and cessation of oil-related activity on the North Slope narrow the economic base of the state. Without a viable petroleum industry (except for the small activity in Cook Inlet) and the activities dependent on it, the economic base of the state will consist of federal government spending (including military spending), non-oil resource industries (seafood, timber, and mining), and tourism. This reduces the stability of the economy and increases its seasonality.

The resource industries are particularly vulnerable to commodity cycles that influence prices and demand. The instability this creates in employment and income in these industries is compounded by the great distance of Alaska from market centers. The result is a “last-in and first-out” phenomenon whereby Alaska resource production, employment, and income levels tend to be more sensitive than those of competitors located closer to market centers. Although this is also true for petroleum, the Alaska economy is somewhat insulated from petroleum commodity cycles because of the size of the companies involved in production in Alaska. As a consequence, employment and income levels in the oil industry are more insulated from swings in market price and demand than in industries where the companies are smaller and less able to ride out market swings.

Seafood and tourism are highly seasonal industries, and mining and timber also have some seasonality; direct and indirect employment associated with all these industries is higher in the summer than the winter. In contrast, pipeline and oil activity has little seasonality, and some exploration and development activity increases in the winter months. Consequently, the elimination of pipeline and oil employment increases the seasonality of the overall economy. This in turn impacts the utilization rate for fixed assets, the mix of jobs between residents and nonresidents (nonresidents account for a greater fraction of the workforce in highly seasonal industries), and the stability of the economy. The larger the share of workers that live outside the state and the greater the seasonality of employment, the smaller will be the overall economic activity in the region. This is because support businesses in trade, services, and infrastructure will not be able to depend on a steady flow of business throughout the year.

It must be recognized that the pattern and timing of the economic impacts of the no-action alternative are impossible to project with certainty for several reasons:

- Assumptions about the timing of events may be incorrect. Most importantly, DR&R activities and rampdown of employment on the North Slope could be compressed into a shorter time or extended over more years. This would tend to exacerbate or ameliorate the economic expansion and a subsequent downturn associated with DR&R and termination of pipeline and North Slope operations.
- It is impossible to anticipate the events that would precede selection of the no-action alternative. These events could influence how and when businesses and households respond to the downturn in economic activity.

- Measures taken by state and local governments to make up for the loss in revenues from pipeline and petroleum operations and other sources will determine where and when the impact occurs. In particular, if the state chose to liquidate the Permanent Fund, which is currently protected by the state constitution, the near-term economic impact of the no-action alternative would be reduced, but in the longer term the impact would be increased since the earnings of the fund are an important source of purchasing power in the economy.

Regional Effects of the No-Action Alternative

This section details the economic impacts of the no-action alternative on various regions of the state. These impacts were estimated using the econometric models described in Section 4.3.3. The reader uninterested in the detail in this section may wish to skim the text and examine the various graphs. The following overview may prove helpful.

Implementing the no-action alternative will produce both direct and indirect impacts. In the very short run, while DR&R activities are underway, some of the impacts are slightly positive. However, the longer-term impacts are adverse without exception. Direct impacts include a significant loss in employment, per-capita income, and revenues to state and local governments. In turn, these direct impacts produce ripple effects, affecting government policies and other economic activity throughout the state. The total impacts are much greater than the direct effects alone. This section provides quantitative estimates of direct and indirect effects of the no-action alternative on employment (total and resident), per-capita income, and population by community/region in the state. By any reasonable benchmark, these effects are significant and adverse for the state as a whole and for various communities/regions. The no-action alternative would create a recession both deeper and longer lasting than has been experienced in the state.

Though impacts on all areas are significant, there are material differences in these impacts among the various regions. The rank ordering of these effects depends on the particular measure (e.g., employment, per-capita income, population) used. However, the North Slope, Valdez-Cordova, and Fairbanks would be particularly hard hit if the ROW were not renewed.

North Slope Borough. Because pipeline employment is centered in the communities of Fairbanks, Valdez, and Anchorage and workers at Pump Stations 1 through 4 commute from communities throughout the state, employment and income in the North Slope Borough are only marginally directly impacted by cessation of pipeline operations. Workers involved with removing pipeline facilities located in the borough and engaged in transporting scrap out of the state by barge from the North Slope will be based at remote camp sites and will not directly impact the economies of the local communities.

More serious employment reductions for the North Slope and other communities result from the closure of ANS fields, although these losses would be offset in the short term by DR&R activities. Projected direct employment losses for the North Slope total 4,207 jobs by 2010 (Figure 4.4-15).

The DR&R of North Slope oil and gas facilities results in the direct loss of $1.896 billion (1998 dollars) in property tax revenues (Figure 4.4-5). Since the borough is heavily dependent on this revenue to support local government expenditures, without an alternative source of local revenue, this loss results in a reduction in local government employment below the proposed action.

The loss of state pipeline and oil revenues results in a reduction in state-to-local-government transfers in support of education and other locally delivered public programs. This further reduces local government employment compared to the proposed action. State employment in the borough also falls because of reduced state revenues. The loss of state revenues also leads to elimination of the Permanent Fund Dividend and thus reduces per-capita income and local purchasing power.

By 2015, the multiplier effect of the loss of oil-related and local government-related jobs results in a total employment loss compared to the proposed action in the borough

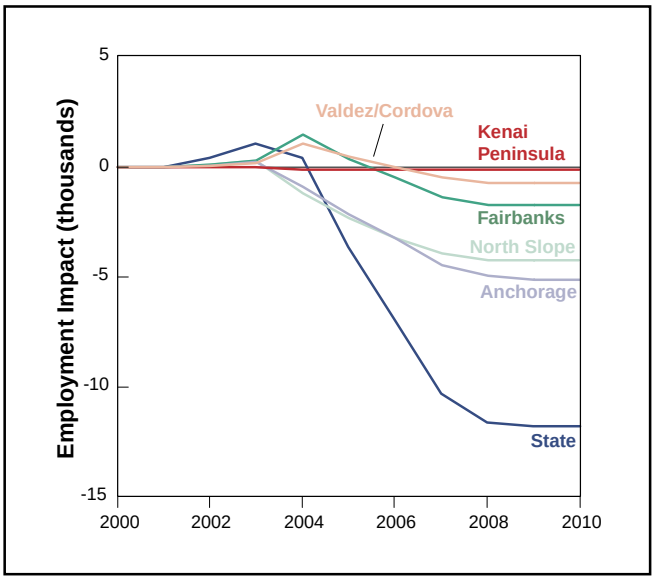
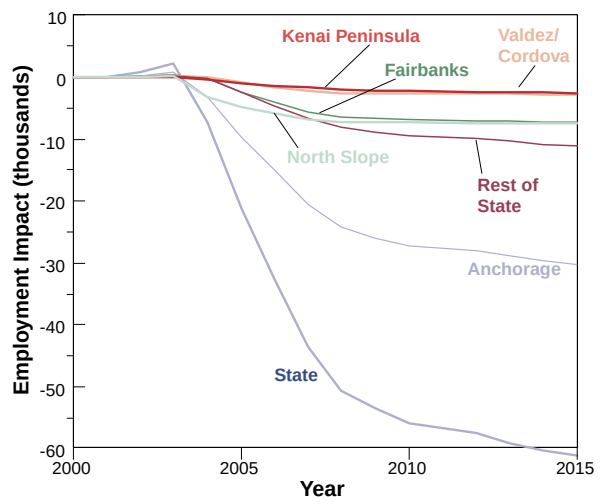


Figure 4.4-15. *Direct employment impacts of the no-action alternative, 2000 to 2010.*

of 7,500 jobs (Figure 4.4-16), or 82 percent of the total (Figure 4.4-17).

After adjusting for the presence of nonresident workers in the borough, North Slope resident employment, mostly in government, trade, and services, will fall by 3,300 in 2015, a 76.1 percent decrease (Figure 4.4-18). Because of the loss of a high percentage of higher-paying jobs in the community and the loss of the Permanent Fund Dividend, real per-capita income falls substantially (Figure 4.4-19). Figure 4.4-20 shows declines in per-capita income by 2015 for the North Slope and other areas. In percentage terms, these impacts are greatest for the North Slope. With the reduction in employment, there is some outmigration and a drop in population. The amount is difficult to project be-



Note: Because the estimated direct and indirect employment losses are nearly identical for Fairbanks and the North Slope, these curves are almost superimposed.

Figure 4.4-16. *Impact of no-action alternative on total wage and salary employment by region, 2000 to 2010.*

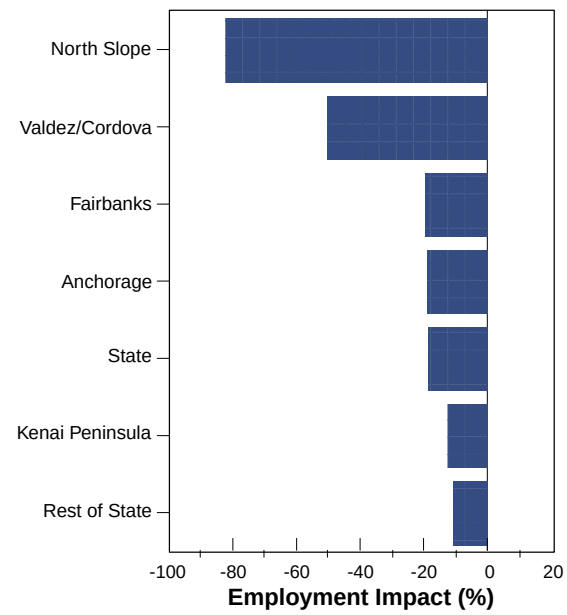


Figure 4.4-17. *Impact of no-action alternative on total wage and salary employment by region in 2015.*

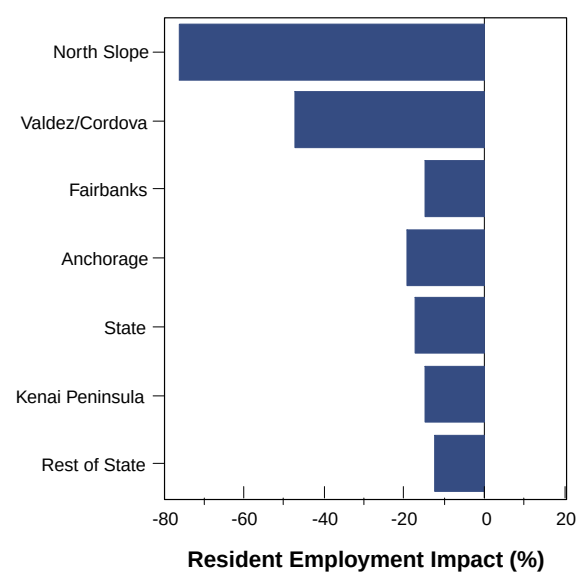


Figure 4.4-18. *Impact of no-action alternative on resident employment by region in 2015.*

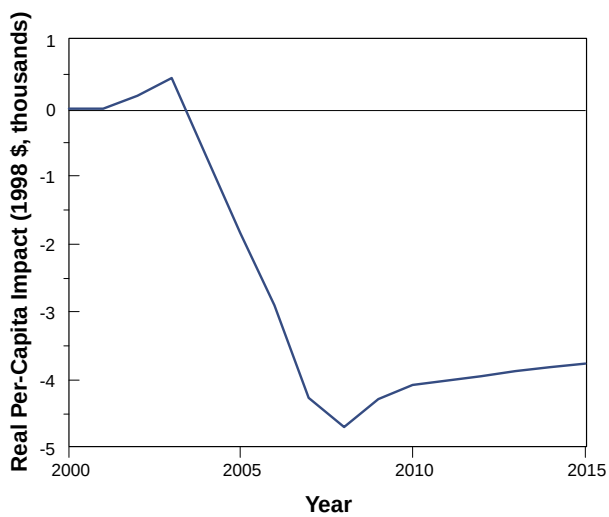


Figure 4.4-19. *Impact of no-action alternative on real per-capita income for North Slope, 2000 to 2015.*

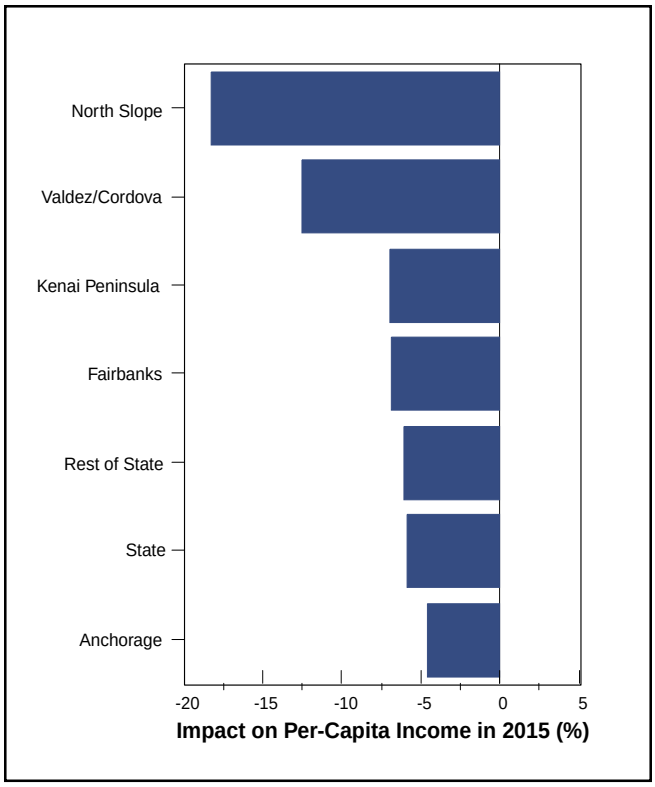


Figure 4.4-20. *Impact of no-action alternative on real per-capita income in 2015 by region.*

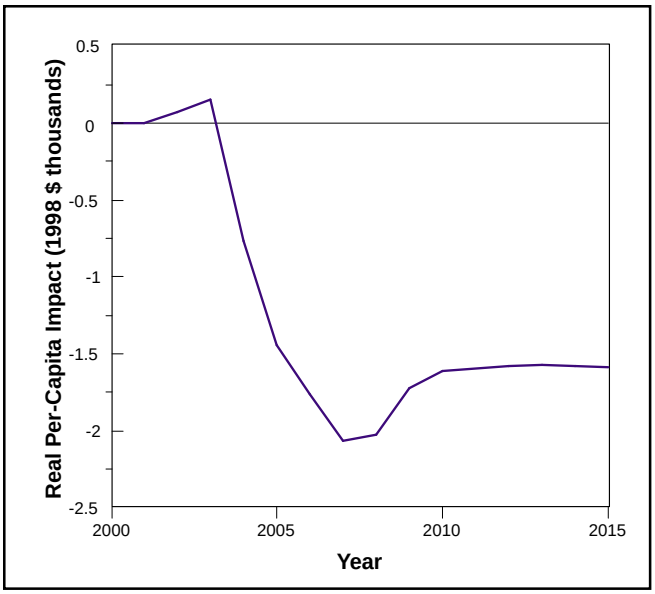


Figure 4.4-21. *Impact of no-action alternative on real per-capita income for Fairbanks, 2000 to 2015.*

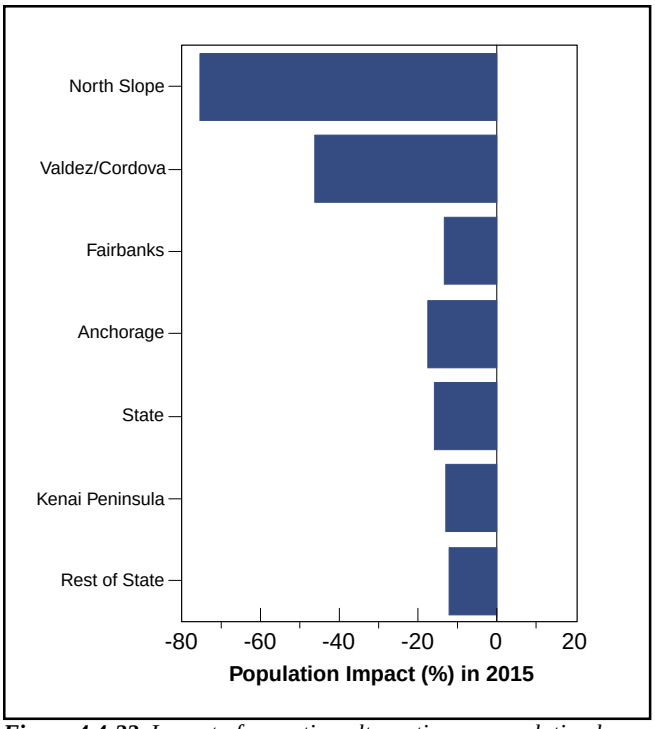


Figure 4.4-22. *Impact of no-action alternative on population by region/community in 2015.*

cause there is no basis for estimating the movement of Alaska Natives in the absence of employment opportunities in their home communities (Figure 4.4-22).

The direct loss of the oil property-tax revenues, combined with the losses in revenues from the contraction of the economy, make it very difficult for the borough to provide public services or to service its outstanding general-fund bonded debt.

Yukon-Koyukuk Census Area. Because pipeline employment is centered in the communities of Fairbanks, Valdez, and Anchorage and workers at Pump Stations 5 through 7 commute from communities throughout the state, employment and income in the Yukon-Koyukuk Census Area are only modestly directly impacted by cessation of pipeline operations. Workers involved with removing pipeline facilities located in the census area and with transporting scrap from DR&R out of the state will be based at remote camp sites and will not directly impact the economies of the local communities in the census area. However, wage employment is scarce in the census area, and the loss of even a small number of pipeline-related jobs by residents of the region would affect the economies of the small communities in the region. This census area is included in the "rest of state" category in Figures 4.4-15, 4.4-16, 4.4-17, 4.4-4.4-18, 4.4-20 and 4.4-22.

Fairbanks North Star Borough (Figures 4.4-15, 4.4-16, 4.4-17, 4.4-18, 4.4-20, and 4.4-22). Pipeline employment is centered in Fairbanks, Pump Station 8 is within the borough, and many workers stationed at the other pump stations reside in the borough. A large share of pipeline DR&R will be coordinated from Fairbanks, and many workers involved in DR&R will be Fairbanks residents or

will temporarily reside there during DR&R. Fairbanks will lose some state and federal workers associated with regulating and overseeing the pipeline.

Fairbanks is a regional headquarters for North Slope oilfield service companies, as well as wholesalers and transport companies dependent on North Slope activity. A portion of the employees of the oil companies, oil service companies, construction firms, and other companies operating on the North Slope reside in Fairbanks. Terminating oil and gas activity on the North Slope impacts all these companies. Fairbanks is also the location of two refineries that cease operation when North Slope crude is no longer available. Furthermore, Fairbanks loses some state and federal workers associated with regulating and overseeing pipeline and North Slope oil activities. The combined direct employment impact of ceasing pipeline and North Slope oil activity is 1,695 jobs by 2010.

DR&R of oil pipeline facilities results in the direct loss of a small share of the revenues of the borough (Figure 4.4-5). Shutdown of the refineries further erodes the property tax base. This leads to some job loss as the borough employs some combination of budget reductions and utilization of new revenues to balance its revenues and expenditures.

The loss of state pipeline and oil revenues results in a reduction in state-to-local-government transfers in support of education and other locally delivered public programs, and this causes a further reduction in local government employment. State employment in the borough also falls because of reduced state revenues. The loss of state revenues also leads to elimination of the Permanent Fund Dividend which reduces per-capita income and local purchasing power.

By 2015, the multiplier effect of the loss of oil-related and local-government-related jobs and income results in a total employment loss in the borough compared to the proposed action of 7,300 jobs, or 20 percent. Fairbanks resident employment falls by 6,100 jobs, or 14 percent, by 2015. Real per-capita income falls $1,586 in 1998 dollars (Figure 4.4-21), or 7 percent, by 2015 because of the loss of a high percent of the higher-paying jobs in the community.

With the reduction in employment, there is some outmigration, and population falls. It does not return to the 2001 level until 2015. Population drops to 13 percent below the proposed action by 2015 (Figure 4.4-22).

The loss of revenues puts pressure on the ability of the borough to service its outstanding general-fund bonded debt.

Southeast Fairbanks Census Area. Because pipeline employment is centered in Fairbanks, Valdez, and Anchorage and some workers at Pump Stations 9 and 10 commute from communities throughout the state, employment and income in the census area are only marginally directly impacted by cessation of pipeline operations. Workers involved with removing pipeline facilities located in the census area and engaged in transporting scrap from pipeline DR&R out of the state will be based at remote camp sites and will not directly impact the economies of the local communities. However, wage employment is scarce in the census area, and the loss of even a small number of pipeline-related jobs by residents of the region would affect the economies of the small communities in the region.

Valdez-Cordova Census Area (Figures 4.4-15, 4.4-16, 4.4-17, 4.4-18, 4.4-20, and 4.4-22). The pipeline terminal is located in Valdez (the largest community in the census area), and Pump Stations 11 and 12 are in the census area. VMT activities also occur in the census area. A large share of DR&R (dismantling the VMT and removing material from the southern portion of the pipeline) will be conducted in Valdez. Although many of the workers involved in DR&R will be residents of the census area, the labor market is not large enough to supply all the demand for labor anticipated during DR&R.

Valdez employment is directly impacted by termination of North Slope oil activity because of the termination of VMT, SERVS, pipeline, and refinery operations. The combined direct employment impact of the cessation of pipeline and North Slope oil activity is 662 by 2010.

The DR&R of oil pipeline facilities results in the direct loss of a share of the revenues of the city (Figure 4.4-5). Shutdown of the refinery further erodes the property tax base. This leads to some job loss as the city employs some combination of budget reductions and utilization of new revenues to balance its revenues and expenditures.

The loss of state pipeline and oil revenues results in a reduction in state-to-local-government transfers in support of education and other locally delivered public programs, and this causes a further reduction in local government employment. State employment also falls because of reduced state revenues. The loss of state revenues also leads to elimination of the Permanent Fund Dividend which reduces per-capita income and local purchasing power.

By 2015, the multiplier effect of the loss of oil-related and local-government-related jobs results in an employment loss by place of work in the census area compared to the proposed action, centered in the city of Valdez, of 2,800 jobs, or 50 percent. Employment by place of residence falls by 2,800, or 47 percent, by 2015. Real per-capita income falls $3,234 in 1998 dollars (Figure 4.4-23), or 13 percent,

by 2015 because of the loss of a high percentage of the higher-paying jobs in the community. With the reduction in employment, there is outmigration, and population falls from 11,100 to 6,300 and will not have returned to the 2001 level by 2015. Population drops to 46 percent below the proposed action by 2015.

The loss of revenues puts pressure on the ability of Valdez to service its outstanding general-fund bonded debt.

Anchorage (Figures 4.4-15, 4.4-16, 4.4-17, 4.4-18, 4.4-20, and 4.4-22). A portion of pipeline employment is centered in Anchorage, and some workers stationed at the pump stations reside in Anchorage. Portions of pipeline DR&R will be coordinated from Anchorage, and many workers involved in DR&R will be Anchorage residents or temporarily reside there during the DR&R effort.

Anchorage is the regional headquarters for the oil companies operating on the North Slope, as well as for oil-field service companies, construction companies, wholesalers, transport companies, and other businesses dependent on North Slope activity. Many of the employees of these firms are Anchorage residents. The termination of oil activity on the North Slope impacts all these businesses. Employment at Anchorage International Airport falls as the international air cargo industry contracts from lack of locally produced and competitively priced jet fuel. Construction employment associated with fabrication of modules for North Slope operations is eliminated. Anchorage loses some state and federal workers associated with regulating and overseeing the pipeline and North Slope oil activities. The combined direct employment impact of ceasing pipeline and North Slope oil activity would be 5,110 by 2010.

The loss of state pipeline and oil revenues results in a reduction in state-to-local-government transfers in support of education and other locally delivered public programs, and this causes a reduction in local government employment. State employment in Anchorage also falls because of reduced state revenues. The loss of state revenues also leads to elimination of the Permanent Fund Dividend which reduces per-capita income and local purchasing power.

By 2015, the multiplier effect of the loss of oil-related and local-government-related jobs and income results in a total employment loss in Anchorage compared to the proposed action of 30,200 jobs, or 19 percent. The Anchorage economy bears a disproportionate share of the multiplier effect of the no-action alternative because it is the regional center for trade, service, and government activity. The loss of purchasing power in virtually any part of Alaska has an impact on the Anchorage economy. Anchorage resident employment falls by 33,800, or 19 percent, by 2015. Real per-capita income falls $1,406 in 1998 dollars (Figure 4.4-24), or 5 percent, by 2015 because of the loss of a high percentage of the higher-paying jobs in the community. The reduction in employment leads to outmigration, and population declines absolutely from 282,000 to 254,000. The 2001 population level is not regained until 2014. Population falls to 17 percent below the proposed action population by 2015.

Kenai Peninsula Borough (Figures 4.4-15, 4.4-16, 4.4-

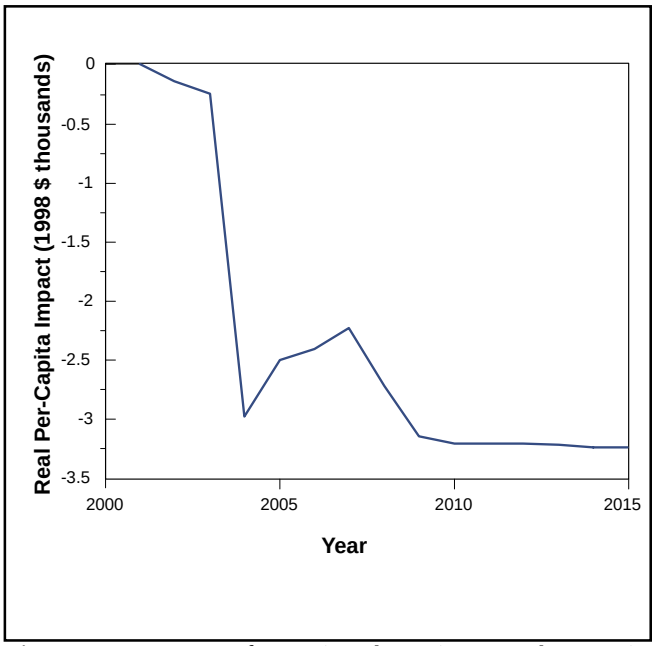


Figure 4.4-23. *Impact of no-action alternative on real per-capita income for Valdez/Cordova, 2000 to 2015.*

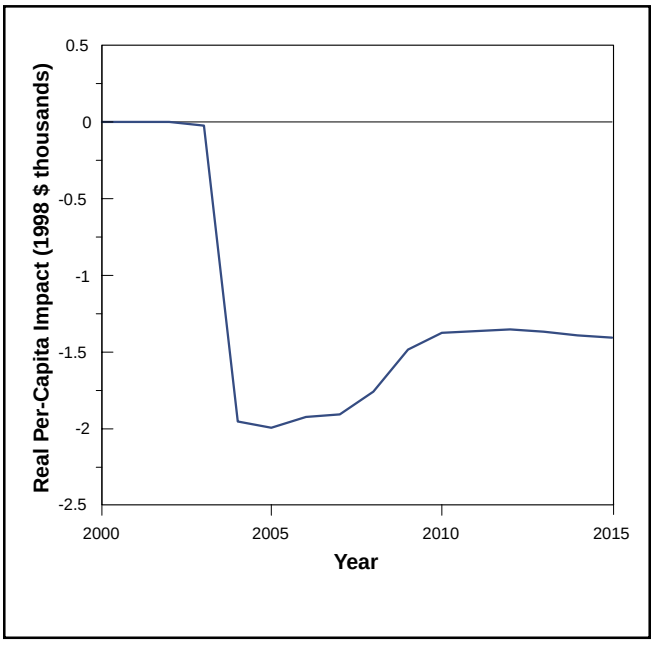


Figure 4.4-24. *Impact of no-action alternative on real per-capita income for Anchorage, 2000 to 2015.*

17, 4.4-18, 4.4-20, and 4.4-22). Employment around the City of Kenai is directly impacted by termination of North Slope oil activity since some construction of modules for North Slope oil facilities occurs at Nikiski near Kenai.

Some North Slope oil workers live in communities on the Kenai Peninsula. The loss of state pipeline and oil revenues results in reduced state-to-local-government transfers in support of education and other locally delivered public programs, and this causes a further reduction in local government employment. State employment in the borough also falls because of reduced state revenues. The loss of state revenues also leads to elimination of the Permanent Fund Dividend which reduces per-capita income and local purchasing power.

By 2015, the multiplier effect of the loss of oil-related jobs and other sources of purchasing power result in a total employment loss compared to the proposed action in the borough (centered in the City of Kenai) of 2,600 jobs, or 12 percent. Kenai resident employment falls by 3,400 jobs, or 15 percent, by 2015. Real per-capita income falls $1,686 in 1998 dollars (Figure 4.4-25), or 7 percent, by 2015 because of the loss of a percentage of the higher-paying jobs in the community. The reduction in employment leads to outmigration, and the population declines absolutely. The 2001 population is regained in 2009. Compared to the proposed action, the population falls 13 percent by 2015.

Rest of the State (Figures 4.4-15, 4.4-16, 4.4-17, 4.4-18, 4.4-20, and 4.4-22). Economic impact on the rest of the state results from several factors:

- Some oil and pipeline employees live in the rest of the state.

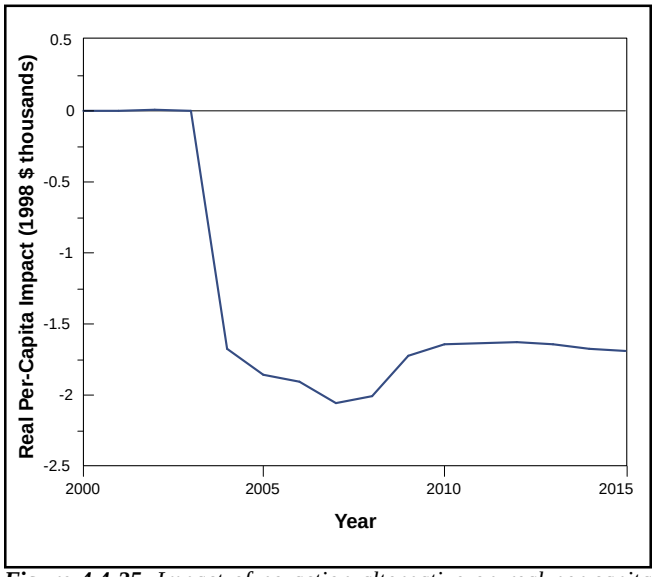


Figure 4.4-25. *Impact of no-action alternative on real per-capita income for Kenai Peninsula Borough, 2000 to 2015.*

- All communities lose state revenue sharing in support of education and other programs.
- Direct state-government spending for program delivery declines because of reduced revenues.
- Elimination of the Permanent Fund Dividend reduces purchasing power in all communities in the state.

By 2015, the multiplier effect from this direct loss of public and private income results in a total employment loss in the rest of the state compared to the proposed action of 11,000 jobs, or 11 percent. Resident employment falls by 14,400, or 12 percent, by 2015. Real per-capita income falls $1,334 in 1998 dollars, or 6 percent, by 2015 because of the loss of a high percentage of the higher-paying jobs in the state. The reduction in employment leads to outmigration and population declines. Population is 12 percent below the proposed action by 2015.

No-Action Alternative Impact on Alaska Natives

Employment. The Alaska Native unemployment rate has remained high while high economic growth in Alaska has rapidly added new jobs to the economy. In the future it will be a challenge to keep that unemployment rate from increasing as the number of new jobs diminishes and the number of young Alaska Natives entering the job market expands. New jobs and high turnover in the job market are necessary to employ a larger percentage of Alaska Natives (McDiarmed et al., 1998).

Alaska Natives are under-represented in virtually all industries, particularly oil and gas, transportation, and construction. In these industries they tend to be in the lower-paid categories. The direct loss of job opportunities in the no-action alternative thus would be relatively modest for Alaska Natives. However, jobs in these industries are particularly important to Alaska Natives because they represent industries with relatively high wages where Alaska Natives, particularly males, have relatively easy access and entry. These high-wage jobs are an important source of income to Alaska Native households and provide access to additional employment opportunities.

Since Alaska Natives are under-represented in urban support sectors of the economy, the loss of other job opportunities due to the multiplier effect will not disproportionately impact Alaska Native workers except to the extent they are concentrated in more vulnerable positions in those industries or are concentrated among workers with short on-the-job tenure.

The decline in the number of jobs, followed by a slow return to job growth, means that the turnover rate of jobs may fall, which would tend to work against Alaska Natives entering the work force.

Alaska Natives are highly represented in the public and nonprofit sectors of the economy. As revenues to state and local governments and nonprofit corporations providing health and other public services to rural and Alaska Native communities shrink, employment in these sectors will fall. This will disproportionately impact Alaska Native employment.

Unemployment. Unemployment of Alaska Natives likely would increase in the no-action alternative because of the decline in total employment combined with a low propensity of Alaska Natives to migrate from the state in response to labor market conditions. The higher unemployment rate is likely to be permanent because the size of the economy will be permanently smaller in the no-action alternative case.

Population. Reductions in employment opportunities in both urban and rural Alaska, along with reduction in the level of public services and infrastructure in both urban and rural Alaska, make it difficult to predict how the distribution of Alaska Native population between rural and urban areas will be affected.

Income. The reduction in the average annual earnings due to the loss of high-wage jobs in oil and gas, transportation, construction, and other sectors — combined with an increase in the unemployment rate — will probably impact Alaska Natives disproportionately. The average household cash income is lower in rural communities than in urban Alaska, and a proportionate loss in income across households would have a disproportionate effect on rural and Alaska Native households.

Further erosion of Alaska Native household income would result from elimination of the Permanent Fund Dividend. Because it is an equal distribution to all Alaskans independent of income, lower-income Alaskans are more heavily impacted when it is terminated. Finally, reduced public spending by state and local government on transfer payments and other programs providing "in kind" income disproportionately to rural and Alaska Native areas of the state would disproportionately impact rural and Alaska Native income.

Public Resources. Outside the pipeline study areas, most of the loss of private jobs and reduction in population and households will occur in the urbanized parts of the state. As a consequence, the entire state will become less urban and more rural. Since a major part of public services in rural Alaska not supported by the federal government is provided by the state through revenue sharing and direct service delivery and the cost of public service delivery per capita is higher in rural areas of the state, the quality of public services will decline throughout the state since per-capita public revenues will decline. The decline in public services in rural Alaska, where the majority of Alaska Natives live, may be disproportionately high, depending on the mechanisms used to deal with the decline in revenue. State expenditures for education, health and human services, community assistance, etc. will be reduced for communities throughout the state.

Communities. Reduction in household income and public income will reduce the ability of small local governments in rural, primarily Alaska Native communities to function and thus will affect the ability of these communities to survive. Reductions in funding for specific programs that lower the cost of electric power in rural areas, and for water and sewer plant construction, school construction, etc., will challenge the ability of these communities to function.

Pressure on Natural Resources. The outmigration in response to the decline in jobs will be concentrated among non-Natives. The civilian non-Native population will be 106,000, or 20 percent, below the proposed action by 2010. This could reduce the pressure on all the natural resources harvested by the Alaska Native community; however, reduced incomes of the remaining non-Native residents could result in increased harvests of natural resources for food. Any net reduction in harvest would be one of the few positive impacts of the no-action alternative.

4.4.3.2 Sociocultural Systems

By M. Galginaitis, C. Gerlach, P. Bowers, and C. Wooley

The major adverse economic impacts of the no-action alternative identified above presage corresponding adverse impacts on the structure and function of the socioeconomic systems of the North Slope, Prince William Sound, and the communities along the pipeline. This section examines the probable consequences of the economic impacts on various segments of the study area. Understanding of sociocultural systems is fundamentally more qualitative than that of economic systems. The projections and estimates in this section are directionally correct, but inherently less precise than those for economic impacts. To avoid repetition, numerous qualifiers are omitted in the material presented below, but these limitations should be borne in mind when reading this section. It should be assumed that estimates of social impacts are more speculative.

Only the effects on the Central TAPS study area can be considered direct effects of the no-action alternative. Impacts associated with closure of the ANS fields and the marine transportation link are indirect and/or cumulative and are discussed in the Section 4.5.

The potential direct and indirect effects of the no-action alternative on communities and areas in the Central TAPS study area vary depending on whether a community is urban, predominately non-Alaska Native, and primarily involved in the wage-labor/cash economy, or rural and dependent on a mixed subsistence/cash economy. The Fairbanks North Star Borough and Delta Junction, in particular, are likely to be directly affected by the individual loss of employment opportunities in the ANS fields, pipeline, or businesses that provide services to these facilities. As noted in the economics section, there will be substantial decreases in resident employment (Figure 4.4-18), real per-capita income (Figure 4.4-20), population (Figure 4.4-22), and petroleum property taxes (Figure 4.4-5). Although these decreases are projected to be proportionately lower than those for the NSB, the effects are significant nonetheless. These adverse economic impacts will alter the regional and community characteristics.

Direct and indirect impacts on rural communities are predictably different than those in more urbanized areas. Rural Interior communities generally are more affected by the overall reduction in state government expenditures resulting from reduced or lost state revenues from pipeline or oil and gas operations than by direct effects. Because state matching funds are also likely to be reduced, federal funds to rural areas would be reduced. Interior rural, primarily Alaska Native communities would be adversely impacted by reduced revenues for regional Native corporations — such as Doyon, Ltd., and Ahtna, Inc. — that provide services to the oil and gas industry. Native corporation dividends paid to shareholders would likely be reduced. The revenue stream that supports government and community services will be considerably reduced. The reduction in Native corporation contract work and employment will not affect the Interior as heavily as it will the North Slope because rural Interior residents are not as directly dependent on TAPS as are the North Slope Iñupiat. Seasonal local employment would be affected by the elimination of TAPS-related jobs, but this effect is expected to be minimal. Tensions between village residents and the oil industry, particularly in Stevens Village and other Interior Alaska Native communities, would be reduced or eliminated, although at a substantial social cost.

4.4.3.3 Subsistence

By M. Galginaitis, C. Gerlach, P. Bowers, and C. Wooley

It is difficult to assess the effects of the no-action alternative on subsistence harvest and activity. Certainly the economic losses will create a powerful incentive for many to attempt to compensate for decreases in their per-capita income by increasing subsistence efforts. Other factors held constant, outmigration will reduce the hunting/fishing pressure, but increased subsistence activity among those who remain acts to increase hunting/fishing pressure. But there is more to it than the population and activities of hunters, because there is a link between the subsistence and cash economies. Wage employment reduces the time available for subsistence pursuits. However, earnings are used to purchase equipment and materials (e.g., fuel, snow machines, ATVs, small boats, outboard motors, guns, ammunition) that make subsistence activities more efficient.

In a post-oil economy, the trend towards using modern hunting/fishing and transportation technology may be reversed. A return to the pre-oil status quo is likely to be difficult, however, because of the cumulative social changes that have occurred in the past 30 years.

DR&R activities could disrupt subsistence activities in localized areas. Once these cease, however, there will be no oil and gas development-related activities in the Central TAPS study area that could impact wildlife populations or subsistence harvests. For example, the threat of a pipeline oil spill would be removed. (Oil now supplied to Alaska from the ANS fields would have to be imported, however, and this transportation link would have the potential for oil spills.)

4.4.3.4 Cultural Resources

By C. Gerlach, P. Bowers, and C. Wooley

DR&R entails ground-impacting activities to dismantle various facilities in the project area (Section 4.1.1). These “deconstruction” activities will have qualitatively similar impacts to those experienced during construction of the pipeline. Increased workers and traffic on the Dalton Highway for the limited duration of DR&R would lead to increased immediate impacts, with decreased long-term impacts. Impacts could result from overland moves of equipment, which could damage surface, above-ground, or shallowly buried sites. Major direct impacts to TAPS-related historic properties should be minimized by compliance with the Stipulations and the Section 106 process.

It is possible that an increased number of DR&R workers may also pose increased indirect impacts on cultural resources. However, this would be partially compensated for by a decrease in the area’s commercial developments and would be of short duration.

Choice of the no-action alternative would eliminate the potential for adverse impacts on cultural resources from operational and accidental crude oil and product spills.

DR&R activities will result in minor product spills (e.g., resulting from vehicle accidents, fueling leaks, etc.) that could adversely impact cultural resources.

4.4.3.5 Land Ownership

By ClearWater Environmental, Inc. staff

The no-action alternative is unlikely to result in significant changes in the pattern of land ownership, with the exception of those few parcels acquired by the permittees for specific facilities such as the Valdez Marine Terminal. Those parcels could be subject to private sale. The ROW itself is an easement on which TAPS and its associated facilities were constructed, and permittees do not own the majority of lands over which the easement is placed.

4.4.3.6 Land Use

By ClearWater Environmental, Inc. staff

DR&R would remove above-ground pipeline and associated facilities; however, the Dalton Highway would not be removed. Therefore, the Dalton Highway would continue to be used as today, with the exception of traffic related to TAPS and North Slope oil and gas operations. This includes tourist and recreational use. Other uses would remain consistent with those described in Section 3.3.5.3.

4.4.3.7 Coastal Management

By ClearWater Environmental, Inc. staff

The no-action alternative would result in cessation of presently permitted uses of lands and waters in the North Slope Borough and Valdez coastal districts for pipelines, the marine terminal, and tanker shipping of crude oil. No new facilities or activities that require changes in the coastal zone management plans would be associated with the no-action alternative.

4.4.3.8 Recreation

By ClearWater Environmental, Inc. staff

Because the Dalton Highway would not be removed as part of DR&R, there would be no impact on present recreational uses.

Some facilities along TAPS are tourist attractions at present. Removal of these facilities would create minor and localized adverse impacts on tourism.

4.4.3.9 Visual Resources

By ClearWater Environmental, Inc. staff

Removing the above-ground portions of the pipeline and facilities would restore those areas to natural environments in which industrial facilities would no longer be visible. The no-action alternative also would result in removal of various pipeline overlooks and visitor centers that are now popular tourist attractions.

4.4.3.10 Wilderness

By ClearWater Environmental, Inc. staff

No wilderness lands are presently included in the TAPS ROW. Since the Dalton Highway is not part of the ROW and would remain after DR&R, no lands presently in the ROW would revert to wilderness status. The no-action alternative would have no effect on presently designated wilderness lands.

4.4.3.11 Transportation

By ClearWater Environmental, Inc. staff

The no-action alternative could result in major impacts on transportation systems:

- Use of the road system for operation and maintenance of North Slope oil and gas facilities and TAPS would be eliminated after heavy use during DR&R.
- Decommissioning TAPS and closing the Valdez Marine Terminal would cause the most extensive crude-oil tanker system on the U.S. West Coast to cease operations. Increased incoming tanker shipments of refined product would be necessary, and would most likely be made through Cook Inlet.
- Because inland waterways are not presently used to support TAPS operations and maintenance, the use of inland waterways would not be affected.
- Decommissioning TAPS would reduce the amount of air freight and passenger traffic through the major airports at Anchorage, Fairbanks, and Deadhorse.

4.5 Cumulative Impacts

This section identifies and evaluates potential cumulative effects of the proposed and no-action alternatives in combination with other past, present, and reasonably foreseeable actions. The goal is to ensure compliance with federal regulations and guidelines, and to thoroughly address the physical, biological, and social components of the affected environment.

In 1978, the Council on Environmental Policy (CEQ) issued regulations (40 CFR 1500-1508) that require the EA or EIS preparer to consider not only the individual direct and indirect effects of a proposed action and each of its alternatives, but also the potential *cumulative* impact, which is defined as follows (40 CFR 1508.7):

> ...the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

In 1997, the CEQ issued a detailed handbook on cumulative effects assessment (CEQ, 1997). CEQ emphasizes that the handbook "is not formal guidance nor is it exhaustive or definitive; it should assist practitioners in developing their own study-specific approaches" (CEQ, 1997, p. vi). This handbook identifies three basic components of such an assessment:

1. The predicted direct and indirect effects of a described future action;
2. Effects of other past, present, and reasonably foreseeable future actions; and
3. Additive relationships or synergies between (1) and (2) that result in cumulative effects.

The cumulative effects analysis in this report incorporates the procedures and information identified by CEQ as essential to be rigorous, comprehensive, and complete. At the same time, the authors have developed original procedures for screening issues and ranking potential cumulative effects by magnitude and probability. The result is a cumulative effects assessment tailored to TAPS ROW renewal.

Section 3 of this report describes the affected environment, while Sections 4.1 through 4.4 cover direct and indirect environmental consequences of the proposed and no-action alternatives. This cumulative effects analysis differs in scope in three main ways.

First, the analysis considers the effects of the renewal of the TAPS ROW together with the continued operation of the ANS oil fields, the VMT, and the associated marine transportation link. These facilities, although distinct from the pipeline, are clearly related activities. In fact, none of these facilities would be viable economically if the others did not exist. These facilities were treated as a group in the economic analysis in Sections 4.3.3.1 and 4.4.3.1, because the econometric models employed for the different facilities were linked, and it was not feasible to undertake the analysis on a facility-by-facility basis. Because the cumulative economic effects of these assets were addressed in the previous sections, only the highlights are given here.[1]

Second, inclusion of ANS oil fields, the VMT, and the marine transportation link broadens the geographic area covered by this analysis of cumulative effects. The overall project study area is divided into the ANS, Central TAPS, and Valdez/Prince William Sound (PWS) study areas.

Third, the CEQ definition of cumulative impacts obviously includes the ANS fields, VMT, and marine transportation link, but may also include other actions. EISs covering other Alaskan development proposals have included potential oil and gas activities on the North Slope; these documents are incorporated by reference (e.g., FERC, 1993, 1995; FPC, 1976; USACE, 1997, 1999; BLM, 1976; BLM and MMS, 1998; MMS, 1987a, b, 1990, 1991, 1996a, 1998).

This section is organized into five parts. Section 4.5.1 describes the methodology for the cumulative effects analysis. Section 4.5.2 summarizes past, present, and reasonably foreseeable actions and the documented environmental is-

[1]Sections 4.3.3.1 and 4.4.3.1 do not consider the economic impacts of possible projects to commercialize ANS natural gas (discussed in this cumulative effects section). Therefore, the incremental economic effects of gas commercialization must be added to those estimated in Sections 4.3 and 4.4.

sues associated with them. These actions and issues, along with potential direct and indirect effects of the alternatives, form the basis for the cumulative effects analysis. Sections 4.5.3 and 4.5.4 present detailed discussion of the potential cumulative effects of the proposed and no-action alternatives categorized by geographic region, environmental component (physical, biological, or social), and suggested levels of intensity and probability (together comprising significance). Section 4.5.5 contains the conclusions.

4.5.1 Methodology

By R.G.B. Senner

The basic idea behind cumulative effects assessment is that if proposed actions are evaluated singly, the big picture will be missed: the additive result of many actions, each exerting its beneficial or adverse environmental influence over time. This need to avoid the piecemeal assessment of environmental impacts led to inclusion of the cumulative effects requirement in the 1978 CEQ regulations and to the eventual development of the CEQ's cumulative effects handbook (CEQ, 1997) and federal agency guidelines based on that handbook (e.g., EPA, 1999a). Although predictions of direct effects of individual proposed actions tend to be more certain, cumulative effects may have more important consequences over the long term. The possibility of these "hidden" consequences presents a risk to decision-makers, because the ramifications of an individual decision are not always obvious. The goal of identifying potential cumulative effects, therefore, is to allow informed decisions — choices with some awareness of implications and consequences beyond the immediate effects of the project under consideration.

To be reliable, any cumulative effects analysis must use a procedure that is (1) logical and methodical and (2) transparent and reproducible. The following discussion reviews the methods used in this analysis.

Cumulative effects analysis must combine three components: (1) a *scope* that sets boundaries in location and time; (2) past, present, and predicted *issues*; and (3) past, present, and predicted *actions*. The CEQ (1997) has established eight principles (Table 4.5-1) that expand on this idea. These principles guided the analysis of potential cumulative effects of the proposed and no-action alternatives.

Beyond the general principles, a stepwise procedure is required to ensure that the analysis is conducted in a systematic, reproducible way that anyone can independently examine and evaluate. The procedure recommended by CEQ (1997) is followed, with some modifications to account for the fact that, unlike most proposed actions, the TAPS ROW renewal decision will be made almost three decades following construction and after many years of continuous operation and maintenance.

In addition, the discussion is amplified in various places to present policy-relevant material. For example, CEQ Principle 2 indicates that effects should be considered without regard to who has taken (or will take) the action. This principle is followed, but it is also relevant to distinguish between actions and effects that are controllable by the sponsors of the proposed action and those that may be taken by other individuals, firms, or agencies. For example, continued operation of TAPS and the Alaska North Slope oil fields will generate future revenues for federal, state, and local governments (among others). How these revenues are spent, however — whether on infrastructure development, education, health care, or any of the other goods and services provided by government — is beyond the control of the applicants for the ROW renewal. Similarly, construction of the Haul Road (now the James Dalton Highway) was integral to the TAPS project. But the decision to lift public access restrictions was not under the control of the ROW applicants, and whether this policy is maintained or reversed in the future will also be beyond their control.

4.5.1.1 Sequence of Analysis

The cumulative effects analysis followed 11 steps that can be classified into four stages: *scoping*, *organizing*, *screening*, and *evaluating*. Table 4.5-2 compares the CEQ procedure side-by-side with the method actually used in this report, and shows how the individual parts of the CEQ approach were adapted and applied to the two alternatives.

The sequential approach can be compared to a series of filters or meshes, each one finer than the one before. In a step-by-step process, the analysis progressed from broad scoping, through classifying and consolidating, to the selective screening and capture of potential cumulative effects. The basic sequence is to:

- Describe the potential direct and indirect effects of each alternative;
- Identify other external actions that could have additive or synergistic effects with the alternatives;
- Screen all of the issues to capture those effects that are potentially cumulative in nature;
- Rank the potential cumulative effects by *intensity* and *probability*; and
- Present the results in a simple but informative matrix in accordance with CEQ guidance.

The *significance* of a potential cumulative effect is de-

Table 4.5-1. *CEQ principles of cumulative effects analysis.*

	Principle	Explanation
1.	**Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions.**	The effects of a proposed [or alternative] action on a given resource, ecosystem, and human community include the present and future effects added to the effects that have taken place in the past. Such cumulative effects must also be added to effects (past, present, and future) caused by all other actions that affect the same resource.
2.	**Cumulative effects are the total effect, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken, no matter who (federal, nonfederal, or private) has taken the actions.**	Individual effects from disparate activities may add up or interact to cause additional effects not apparent when looking at the individual effects one at a time. The additional effects contributed by actions unrelated to the proposed [or alternative] action must be included in the analysis of cumulative effects.
3.	**Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected.**	Environmental effects are often evaluated from the perspective of the proposed [or alternative] action. Analyzing cumulative effects requires focusing on the resource, ecosystem, and human community that may be affected and developing an adequate understanding of how the resources are susceptible to effects [i.e., the pathway or mechanism by which the effect is produced on the resource].
4.	**It is not practical to analyze the cumulative effects of an action on the universe; the list of environmental effects must focus on those that are truly meaningful.**	For cumulative effects analysis to help the decision-maker and inform interested parties, it must be limited through scoping to effects that can be evaluated meaningfully. The boundaries for evaluating cumulative effects should be expanded to the point at which the resource is no longer affected significantly or the effects are no longer of interest to affected parties.
5.	**Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries.**	Resources typically are demarcated according to agency responsibilities, county lines, grazing allotments, or other administrative boundaries. Because natural and sociocultural resources are not usually so aligned, each political entity actually manages only a piece of the affected resource or ecosystem. Cumulative effects analysis on natural systems must use natural ecological boundaries and analysis of human communities must use actual sociocultural boundaries to ensure including all effects.
6.	**Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects.**	Repeated actions may cause effects to build up through simple addition (more and more of the same type of effect), and the same or different actions may produce effects that interact to produce cumulative effects greater than the sum of the [individual] effects.
7.	**Cumulative effects may last for many years beyond the life of the action that caused the effects.**	Some actions cause damage lasting far longer than the life of the action itself (e.g., acid mine drainage, radioactive waste contamination, species extinctions). Cumulative effects analysis needs to apply the best science and forecasting techniques to assess potential catastrophic consequences in the future.
8.	**Each affected resource, ecosystem, and human community must be analyzed in terms of its capacity to accommodate additional effects, based on its own time and space parameters.**	Analysts tend to think in terms of how the resource, ecosystem, and human community will be modified given the action's development needs. The most effective cumulative effects analysis focuses on what is needed to ensure long-term productivity or sustainability of the resource.

Source: CEQ (1997). Bracketed text added by author.

fined in terms of its intensity and probability. Intensity is evaluated in the context of the potential magnitude, geographic extent, and frequency or duration of the cumulative effect. Probability is estimated on the basis of available evidence about the effect or similar effects, including its known past or present occurrence. Finally, the intensity and probability rankings are entered onto a matrix that provides a distribution of the potential cumulative effects with respect to their relative significance (Figure 4.5-1).

Techniques were required that could be easily followed and understood. This is important because each analytical step forms a premise on which the next step is based. If something is wrong in an early step, it can affect all of the following steps and ultimately, the conclusions. The following briefly explains how each stage was conducted to ensure that the next step would be on a solid footing.

Scoping

Step 1: Review potential effects of the alternatives.

The first step in the analysis was to review the predicted direct and indirect effects of the proposed and no-action alternatives on the physical, biological, and social components of the environment. Sections 2, 3, and 4.1 through 4.4

Table 4.5-2. *Procedure for cumulative effects analysis in this report.*

Steps Used in This Analysis	Recommendations from CEQ (1997)
A. Scoping: Identify Issues, Actions, and Boundaries	
1. Review the predicted direct and indirect effects of the proposed and no-action alternatives on the physical, biological, and social environments (Sections 2, 3, and 4.1 through 4.4).	1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.
2. Geographic scope divided into three regions: Alaska North Slope, Central TAPS, and Valdez/PWS.	2. Establish the geographic scope for the analysis.
3. Time frame established as 1974 through 2034.	3. Establish the time frame for the analysis.
4A. Review past environmental impact statements, environmental reports, and the peer-reviewed literature to identify actions and issues of concern.	4. Identify other actions affecting the resources, ecosystems, and human communities of concern.
4B. Interview private and federal, state, borough, and local agency personnel to determine potential future actions that have received preliminary agency notice or review, and to identify new or emerging issues of concern.	
B. Organizing: Characterize and Consolidate Issues	
5. Organize identified issues hierarchically by: a. Proposed or no-action alternative b. North Slope, Central TAPS, or Valdez/PWS c. Physical, biological, or social	5. Characterize the resources, ecosystems, and human communities identified during scoping in terms of their response to change and capacity to withstand stresses.
6. Identify and document issues relating to physical, biological, and social features and to laws, regulations, permits, and stipulations.	6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds
7A. Consolidate similar issues.	7. Define a baseline condition for the resources, ecosystems, and human communities.
7B. In the detailed discussions of issues and results (Sections 4.5.3 and 4.5.4), explain baseline conditions and impact pathways where data allow.	
C. Screening: Identify Potential Cumulative Effects	
8. From the consolidated issues, identify potential cumulative effects of the proposed and no-action alternatives.	8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.
D. Evaluating: Rank by Magnitude and Probability	
9. Using appropriate evaluation criteria (CEQ, 1997; McMillen, 1993), rank potential cumulative effects by intensity and probability, using a matrix to show the approximate risk associated with each. Intensity is a function of magnitude, geographic scope, and frequency/duration.	9. Determine the magnitude and significance of cumulative effects.
10. Either alternative will be in full compliance with laws, regulations, permits, and stipulations, and will incorporate mitigation measures.	10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.
11. Monitoring is beyond the scope of this analysis.	11. Monitor the cumulative effects of the selected alternative and adapt management.

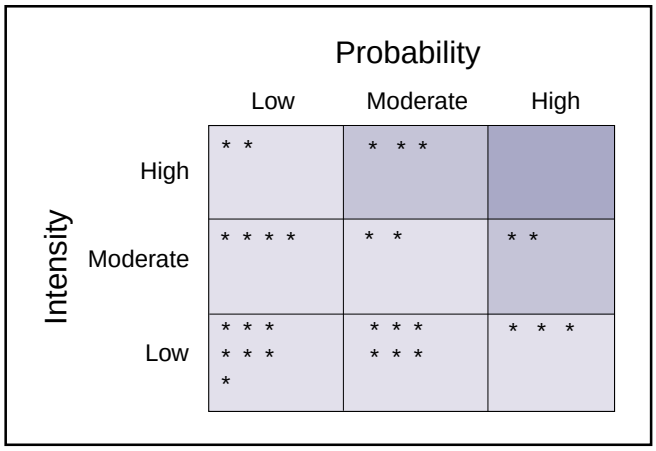


Figure 4.5-1. *Use of a simple matrix to show the distribution of potential cumulative effects (*) when ranked by* intensity *and* probability. *The level of significance is suggested to approximate* intensity X probability *and to increase toward the upper right portion of the matrix. The shaded area represents the distribution of potential cumulative effects defined as* significant *for this analysis. Adapted from Muhlbauer (1996), p. 12.*

were the basis for much of this review, along with new material on the ANS and Valdez/PWS study areas prepared specifically for this analysis. The predicted beneficial and adverse effects of both alternatives were tabulated by physical, biological, and social categories.

Step 2: Establish geographic scope.

It became apparent that for the physical and biological categories, the geographic scoping used for earlier parts of this report — ANS, Central TAPS, and Valdez/PWS — would be appropriate for the cumulative effects analysis. The impact mechanisms for predicted physical and biological effects, whether direct or indirect, were not dispersed enough to produce notable influences beyond the airshed, lands, waterbodies, and surrounding marine environment of Alaska — with the exception of special cases such as atmospheric changes or a tanker accident on the high seas. In the social category, however, the analysis was left open-ended enough to accommodate economic influences on market environments outside Alaska.

Step 3: Establish time frame.

The CEQ definition (40 CFR 1508.7) and principles of cumulative effects analysis (Table 4.5-1) specify that past effects of actions must be considered along with present and reasonably foreseeable ones. In addition to the forward-looking projection of the proposed action from 2004 to 2034, the proposed term of ROW renewal, it was necessary to look back to construction startup in 1974 to take into account the preceding three decades of TAPS construction, operation, and maintenance under the existing ROW. Therefore, the time frame for the cumulative effects analysis was defined as the 60-year period from 1974 through 2034. This considerable time is divided almost equally between past and future, and thus between the documentation of past effects and the prediction of future outcomes. Because the pipeline system has operated continuously since 1977, there is a reliable basis for projecting the probable future effects of its uninterrupted continuation. Also, the proliferation of ANS oil fields has occurred during approximately the same time as TAPS construction and operation, and the environmental effects of North Slope petroleum development may be the most heavily documented anywhere in the world. From the standpoint of cumulative effects involving North Slope petroleum production, therefore, the 1974-2034 time frame is appropriate, although earlier environmental effects of exploration in NPR-A are also taken into account.

Step 4A: Review other actions and their documented or potential environmental effects.

Many other documents were examined to identify other actions and their associated environmental impact issues that could contribute to cumulative effects of the proposed and no-action alternatives. These included EISs, environmental assessments (EAs) prepared by project sponsors, agency critiques such as the JPO Comprehensive Monitoring Reports, scientific and technical articles published in peer-reviewed journals, and numerous reports documenting studies by government, industry, and consultants during the past 30 years and more.

Step 4B: Interview knowledgeable people.

Representatives of federal and state agencies and local jurisdictions were interviewed to identify development plans that had come to their attention. Agency representatives are typically well-informed about projects proposed by the private sector, because agency review and approval are usually required for such actions. Similarly, staff of the North Slope petroleum producers and of Alyeska were interviewed to identify planned oil and gas projects. Agency and industry representatives were also interviewed to identify recent or emerging environmental issues that had not yet been captured in the literature. These issues were cited as personal communications and added to the data.

Organizing

Step 5: Determine the structure of the analysis.

The cumulative effects analysis was organized first by alternative (proposed or no-action), then by region (ANS,

Central TAPS, Valdez/PWS), and finally by type of issue (physical, biological, social). This approach acknowledged the major differences among the three regions and allowed each region to be discussed cohesively with respect to its distinctive and sometimes unique physical, biological, and social characteristics.

Step 6: Tabulate environmental issues.

Physical, biological, and social issues were tabulated, using information from Steps 1, 4A, and 4B. The issues included beneficial and adverse environmental effects of TAPS construction, operation, and maintenance, and of ANS oil and gas development. All were organized into categories to aid consolidation of similar issues in Step 7A.

Step 7A: Consolidate similar issues.

Similar issues were consolidated into general statements to make further analysis more convenient.

Step 7B: Characterize resources, impact pathways, relevant regulatory factors, and mitigation.

After the potential cumulative effects were identified, each was characterized with respect to the following:

- Magnitude, probability, and associated risk;
- Supporting evidence; baseline information if available;
- Impact pathways;
- Laws, regulations, or stipulations where pertinent; and
- Mitigation opportunities.

Screening

Step 8: Identify potential cumulative effects of the alternatives.

Each consolidated issue was screened to determine whether it qualified as a potential cumulative effect, using the steps shown in Figure 4.5-2. The screening matrix was used to apply the following sequence of criteria:

- Did the effect occur in the past?
- Is the effect occurring now?
- Has the effect been fully mitigated?
- Could the effect occur in the future?
- If adverse, is the effect unavoidable?
- Is this a potential cumulative effect?
- If no, why not?
- If yes, in combination with what actions?
- How adequate are the evaluation data, in terms of quality and quantity?

CEQ's Step 10 indicates that alternatives should be modified or added to "avoid, minimize, or mitigate significant cumulative effects." Note also that according to this step, "either alternative will be in full compliance with laws, regulations, permits, and stipulations, and will incorporate mitigation measures." This analysis intentionally limits mitigation measures to those under the control of the applicants, on the belief that it is beyond the scope of this effort to recommend mitigation measures the applicants cannot implement. Where appropriate, potential mitigation strategies are addressed in the context of public policy.

Although the screening process yielded potential cumulative effects, it did not address their magnitude, probability, or level of risk relative to the proposed action or no-action alternative. In other words, all of the screened cumulative effects at this stage are equivalent and cannot be weighed against one another. The final stage of evaluating the potential cumulative effects, and suggesting an approximate level of risk that might be associated with each, was completed in Step 9.

Evaluating

Step 9: Organize, evaluate, and rank potential cumulative effects.

Once the potential cumulative effects were identified through the screening process described above, it was necessary to organize, evaluate, and rank them. Evaluating and ranking are the most challenging part of the cumulative effects analysis process, for the following reasons:

- There is no single, widely accepted method for ranking any type of potential environmental impact, whether direct, indirect, or cumulative.
- Guidance on determining the magnitude and significance of cumulative effects provided by the CEQ handbook, while pertinent and useful, leaves the specific approach up to the analyst (CEQ, 1997, pp. 41-45). Appendix A of the CEQ handbook suggests a wide range of analytic methods, but none applies directly to evaluating and ranking cumulative effects relative to one another.
- An extensive review of previous EISs and EAs confirmed that the literature yields no consistent pattern or consensus on methods for ranking or writing about cumulative effects. Lacking this precedent, the analyst must select or devise the method to be used when undertaking each new cumulative effects assessment, as consistent with the CEQ guidance cited above.
- Because the significance of a potential cumulative effect must depend on *context* as well as *intensity* (CEQ, 1997, p. 44), the evaluation must consider the

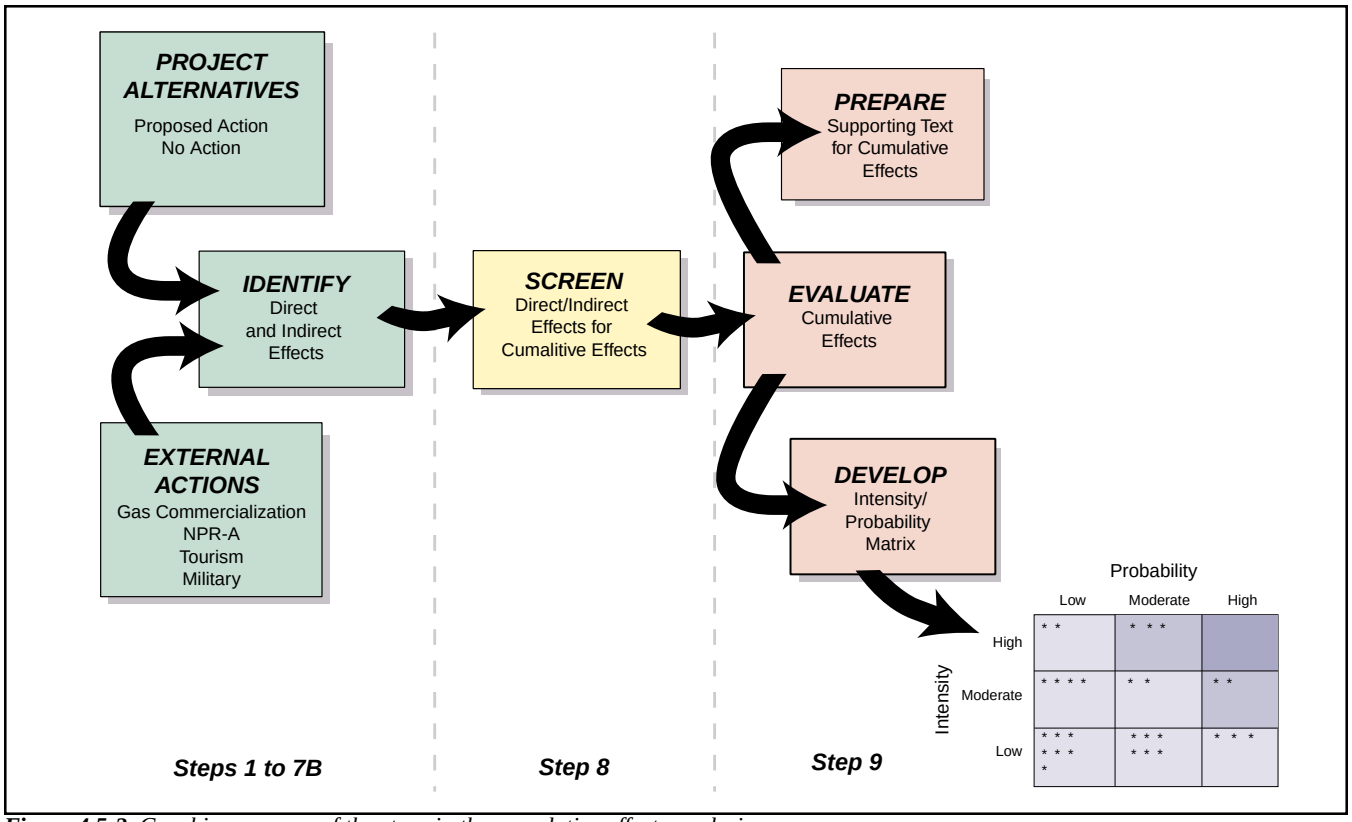


Figure 4.5-2. *Graphic summary of the steps in the cumulative effects analysis.*

unique circumstances (history, geographic setting, characteristics of human communities and ecosystems, etc.) of the action under consideration. Consequently, a one-size-fits-all approach is not likely to work well.

- Criteria for ranking cumulative effects must also vary by environmental component. In this case, the criteria depended on whether the effect related to the physical, biological, or social component of the environment. This situation became more complicated when a potential cumulative effect related to more than one component. For example, the significance of a predicted decline in a local moose population may be low or moderate from a biological standpoint, but high from a social standpoint if local residents depend on the moose population for subsistence.

Given these considerations, the significance of a potential cumulative effect was defined as a function of its *intensity* and *probability*. *Intensity* is evaluated as high, moderate, or low in the context of magnitude, geographic scope, and frequency/duration, using the criteria defined above. The rationale for the assigned intensity ranking is explained in the discussion of each potential cumulative effect. *Probability* presents a special problem, because of uncertainty regarding future actions and outcomes. Rather than attempting to derive mathematical probabilities, the authors have chosen to weigh the available evidence and make an informed assessment as to how likely a potential cumulative effect is to occur. As a rough guideline, a probability ranking of *low* approximates a probability of less than 0.3; *moderate*, a probability in the 0.3 to 0.6 range; and *high*, a probability greater than 0.6. Although this approach is subjective, each probability assessment is explained in writing, allowing the reader to weigh the assessment on an informed basis.

This approach closely follows National Environmental Policy Act (NEPA) precedent and CEQ guidance in assuring that each potential cumulative effect is assessed in its own specific context, using such factors as magnitude, geographic extent, and frequency/duration to evaluate intensity (CEQ, 1997, p. 44). Based on this contextual analysis, intensity is ranked as low, moderate, or high, along with an estimate of probability (again low, moderate, or high). These two rankings together suggest the level of significance associated with the effect. *Significant* outcomes are defined as those ranked as having (a) high intensity/high probability, (b) high intensity/moderate probability, or (c) moderate intensity/high probability. Finally, the results are presented in a simple matrix format that allows the reader to assess at a glance the distribution of potential cumulative

effects and their relative significance. This approach, adapted from a matrix used by Muhlbauer (1996) in a simple risk assessment model, is shown conceptually in Figure 4.5-1.

4.5.1.2 Detailed Discussion of Methods for Evaluating Cumulative Impacts

The advantages of the approach outlined above are that it (1) closely follows CEQ guidance, (2) employs an orderly and explicit procedure that is transparent to the reader, and (3) is well-grounded in both the NEPA and risk assessment literature. Several authors have recently suggested workable approaches to ranking environmental impacts and assigning levels of significance, and pertinent elements of their methodologies have been incorporated in this analysis. For example, both March (1996) and McMillen (1993) emphasize the central importance of *significance* in good NEPA practice, and both provide systematic frameworks for establishing the significance of potential effects in terms of context and intensity, in compliance with CEQ regulations (40 CFR 1508.27).

March's approach determines significance by applying seven tests in a specific sequence, with each step serving as a threshold test in the context of the particular criterion being applied: environmental receptors, activities that might affect the receptors, legal compliance, risk/uncertainty, cumulative effects, establishment of a precedent, and controversy. However, March's approach does not provide an explicit method for putting all seven test results together and reaching a conclusion about the overall significance of the potential effect. He states that the Department of Energy's (USDOE) "practice, in effect, requires that the forms of evidence in support of significance findings be defined by a professionally knowledgeable group of people taking into account all context and intensity factors, and responding to the criterion stated in [CEQ scoping regulation *40 CFR*] *1500.1 (b)*. We recommend that all NEPA document planning include a similar early step in which the form and scope [of] evidence in support of *significance* determinations are to be specified in detail." Thus, the March approach does not specify what to do with the test results, other than to apply professional judgment to this question at the beginning of the process, during scoping. In particular, no system or technique is provided by which to weigh, compare, or otherwise combine the seven test results to produce an outcome that will be readily understandable, resistant to misinterpretation, and widely acceptable. Thus, March's method, while closely compliant with CEQ regulations and providing excellent guidance on criteria of significance, requires further development with regard to closure.

McMillen (1993) explicitly recognizes this problem: "In reality, any number of criteria can be used in the significance assessment. However, the more criteria used the more difficult it is to develop the test used to identify the degree of magnitude of the impact" (p. 199). The problem is that as criteria are systematically applied, the question of how to integrate them logically becomes increasingly complicated. McMillen's solution is to apply four fundamental criteria of significance: magnitude, geographic extent, duration and frequency, and probability, consistent with the subsequently published CEQ handbook (CEQ, 1997). These criteria are applied through a series of questions with yes/no answers. The questions are given different weights depending on their importance in the view of the practitioner. For example, a question about human health or safety is given greater weight than a question on violation of a permit. The sum of the weighted "yes" responses is then used to determine whether the impact rating for a particular criterion is high, medium, or low.

In the McMillen method, the potential effect being analyzed thus receives four ratings, one each for magnitude, geographic extent, duration and frequency, and probability. Each rating can be high, medium, or low. The four ratings are then combined to achieve a final score for significance (also high, medium, or low). McMillen is not explicit, however, about how the score for significance should be determined. He presents a table (Table 1-2, p. 202) that shows "Criteria for Determining Significant Adverse Biological Impacts," and it is apparent that this table incorporates a weighting system that gives priority to magnitude. But the nature of the weighting system and the underlying rationale for giving priority to magnitude are not explained. The final ranking for significance clearly must depend on the relative weights as well as the relative scores given to the four criteria, but the reasoning behind the weighting is not discussed.

The McMillen method was tested in an earlier version of this cumulative effects analysis for TAPS ROW renewal. While the method is convenient and easy to apply, two difficulties were found. First was the issue of transparency. Although each potential cumulative effect was given a rating with respect to magnitude, geographic extent, frequency/duration, and probability, the reason for each rating, based on the practitioner's judgment, was not documented. If the reader questioned a conclusion, there would be no way to examine the professional judgment that led to it. As noted in the preceding paragraph, another transparency problem in McMillen's method was the lack of explanation

regarding how the ranking system for significance was structured, particularly for the weighting of criteria.

The second concern is that *likelihood* — the probability that a cumulative effect would indeed occur — seemed to be fundamentally different from the *intensity*-related criteria of magnitude, geographic extent, and frequency/duration. Together, however, these two fundamental characteristics — intensity and probability — were what really mattered in assessing the overall significance of the event. Accordingly, an alternative approach was chosen in which *intensity* (based on the context of magnitude, geographic extent, and frequency/duration) and *probability* would be ranked separately (low, moderate, or high), and the two rankings weighed against each other to suggest the *significance* of a potential cumulative effect. In this way, the systematic clarity of the McMillen approach was used, but a new method was developed that has much in common with the separate but allied discipline of risk assessment.

In his *Pipeline Risk Management Manual*, Muhlbauer (1996) presents a basic model in which the risk of a proposed action or policy can be defined by answering three questions:

- What can go wrong?
- How likely is it?
- What are the consequences?

These questions suggest a parallel approach to assessing the significance of potential environmental impacts. Taken in order, they identify the potential impact, assess its probability, and describe its intensity. Answering the first question is equivalent to stating the nature of the potential environmental effect. The second item is a straightforward query about probability, and the third question really asks what the intensity of the potential impact would be, in the context of relevant factors such as McMillen's magnitude, geographic scope, and frequency or duration. Thus, the Muhlbauer model presents a clear and simple framework for assessing environmental effects, whether direct, indirect, or cumulative, that corresponds closely to the guidance presented in the CEQ handbook (CEQ, 1997).

Parallels between risk assessment and environmental impact assessment extend to useful similarities between risk and significance. A standard way of evaluating risk is to define it as a function of consequence and probability, where:

R = risk;
C = consequence;
L = likelihood; and
R = CL.

This suggests the parallel approach used in this analysis, where:

S = significance;
I = intensity;
P = probability; and
S = IP.

Muhlbauer presents a simple hazard matrix that provides a framework for assessing relative risk, based on consequence and likelihood (Figure 4.5-3). In this model, the more important risks are those with higher consequences and higher probability. The advantage to the reader is that the matrix allows a rapid grasp of how the issues are distributed and which ones should be of greater concern. Thus, Muhlbauer's approach was adapted, and the analogous matrix was developed based on intensity and probability shown previously in Figure 4.5-1.

Finally, in developing the approach, the question of objectivity versus subjectivity was faced. This was especially apparent as potential cumulative effects were ranked with respect to intensity and probability. Several lessons were learned. First was the importance of a thoughtful and explicit method with clearly defined criteria and replicable procedures. McMillen (1993, p. 197) is particularly eloquent on this point:

> "Without a well conceived methodology, the defensibility of the document reverts back to the subjective instincts of the analyst (i.e., professional judgement). In which case, if the results of the analyses are disputed, the personal integrity/judgement of the analyst is directly contested. On the other hand, when a methodology is contested, the result is usually an improvement in the methodology, aided by the person or organization that took issue with it (i.e., they point out what is wrong and allow for correc-

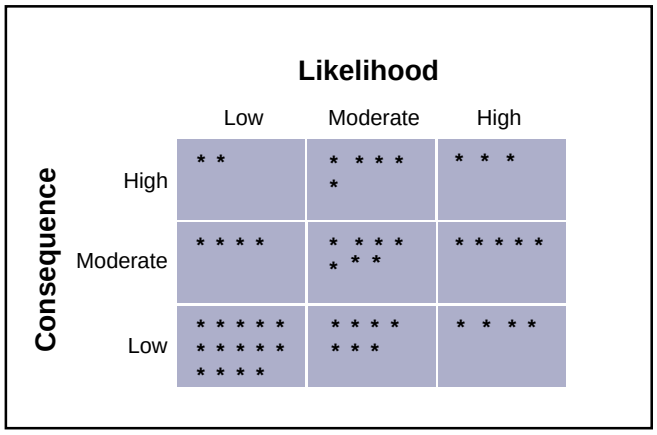


Figure 4.5-3. *Muhlbauer's hazard-consequence-likelihood matrix. In this case, the asterisks represent potential incidents. Each potential incident is ranked by consequence and likelihood, and these two parameters, taken together, represent risk. The shaded areas contain potential incidents that pose the greater risk. Adapted from Muhlbauer (1996), p. 12.*

tions/improvements to be made). When personal judgement is contested, the result is at best a damaged ego, and possibly a destroyed reputation. Given this, the analyst's choice concerning whether or not to use an explicit methodology should be self evident."

Even in the most structured and methodical analysis, however, one cannot achieve total objectivity: Professional judgment will always come into play at some point. Although McMillen emphasizes the importance of developing quantitative (as well as qualitative) criteria in ranking magnitude, geographic extent, frequency/duration, and likelihood, professional judgment is still required. He provides a hypothetical example in which he uses percentages of allowable harvest levels for certain game species to rank the magnitude of the harvest impact as low, moderate, or high. However, even after extensive research to establish game population estimates, determine allowable harvest levels, and compile harvest data, the analyst must still decide what ranges between 0 and 100 percent equate to low, moderate, and high levels of magnitude (McMillen 1993, p. 201).

Along with professional judgment, there will always be predictive errors in assessing the direct, indirect, and/or cumulative effects of any proposed action. Uncertainty about the future is a fact of life. It was concluded that the important goal is to achieve a spirit of objectivity in which the analyst does everything possible to be objective and to base conclusions on documented evidence, but is self-consciously aware of the subjective and uncertain components of the analysis and points them out to the reader. The goal therefore, was to be orderly, methodical, explicit, and transparent — but not truly objective in any absolute sense.

It was concluded that the best approach was to develop measurable criteria for ranking, employ professional judgment in applying the criteria, and most important, explain the logic and rationale for each ranking. With this approach, the reader might disagree with a conclusion but will always be able to trace it back to a specific statement explaining the reasons for that conclusion. The thought processes behind each ranking are thus made explicit so that the reader can judge their validity.

4.5.2 Other Past, Present, and Reasonably Foreseeable Future Actions and Associated Environmental Issues

By R.G.B. Senner and D.L. Maxim

The analysis of potential cumulative effects requires that the predicted direct and indirect effects of a proposed action and its alternatives be examined in combination with potential effects of other past, present, and reasonably foreseeable future actions. To accomplish this, the other past, present, and future actions and their actual or potential direct and indirect effects must be defined.

Sections 4.3 and 4.4 discuss potential direct and indirect effects of the proposed and no-action alternatives on physical, biological, and social components of the environment. This section briefly highlights other actions within the geographic scope of the analysis that could have additive effects with renewal of the TAPS ROW in the case of the proposed action or with removal of above-ground TAPS infrastructure (DR&R) and closure of ANS petroleum production facilities in the case of the no-action alternative. Table 4.5-3 summarizes these other actions, which are discussed in detail below.

4.5.2.1 Other Actions

Development activities and physical change on the North Slope since the mid-1960s have been driven in large part by oil and gas exploration and production (Appendix D). Revenues from petroleum production, in combination with the success of ANCSA-related Native corporations, have had a major economic influence on the Iñupiat people and on the growth and development of North Slope Borough communities. A growing tourism industry and increasing public recreational use of state and federal lands, the latter accelerated by ANILCA, have influenced planning by local, state, and federal agencies. New policies increasingly emphasize and encourage public access and the development of supporting amenities such as campgrounds and public service facilities along the Dalton Highway and at Deadhorse.

In the Central TAPS study area, physical change has been less dramatic, but communities such as Delta Junction and Glennallen have grown in size and in the number and variety of public accommodations available, aided in part by economic-development planning by Alaska Native corporations. Public accommodations along the Richardson Highway have increased in number since TAPS construction, and the overall level of human activity, particularly year-round recreational use, continues to grow. The continued presence of the U.S. Army base at Ft. Wainwright and the U.S. Air Force base at Ft. Eielson, both near Fairbanks, has had a sustained positive economic influence on the region. In addition, proposals have been advanced for the partial conversion of the U.S. Army base at Ft. Greely near Delta Junction to a prison and alternatively, for its use as a

Table 4.5-3. *Past, present, and reasonably foreseeable future actions.*

	Past Actions	Present Actions	Reasonably Foreseeable Future Actions
PIPELINE CORRIDOR			
Oil and Gas Related	• Construction, operation, and maintenance of TAPS. • Construction/operation of MAPCO/Williams refinery. • Oil/fuel spills along TAPS ROW.	• Planned rampdown of several pump stations as flows are reduced. • Planned maintenance; small "digs". • Oil/fuel spills along TAPS ROW.	• Gas commercialization-construction issues depending on gas option chosen. • Oil/fuel spills along TAPS ROW. • Planned pipeline maintenance and small "digs". No large digs planned.
Transportation, Tourism/ Recreation	• Construction of Haul Road (now Dalton Highway). • Opening of Dalton Highway to all commercial traffic (1980s) then to public (1990s).	• Use of Dalton Highway by all commercial operators, then by public (tour buses, private vehicles, hunting, fishing, hiking, camping, sightseeing).	• Development of rest stops, lodges, or hotels along the Dalton Highway. • Dalton Highway: Increased recreational traffic/improved access, changes in land-use patterns, increased hunting, fishing.
Other Industry	• Installation of fiber optics line.	• None	• Localized facilities particularly near population centers or south of Brooks Range.
Military	• None	• No present military activities	• Delta National Missile Defense System Facility
Economic/ Cultural	• Alaska Native Claims Settlement Act. • Alaska National Interest Lands Conservation Act. • Chartering of Native Corporations. • Creation of Permanent Fund.	• Deposits to Permanent Fund.	• Deposits to Permanent Fund (with proposed action).
NORTH SLOPE			
Oil and Gas Related	• Oil field development including: - Prudhoe Bay Unit - Kuparuk River Unit - Duck Island Unit (Endicott) - Milne Point Unit - Tarn • Area-wide enhancement of existing facilities.	• Oil field development including Badami Unit and Alpine/Colville River.	• New oil field developments (would not apply under no-action alternative): Northstar Unit, Liberty, NPR-A, other unspecified fields. • Development of ANWR not required to sustain sufficient throughput. • Gas commercialization options: - New pipeline to market - New pipeline with LNG tankers - Gas-to-liquid conversion and transport through TAPS
Tourism/ Recreation	• Access to Deadhorse for tourists by opening of Dalton Highway. • Regularly scheduled commercial airline flights to Deadhorse. • Tourist use of existing Deadhorse facilities. • Escorted tours of oilfield facilities provided by field operators. • Increased hunting, fishing, resource use at north end of Dalton Highway.	• Continued tourist activities in Deadhorse. • Increased hunting, fishing, resource use at northern terminus of Dalton Highway, Prudhoe Bay area.	• Development of additional tourist facilities in Deadhorse. • Alteration of oil field facilities for tourism. • Increased traffic in Deadhorse or within oil field facilities. • Increased hunting, fishing, resource use at northern terminus of Dalton Highway, Prudhoe Bay area.
Other Industry	• Development of oil field services industries in Deadhorse.	• Continued service industry development. • Cleanup of contaminated and often abandoned service industry sites.	• No new industries expected.
Military	• DEW Line stations.	• No present military activities.	• None expected.
Economic/ Cultural	• Alaska Native Claims Settlement Act. • Alaska National Interest Lands Conservation Act. • Chartering of Native Corporations. • Creation of Permanent Fund.	• Deposits to Permanent Fund.	• Deposits to Permanent Fund (with proposed action).

Table 4.5-3 (cont'd). *Past, present, and reasonably foreseeable future actions.*

	Past Actions	Present Actions	Reasonably Foreseeable Future Actions
VALDEZ/PRINCE WILLIAM SOUND			
Oil and Gas Related	• Construction and operation of crude oil refinery • Construction and operation of Valdez Marine Terminal (VMT). • Modifications to VMT such as vapor recovery and ballast water treatment process. • *Exxon Valdez* oil spill, subsequent cleanup, and associated research and monitoring.	• Operation of refinery. • Operation of VMT. • Operation of SERVS tanker escort system.	• Gas commercialization (construction issues depending on which gas option is chosen). • Use of double-hull tankers.
Tourism	• Escorted tours of VMT. • Extreme and heli-skiing in nearby mountains based in Valdez. • Tour boat industry.	• Escorted tours of VMT. • Extreme and heli-skiing in nearby mountains based in Valdez. • Tour boat industry.	• Construction of new hotels/tourist facilities in Valdez. • Increased boat/cruise ship traffic with potential for construction of additional dock/harbor facilities.
Other Industry	• Fishing.		• None expected.
Economic/ Cultural	• Alaska Native Claims Settlement Act. • Alaska National Interest Lands Conservation Act. • Chartering of Native Corporations. • Creation of Permanent Fund.	• Deposits to Permanent Fund.	• Deposits to Permanent Fund (with proposed action).

National Missile Defense System (NMDS) site.

At Valdez on Prince William Sound, the sustained economic influence of VMT operations has contributed to population and infrastructure growth. The PWS region has also experienced an increase in recreational tourism in recent years. The *Exxon Valdez* oil spill (EVOS) brought international attention to Valdez and to PWS, resulting in greater awareness and study of the PWS ecosystem, its recreational opportunities, and the need for stricter regulation of the growing human presence in the region. Recent construction of a road connecting the port of Whittier to Alaska's highway system will bring further recreational growth to the PWS region.

Despite the proliferation of other activities on the ANS, in the Central TAPS study area, and in Valdez/PWS region, the petroleum industry continues to provide the greatest impetus for change in these regions. In particular, two categories of oil and gas activities are logical candidates for inclusion in this cumulative effects analysis. These are:

- First, expansion and further development of existing and new ANS oil fields are likely. In the aggregate, these fields are included in the baseline TAPS throughput assumption provided in Appendix A.
- Second, commercialization of ANS natural gas reserves is "reasonably foreseeable" during the ROW renewal period, provided market conditions become more favorable.

Although logically separate, these developments are linked. Commercialization of ANS gas, for example, may provide economic impetus for further exploration and development of oil and gas reserves.

Alaska North Slope Crude Oil Production

Appendix A provides the baseline ANS production and TAPS throughput assumption used in this report. Rather than employing a field-by-field analysis, this assumption is based on forecasts by the USDOE through 2020 and extended through 2034. In this context, it is useful to examine the possible distribution of production fields. Table 4.5-4 shows past (through 1996) and possible future ANS production as presented in the NPR-A (BLM and MMS, 1998) and Northstar (USACE, 1999) EISs. Fields are divided into onshore and offshore categories.

Historically, onshore production accounted for 97.1 percent of ANS production through 1996. Offshore production will probably account for a greater percentage of future ANS production; the specific percentage depends on whether "speculative" future production is included. However, onshore production is projected to account for the majority of total production: nearly 81 percent if expected production is included, compared to 76 percent if speculative production is also included.

Table 4.5-4. *Past and potential future crude oil production from North Slope fields. This analysis is based on the premise that the majority of future ANS oil production will come from onshore fields.*

Activity	Onshore (billion bbl)	Offshore (billion bbl)	Subtotal (billion bbl)
Production to date (through 1996)	11.23	0.34	11.57
Percent of total	97.1%	2.9%	100.0%
Expected future production			
Existing fields	6.15	0.26	6.41
Planned fields	0.53	0.27	0.80
Subtotal	6.68	0.53	7.21
Possible future production	1.85	0.46	2.31
Possible OCS projects (unleased)	0.00	1.20	1.20
NPR-A			
Northeast Planning Area*	0.28	0.00	0.28
Western Planning Area*	0.39	0.00	0.39
Subtotal	0.67	0.00	0.67
Speculative future production	4.00	2.00	6.00
Total future (expected, possible, NPR-A)	9.20	2.19	11.39
Percent of total	80.8%	19.2%	100.0%
Total future (including speculative)	13.20	4.19	17.39
Percent of total	75.9%	24.1%	100.0%

*NPR-A values are calculated as the geometric mean of endpoints of reported range.
Source: Adapted from data given in BLM and MMS (1998): Table IV.A.5–7; USACE, 1999: Table 10-3.

Commercialization of ANS Natural Gas Reserves

The North Slope has over 30 trillion cubic feet (tcf) of proven natural gas reserves, and more may be discovered (CERA, 1999a; Sherwood and Craig, 2000).[2] To date, the vast majority of gas produced has been only in association with crude oil. The balance of gas production is returned to the reservoir (reinjected) to enhance oil recovery. Some gas has been used as fuel for production operations and for TAPS Pump Stations 1 through 4.[3] Thus, the gas has some utility, but it is effectively "stranded" because local markets are minimal and high transportation costs to a suitable market preclude commercialization. In the future, substantial amounts of this natural gas could be produced for sale possibly in Asian or North American markets without adversely affecting oil recovery (CERA, 1999a).

Three proposals for gas commercialization have been advanced over the years:

- Transport of natural gas by a new pipeline to a new terminal near Valdez, where the gas would be liquefied for shipment to markets in liquefied-natural-gas (LNG) tankers,
- Transport of natural gas by a new pipeline through portions of Alaska and Canada to the Midwest and Pacific Coast regions of the United States, and
- Operation of a gas-to-liquids (GTL) conversion facility on the North Slope with transport of the resulting GTL liquids through the existing TAPS pipeline and subsequent shipment in conventional tankers to locations in the Far East and the United States.

None of these projects has yet proven economically viable, largely because of the substantial capital investments required and projected energy prices and markets. The LNG and Alaska-Canada pipeline options have been the subject of previous EISs and have received major federal and state approvals to proceed. No EIS has been written for a GTL project, but several parties have expressed interest in a GTL alternative.

The LNG option, known as the Trans-Alaska Gas System (TAGS), and the Alaska-Canada gas pipeline option, known as the Alaska Natural Gas Transportation System (ANGTS), are included in the cumulative effects discussions of some North Slope EISs [e.g., NPR-A (BLM and MMS, 1998) and Northstar (USACE, 1999)], although not in others [e.g., Beaufort Sea Planning Area Sale 144 (MMS, 1996a), Sale 170 (MMS, 1998), Chukchi Sea Oil and Gas

[2]By some estimates (Sherwood and Craig, 2000), there are 194 tcf of undiscovered natural gas resources for Alaska and the Alaska federal offshore areas. Details of these reserve estimates can be found in Sherwood and Craig (2000).

[3]Four percent (1 tcf) of Alaska's gas reserves occur within fields in the Cook Inlet basin (Sherwood and Craig, 2000). Alaska exports small amounts (0.06 tcf/yr) of LNG from fields in Cook Inlet to Yokohama, Japan (Sherwood and Craig, 2000).

Lease Sale 126 (MMS, 1991)]. Both possibilities are discussed in the Northstar EIS (USACE, 1999), but both were believed highly speculative at that time, based on prevailing energy prices, demand, and probable transportation costs. An economic analysis prepared by the State of Alaska (Condon et al., 1998) found that gas commercialization was not economically feasible at prevailing prices. CERA (1999a) prepared an updated analysis of ANS commercialization options, which generally reached the same conclusions.

In the years since many of these analyses, crude oil and natural gas prices have risen dramatically. However, it is important to note that energy prices must remain high enough over the lifetime of the project to justify the multi-billion-dollar investments such projects require. Future crude-oil prices are very difficult to forecast, but many observers do not believe that today's prices are sustainable in the longer term. For example, the State of Alaska Department of Revenue forecasts that world crude oil prices will decrease in the year 2002 and thereafter (ADOR, 2000). Therefore, despite recent energy price increases, the economic attractiveness of various options for commercialization of Alaska natural gas remains uncertain.

Nonetheless, companies are interested in projects to free stranded natural-gas reserves. ExxonMobil, for example, has reportedly invested more than $110 million studying North Slope gas commercialization options and has dedicated $400 million over the past 20 years to develop gas conversion technologies (Portman, 2000). And BP recently announced plans to build an $86 million GTL pilot plant in Nikiski, Alaska. Another scheme, the Alaska natural gas-to-liquids (ANGTL) project, has also been proposed. Favorable economic developments (chiefly recent increases in energy prices) have also been the impetus for renewed interest in both the TAGS and ANGTS options. It is still too early to know whether or when gas commercialization will prove economically feasible or to identify a favored option (Sherwood and Craig, 2000). Changing costs and market conditions may make such projects viable in the future.

For purposes of the cumulative effects analysis, one or more gas disposition projects are assumed to be "reasonably foreseeable." The three options noted above are not necessarily mutually exclusive; however, simultaneous implementation of TAGS and ANGTS would require the discovery of additional reserves (CERA, 1999a). It is thus assumed that for the proposed action, gas disposition projects go forward at some time during the TAPS ROW renewal period (2004-2034). Since there is no clear basis to select any one alternative, the incremental effects of all three options are considered.

Because it is assumed that the North Slope production and support infrastructure would be dismantled in the no-action alternative, it is difficult to imagine circumstances that would permit gas commercialization if the TAPS ROW were not renewed. Therefore, no gas disposition projects are included in the cumulative effects analysis of the no-action alternative.

Brief summaries of the TAGS (LNG), GTL, and ANGTS options are provided below. Sufficient detail is presented for each option to provide a basis for estimating possible cumulative impacts, but it is important to emphasize that these options are still in the conceptual stage. Any actual projects may differ from those described here and must be evaluated on the basis of project-specific EISs.

LNG Option. The TAGS concept involves construction of a gas pipeline to carry conditioned natural gas from the North Slope to Valdez, where it would be liquefied by a cryogenic process for shipment in specially designed tankers to various countries — probably Japan, Korea, Taiwan, and in the future, mainland China.[4] The LNG is vaporized and the gas used in power plants and or for other uses.

The TAGS project includes a North Slope gas-conditioning facility, 800-mile-long large-diameter (42-inch) chilled buried pipeline adjacent to TAPS, and ten mainline compressor stations along the pipeline route to maintain required operating pressures. Also included are an LNG plant with associated storage tanks, two berths for accommodating LNG tankers at Anderson Bay 3.5 miles west of the VMT, loading facilities, and specially designed cryogenic LNG tankers. Nominal specifications and relevant characteristics of each of these system elements are shown in Table 4.5-5. The pipeline portion of this system (BLM and

[4]The U.S. is a net importer of natural gas and is a candidate market for ANS gas; however, it is unlikely to be an attractive destination for Alaskan LNG. There are only four LNG receiving facilities in the U. S.. Two (Everett, MA, and Lake Charles, LA) are in operation and two others (Cove Point, MD, and Elba Island near Savannah, GA) are shut down, but may be reopened (USDOE, 2000). Seaborne transportation costs for LNG are a significant component of the total cost, and ports on the U.S. East Coast are not logical destinations for Alaska LNG (CERA, 1999a). Environmental sensitivities would probably preclude locating LNG facilities on the West Coast. The Federal Power Commission prepared a final EIS for the so-called El Paso Alaska system, which envisioned an LNG option similar to TAGS except that the LNG facilities would be located at Point Gravina, Alaska (FPC, 1976). The El Paso concept envisioned shipment in LNG carriers to a receiving terminal near Point Conception, California. FPC staff concluded that this LNG option was less attractive than a gas export pipeline, in part because of environmental issues related to facility siting in California. Regardless of the ultimate destination of ANS natural gas, the U.S. would still benefit from its development and commercialization, because this would reduce U.S. net imports of gas and the balance of trade deficit in energy.

Table 4.5-5. *Basic elements of the proposed Trans-Alaska Gas System (TAGS).*

Element	Where Located	Additional Details
Gas conditioning facility	North Slope	300-acre facility to remove entrained liquid hydrocarbons and carbon dioxide
Pipeline	Central TAPS study area	800-mile-long, large-diameter (36- to 42-inch) chilled buried pipeline; ten mainline compressor stations located along route
Liquefied natural gas (LNG) plant and marine loading facility consisting of 2 berths capable of accommodating LNG tankers with a capacity of 165,000 cubic meters	Anderson Bay, approximately 3.5 miles west of the VMT	Facility occupies 390 acres; includes 2.1-billion-cubic-feet-per-day gas liquefaction plant; four 800,000-bbl storage tanks; and marine loading facility
LNG tankers	Ply routes from Valdez to Asia	Fifteen 125,000-cubic-meter LNG tankers involving 275 tanker loadings per year at design terminal throughput of 14 million tons (29.3 million cubic meters) per year

Sources: BLM and MMS (1998), FERC (1993), BLM and USACE (1988)

USACE, 1988) and the LNG production, storage, and marine transportation components (FERC, 1993, 1995) have been described in previous EISs.

There are substantial economies of scale in the construction and operation of these facilities. Therefore, this project must be large enough to reduce gas transportation costs to a competitive level. For both the LNG and the pipeline export project (CERA, 1999a), the projected gas volume is approximately 2 billion cubic ft (bcf) per day. The capacity of the liquefaction facilities (CERA, 1999a) would be compatible at 14 million tons per year (29.3 million cubic meters). A fleet of 15 tankers of 125,000-cubic-meter capacity would make about 275 loaded voyages per year to receiving terminals in the Pacific Rim once LNG production was at full capacity (FERC, 1993). The tanker berths were designed to accommodate these vessels and also to accommodate the next generation tankers of up to 165,000-cubic-meter capacity (FERC, 1993).

Additional relevant characteristics of TAGS are summarized in Table 4.5-6. Recent estimates of construction costs for this project are $4 billion for the pipeline and $8 to $10 billion for the other elements, including the tanker fleet (CERA, 1999a). Public revenue impacts of this project, including property taxes, severance taxes, and royalties, were estimated to be approximately $377 million annually (BLM and USACE, 1988), but could be higher or lower depending on future energy prices. This source does not provide a time profile of annual revenues, but the economic life of the project is given as 30 years (BLM and USACE, 1988). Other characteristics are summarized from recent EISs. Based on an assumed construction period of 10 years, the earliest time the facility could be operational would be 2010, assuming a year 2000 start date. This assumption is made for illustrative purposes only, as explained above.

Relative to TAPS, TAGS would cost less [TAPS cost $8 billion when constructed and would cost nearer to $25 billion today (APSC, 1999c)], would generate less revenues, and would employ fewer people for both construction and operation.

As with other gas commercialization proposals, TAGS has the potential to cause physical, biological, and economic, social, and cultural impacts. Although some of these impacts (e.g., increased state and local revenues, reduced deficits in the balance of trade in energy) are common to all gas commercialization options, others are project-specific. For example, the TAGS project entails the construction of an LNG plant and port facilities at Valdez, whereas ANGTS transports natural gas to destination markets in gaseous form via pipeline.

Table 4.5-6. *Additional features of the proposed Trans-Alaska Gas System.*

Feature	Data
Land affected	Construction 23,216 acres; operation 8,425 acres
Construction period	8 to 10 years; peak work force 10,500
Operations	550 direct jobs and 1,250 indirect jobs
Property taxes	$188 million annually
Severance taxes and royalties	$64 million annually severance tax $125 million annually royalty
Construction cost	Pipeline: $4 billion Other facilities (including tankers): $8 to $10 billion

Sources: CERA (1999a), BLM and MMS (1998), FERC (1993), BLM and USACE (1988)

GTL Option. The foundation for GTL technology is the Fischer-Tropsch (FT) process for converting carbon-based materials such as methane and coal into high-quality petroleum liquids such as naphtha and diesel fuel. Numerous FT pilot and production plants are operating throughout the world (HWLF Inc., 1998).

The type and quantity of by-products and process wastes differ among alternative GTL processes. These factors affect capital and operating costs. Some potential by-products/wastes include water and "tail gas" containing hydrogen, carbon monoxide, carbon dioxide, and light hydrocarbon gases such as methane, ethane, propane, butane, and, depending upon process, nitrogen.

The FT conversion rate of natural gas to liquids is approximately 100 million cubic feet of natural gas to yield 10,000 bbl of liquids (Howard et al., 1998). Figure 4.5-4 shows the estimated liquids production rate (bbl/day) as a function of the field life for various values of possible natural gas reserves. The 30 tcf of natural gas presently stranded on the North Slope could equate to a liquids production rate of approximately 274,000 bbl/day, assuming a 30-year project duration.

The GTL liquids produced by FT have a higher value than crude oil extracted directly from the ground.[5] Therefore, it may be necessary to modify TAPS facilities to handle "batched" operations, including the installation of extra tankage at Pump Station 1 and Valdez to handle GTL liquids. However, unlike either the LNG or ANGTS options, no new pipeline would have to be built because TAPS has enough excess capacity.

The chemical conversion of natural gas to liquid hydrocarbons creates a product that is free of polluting agents and that as a transportation fuel could command premium prices, particularly for certain markets such as the U.S. West Coast (Sherwood and Craig, 2000).

Estimated capital costs for GTL units range from $25,000 to $50,000 per bbl/day (Arthur D. Little Company, 1998; ExxonMobil, 2000). The capital cost varies with design output because there are reported (Arthur D. Little Company, 1998) economies of scale for these units.

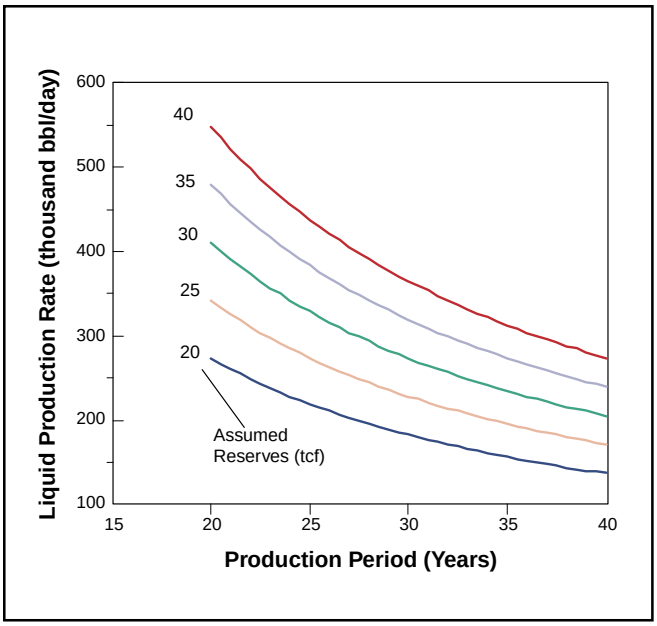


Figure 4.5-4. *Estimated liquid production rate (thousand bbl/day) as a function of assumed natural gas reserves (tcf) and production period (years).*

A potential conceptual design for the North Slope by ExxonMobil (ExxonMobil, 2000) could include an initial plant of 75,000 to 100,000 bbl/day capacity, which would be located near the existing Prudhoe Bay Unit Central Gas Facility. The GTL plant would occupy less than 50 acres and be connected to existing Prudhoe Bay Unit facilities (pipelines, transmission lines, roads, etc.) and house facilities to handle wastes. Facilities for fractionation of GTL liquids would be located at the VMT. Present shipping berths and conventional tankers would be used. The estimated capital cost of these facilities is $3 to $4 billion based on a capacity of 75,000 to 100,000 bbl/day.

In this conceptual plan, the GTL plant would be assembled from 20 to 25 modules (ExxonMobil, 2000), each weighing up to 10,000 tons, fabricated elsewhere, and transported to the North Slope by ocean-going barges during a single summer sealift season. To facilitate implementation, infrastructure upgrades would be made, including a dredged channel to West Dock 2 at Prudhoe Bay, additions/upgrades to dock and berths, and an expansion of the staging area, causeway, and roads.

Liquids from the GTL process could be transported in conventional tankers. Assuming that a 100,000 bbl/day facility were constructed, tanker traffic would increase by approximately 42 tanker loadings/year assuming 7 bbl/ton and shipment in tankers of 125,000 deadweight tons.

As noted above, a GTL proposal has not reached the stage of preparation of a draft EIS, but a USDOE-spon-

[5]There are two reasons for the difference in values. First, GTL products contain naphtha and diesel. Second, these products are free of sulfur, nitrogen, and aromatics — excellent liquids for subsequent conversion to petrochemicals and refining operations. Naphtha is used to make gasoline or is converted to olefins and subsequently into a variety of plastics. Diesel can be used directly. GTL diesel is reportedly cleaner in engine tests. Compared to conventional diesel fuel, GTL diesel offers a 10 to 50 percent reduction in the emissions of hydrocarbons, carbon monoxide, nitrous oxide, and particulate matter (Portman, 2000; Bohn and Benham, 1999; USDOE, 2000). Waxes can be used for such products as candles and in the lumber industry, and white oils can be used for aluminum processing and in the cosmetics industry (ExxonMobil, 2000.)

sored study (INEEL, 1999) concluded that current GTL technology would be economically comparable to the large-scale LNG manufacture-and-export plan. As with other concepts to commercialize ANS natural gas, the GTL option would have both economic and environmental impacts. A GTL project could extend the economic lifetime of the TAPS pipeline, would spread out the cost of TAPS transportation over a greater number of barrels, and would improve the economics of marginal oil fields thus freeing potentially stranded ANS oil and gas[6].

Export Pipeline Option. U.S. natural gas imports totaled approximately 3.585 tcf in 1999. Compared to crude oil, the United States is more self-sufficient in natural gas. Net imports of natural gas (3.38 tcf in 1999) were approximately 15.8 percent of domestic consumption (21.36 tcf), according to estimates in USDOE (2000a). As recently as 1986, net imports only accounted for approximately 4.2 percent of U.S. consumption (USDOE, 1999). Figure 4.5-5 provides a time series of net imports of natural gas imports (tcf) and net natural gas imports as a percentage of domestic demand from 1960 to the present. Domestic production of natural gas is concentrated in Texas, Louisiana, Oklahoma, and New Mexico.

The majority (95.4 percent) of U.S. imports was supplied by natural gas shipped through pipelines, rather than by LNG. Compressed natural gas was imported via pipeline from Canada and Mexico; imports of Canadian natural gas accounted for 3.367 tcf or 98.4 percent of pipeline imports in 1999.

Many alternatives for transportation of Alaskan natural gas to the contiguous 48 states by a pipeline though Canada were evaluated carefully in the late 1970s. In 1976, BLM completed an EIS on the subject and the Federal Power Commission (FPC) completed an environmental and economic comparison of various alternatives with other LNG options then under consideration (FPC, 1976). The gas export pipeline concept, ANGTS, envisioned the construction of a chilled, large-diameter natural-gas pipeline from Prudhoe Bay across Alaska and through Canada to the United States for delivery to U.S. markets. The scale of the ANGTS project would be approximately the same as that of the LNG project (2 bcf/day), approximately 22 percent of U.S. net imports of natural gas in 1999.

Several alternative pipeline routes were evaluated. The preferred northern route described in the ANGTS EIS included an inland, 195-mile-long, buried pipeline extending east from Prudhoe Bay to the Canadian border about 4.5 miles inland from the Beaufort Sea. From there, the pipeline would travel southeast through the Mackenzie Delta into Alberta. Once in Alberta, the pipeline would join the North American pipeline grid and deliver natural gas to locations as far removed as California and Pennsylvania. In addition to transporting ANS natural gas into the U.S., this pipeline would carry natural gas from Mackenzie Delta deposits to southern Canada.

Another northern route entails construction of a buried offshore pipeline from Prudhoe Bay to the Mackenzie Delta. The pipeline would then head south into Alberta and connect to the North American pipeline grid.

Other more southerly routes were evaluated, including a route (the Alcan route) which would follow the existing TAPS ROW from Prudhoe Bay south towards the community of Delta. The pipeline would then head southeast and enter the Yukon Territory of Canada. The distance from Prudhoe Bay to Canada would be approximately 730 miles. Once in Canada, the route would travel through the Yukon Territory and then to Alberta. From there, the pipeline would be connected to the North American pipeline grid by existing or new pipelines for gas distribution in the contiguous 48 states.

Selection of a southerly route through or near Fairbanks would permit gas to be provided to the Fairbanks/North Star Borough as well as offer the possibility of fueling TAPS Pump Stations 5 through 9 with natural gas.

Recently, interest in a gas pipeline has been revived, with both northern and southern routes being discussed. The total capital cost for each of these routes is estimated to be between $5 and $6 billion depending on the route,

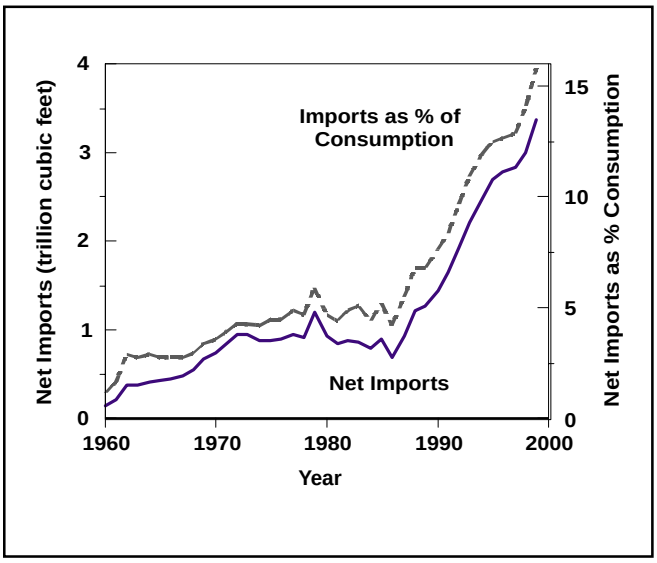


Figure 4.5-5. *Net natural gas imports and net imports as a percentage of domestic consumption according to USDOE (2000a) estimates.*

[6]See Appendix A for a discussion of TAPS throughput projections.

and the pipeline would take more than 7 years to complete (CERA, 1999a). If any export pipeline were built, Alaska would benefit from the sale of currently stranded gas reserves and increased investment in oil and gas exploration in Alaska. Either route would increase the tax base of the North Slope Borough and contribute to state revenues from oil and gas. If the original project had been implemented in the late 1970s, state revenues and royalty payments from ANGTS were projected to be $67 million in 1990. Actual revenues and royalties depend on world energy prices, gas transportation costs, and the terms of the royalty agreement.

The facilities in the pipeline project include a central gas conditioning plant, the gas pipeline (48-inch, 2 bcf/day), compressors, gas chillers, valves, metering stations, and communication sites. In qualitative terms, the construction-related impacts would be similar to those associated with TAPS. During one to several years of construction, there will be temporary disruptions such as worker camps, ports, airstrips, helipads, snow-ice roads, fuel storage sites, material sites, equipment repair facilities, and sewage treatment facilities. Permanent structures such as the buried pipeline, river crossings, compressor stations, repeater stations, permanent roads, and helipads would remain for the duration of the project. The type and number of the permanent structures will depend on the route chosen. For the alternative originally recommended, approximately 4,633 acres of land would be required along the 195-mile segment in Alaska. During operation, the pipeline would require less land (3,720 acres) and fewer people than during construction.

After construction, workers will be used for operations, maintenance, and pipeline inspection. Because the ultimate reserves of natural gas in this region have yet to be determined, the useful life of the facilities is unknown. However, according to FPC (1976) the physical life of the pipeline is expected to be more than 50 years, with a 100-year life "within the realm of possibility" (FPC, 1976). Upon completion of service, DR&R activities would be initiated. Table 4.5-7 summarizes salient characteristics of the ANGTS project.

The extent and location of various physical, environmental, economic, and sociocultural impacts in Alaska depend on the specific route selected. Under a northern alternative, only a short stretch of the entire pipeline would be in Alaska and it could potentially be buried offshore. A southerly route would be longer and could require additional permanent facilities. Most physical, biological, and sociocultural impacts in Alaska were not projected to be substantial in any of the applicable EISs (e.g., BLM, 1976).

Economic impacts (e.g., property taxes paid to state and local government, employment, Alaska purchases) of a gas export pipeline also vary with the route selected. Selection of the Alcan route for the export pipeline would also permit natural gas to be supplied to Fairbanks. All routes for the gas-export pipeline would generate revenues from royalties, and all routes would have similar impacts on the U.S. balance of trade in natural gas. However, the net wellhead price, and therefore, royalties and taxes, might vary with the route. Bradner (2000) reported that internal studies by state agencies show that because the northern route is shorter and crosses no major mountain ranges, it offers savings that translate into increased wellhead prices.

Table 4.5-7. *Overview of ANGTS project.*

Overview of ANGTS Project	
System Elements	• Gas gathering, conditioning, compression, and chilling facilities on ANS • Pipeline (and block valves) connecting above facilities to major pipelines in North American grid • Gas compressor/chiller stations along pipeline • Ancillary facilities (e.g., taps along pipeline, material stockpile sites, helipads, airstrips, seaport areas, communications sites, meter station, water and fuel storage, garage and repair facilities, electrical generation facilities, living quarters, etc.)
Route	Several under consideration (see text).
Throughput	2 bcf/day with possible future expansion
Capital Cost	Detailed costs under study but are likely to depend upon route. CERA (1999a) estimates costs in $5 to $6 billion range
Economic Life	Unknown, dependent upon new discoveries, energy prices, and transportation costs. Could be >50 years.

Sources: FPC (1976), CERA (1999a), BLM (1976).

National Missile Defense System Facility

Plans are now being developed that would locate a launch site for a NMDS in Alaska (U.S. Army Space and Missile Defense Command, 1999). Modifications to the Anti-Ballistic Missile Treaty now being negotiated with Russia would permit the United States to place 100 ground-based interceptor missiles in Alaska, although the administration budget currently funds only 20 missiles. A decision on whether and where to build the $10.5 billion system was expected by late 2000. If authorized at that time, the system could have been operational as early as 2005. However, the program schedule slipped, and the deployment decision was postponed and left for the new administration. No new timetable for a Record of Decision has been announced.

A draft EIS was completed for this system (U.S. Army Space and Missile Defense Command, 1999). The EIS considered three possible sites: the Yukon Training Area near Eielson Air Force Base, south of Fairbanks; Clear Air Station, near Anderson; and Ft. Greely, near Delta Junction. The draft EIS indicated that the Ft. Greely site (at $626 million) would be more expensive than that at Clear, but construction at Clear would disturb 135 acres of wetlands. Construction on the site at Ft. Greely would also ease economic dislocations from the scheduled shutdown of this facility in 2001. Ft. Greely is important to the Delta Junction economy.

Construction of the missile site at Ft. Greely would employ about 300 people for 5 years and result in indirect local expenditures of approximately $62 million per year, which would create about 620 indirect jobs in the Delta Junction and Fairbanks areas during construction (U.S. Army Space and Missile Defense Command, 1999). Once the system was operational, approximately 360 people would be needed to run the base, and operations spending would create an estimated 108 indirect jobs. The economic benefit would help to offset the effects of decommissioning Ft. Greely — the closure will eliminate more than 600 military and civilian jobs. Although local opinion favors the NMDS project, some residents are concerned that the influx of additional personnel will create hunting pressure on local game populations.

The cumulative effects analysis assumes that the decision is made to proceed with the NMDS installation and that the Ft. Greely site is selected.

4.5.2.2 Types of Issues Creating the Potential for Cumulative Effects

Once other past, present, and reasonably foreseeable future actions have been identified, environmental issues associated with those actions must be factored into the cumulative effects analysis. Because of the different natures of the physical, biological, and social environmental components, potential impact issues were organized in the manner most useful and appropriate for the subject. Issues were sorted into broad categories that allowed similar effects to be aggregated. The consolidated issues were the basis for screening and ranking.

In the cumulative effects analysis, the consolidated issues were organized as follows:

1. **Physical Issues**
   - Terrestrial Environment (Land Forms)
   - Oil and Other Spills
   - Permitted Discharges
   - Air Quality
2. **Biological Issues**
   - Obstructions to Movement
   - Disturbance and Displacement
   - Habitat Loss/Alteration/Enhancement
   - Mortality
   - Hunting, Trapping, Fishing, and Recreational Effects
3. **Social Issues**
   - Economics
   - Social Change
   - Subsistence
   - Visual/Recreational
   - Environmental Justice
   - Land Use

The issues were screened to determine whether they might interact with the potential direct or indirect effects of the proposed action and the no-action alternative. The screening process is described in Section 4.5.1. Every issue that received a “yes” during screening as a potential cumulative effect was evaluated, ranked with respect to intensity and probability, and discussed by a specialist in the pertinent subject area (Sections 4.5.3 and 4.5.4).

4.5.3 Results: Proposed Action

This section presents the results of the cumulative effects analysis conducted for the proposed action. Potential cumulative effects are discussed with respect to physical, biological, and social resources and in the context of their most likely geographic locations — ANS, Central TAPS study area, and/or Valdez/PWS. The results were derived by following the procedure for cumulative effects analysis described in Section 4.5.1.

This analysis considers the effects of the renewal of the pipeline ROW along with the continued operation of the ANS oil fields, the VMT, and the associated marine transportation link. All of these facilities are related and interdependent, and none would be economically viable if the others did not exist. The project study area is divided into the Alaska North Slope, Central TAPS, and Valdez/PWS study areas.

The CEQ definition of “cumulative effects” obviously includes the ANS fields, VMT, and marine transportation link but may also include other actions. Other EISs covering Alaska developments have included potential oil and gas activities on the North Slope (ADNR, 1997, 1998, 1999; FERC, 1993, 1995; FPC, 1976; USACE, 1997, 1999; BLM, 1976; BLM and MMS, 1998; MMS, 1987a, b, 1990,

1991, 1996a, 1998).

Other reasonably foreseeable petroleum-related activities that could interact with the alternatives to produce cumulative effects are discussed briefly in Section 4.5.2. These included two main categories: first, expansion and further development of existing and other ANS oil fields (Appendix A), and second, the commercial development of Alaska's substantial natural gas reserves. These and other potential future actions are considered in greater detail in the context of the individual impact discussions that follow.

It is assumed that either a GTL project using the existing TAPS pipeline or a new natural gas pipeline will be implemented in the event that the proposed action is selected; conversely, it is assumed that if the no-action alternative is selected, natural gas commercialization will not be economically feasible. This cumulative effects analysis assumes, for the sake of completeness, that the decision will be made to proceed with the NMDS installation at Ft. Greely, whether or not the proposed action is implemented.

4.5.3.1 Proposed Action: Physical Resources

By R.G.B. Senner, J.M. Colonell, J.D. Norton, and B. Trimm

After almost 25 years of operation, physical resource impacts of TAPS are fairly predictable. This section addresses several areas of potential cumulative effects for reasonably foreseeable future projects and continued operation of TAPS. These effects will likely occur even assuming that TAPS will continue to operate in compliance with permits and stipulations. Table 4.5-8 presents the criteria for ranking potential cumulative effects on physical resources. None of the potential cumulative effects met the intensity and probability criteria for significance.

Direct/indirect effects of TAPS operations and maintenance and of the no-action alternative are described in Sections 4.3 and 4.4, respectively. Because the pipeline system has been in continuous operation since 1977 under stringent regulatory controls, its effects on the physical environment — soils and land forms, air quality, and water quality — are familiar and can reasonably be expected to continue without significant change under the proposed action. Gas commercialization would add to the existing physical effects of TAPS depending on which alternative is implemented. The NMDS installation at Ft. Greely could produce cumulative effects in a small portion of the Central TAPS study area, and growing tourism and recreational activities would provide additional synergies although these impacts are expected to be insignificant.

The following discussion addresses only impacts to physical resources and not impacts on biological and social/cultural resources resulting from impacts to physical resources. For example, impacts of oil spills on the physical environment are discussed in this section, but impacts, if any, to biological resources or social/cultural resources are discussed in Sections 4.5.3.2 and 4.5.3.3, respectively.

The potential cumulative effects of the proposed action described below and are summarized and ranked with respect to intensity and probability in Table 4.5-9. Figure 4.5-6 presents the impact assessment matrix illustrating the significance rankings for the physical cumulative impacts.

Phy1. Changes to terrestrial environment (land forms).

Activities such as ANS development and/or gas disposition projects can change the terrestrial environment and affect visual/recreational resources, as well as the integrity of the terrestrial environment. The latter effects are discussed below. Potential impacts to visual/recreational resources are discussed in Section 4.5.3.3.

The network of gravel roads and pads that support TAPS and the North Slope oil-field infrastructure has unavoidably changed the landscape and will remain throughout the lifetime of the proposed action. Material-site use is consolidated at a few individual, regulated locations and contributes only a very local impact. For many years the petroleum industry has conducted systematic research on the rehabilitation of decommissioned roads and pads in the North Slope oil fields by creating controlled conditions that encourage revegetation by native plants. Experimental test sites have been shown to respond well to this approach, and many inactive gravel structures have become difficult to locate visually after 10 to 15 years (McKendrick, 2000b, pers. comm.).

As a cumulative effect, the network of roads and pads on the North Slope will increase in scope as new fields are brought into production. Roads and facility pads required for gas commercialization could add to the cumulative effect, and there is a potential for recreational facilities to make a further cumulative contribution. The annual increment of oil-field growth effects, however, would continue to decline because of mitigative strategies and technical advances, such as directional drilling, used successfully by the petroleum industry to consolidate production sites and reduce facility footprints. The oil-field infrastructure would remain until DR&R at some unknown future time. Following DR&R, restoration efforts will occur, and it is likely that the tundra will reclaim former oil-field sites and that signs of construction will greatly diminish within 25 years after the sites have been decommissioned.

Actively used gravel roads and pads associated with TAPS will remain throughout the life of the proposed ac-

PHYSICAL CUMULATIVE EFFECTS SUMMARY: PROPOSED ACTION

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
Phy1 **Changes to terrestrial environment (land forms).**	Actively used gravel roads and pads and material sites associated with TAPS would remain throughout the life of the proposed action with their existing changes to the land forms. Significant restoration of the TAPS ROW will not occur until 2034 or later.	Roads and facility pads required for gas commercialization would add to the cumulative impact. For a buried gas pipeline, there would be a requirement for material sites, gravel access roads, gravel pads to support compressor stations, and limited portions of gravel workpad in locations where winter construction techniques would not be feasible.	The network of gravel roads and pads in the North Slope oil fields would remain throughout the proposed action. The annual increment of oil field growth would decline because of mitigative strategies and technical advances. Oil-field infrastructure would be remain until DR&R at some unknown future time. After DR&R, the tundra will reclaim former oil-field sites, and visible signs of construction will greatly diminish within 25 years.	A potential exists for recreational facilities and use to add to the cumulative impact.	Possible, unidentified landform impact from development of facilities.	Possible, unidentified landform impact from infrastructure development.	L	M-H	H	M	L
Phy2 **Changes to soil from dust deposition from gravel roads and pads.**	The dust-shadow effect will continue as at present, producing localized changes in microsite conditions such as moisture, albedo, and soil pH.	Increased traffic during project construction could have a minor, transitory impact.	The dust shadow effect has been well-documented along more heavily used gravel roads in the Prudhoe Bay oil field.	A potential exists for recreational facilities and use to add to the cumulative impact.	Negligible impact.	Negligible impact.	L	L	H	L	M
Phy3A **Changes to soils or water from large spills.**	A climatic or geological event or a mechanical failure could damage the structural integrity of the Trans Alaska Pipeline, resulting in a major spill.	Impact only if GTL liquids spill.	On the ANS, structural integrity of facilities belonging to TAPS, to one or more production units, or to oil-field support services and structures could result in a large spill, leading to a cumulative impact. A tanker spill is possible.	Unlikely that major spill will result.	Negligible impact.	Negligible impact.	H	M	L	H	L
Phy3B **Changes to soils or water from small spills.**	Small spills will continue as a result of leaks at valves and fittings and during fuel and product handling. Most small spills will be on the work pad and contained.	If gas commercialization employs GTL technology, there is a further potential that GTL products would be added to the inventory of fluids transported and total liquids transported will increase.	There will continue to be small spills associated with valve leaks and fuel and product handling.	A potential exists for recreational facilities and use to add to the cumulative impact.	Negligible impact.	Negligible impact.	L	L	M	L	H
Phy4 **Changes in air quality from air emissions.**	Emissions from pump stations and terminal will remain within regulatory standards mandated by regulations. Minor permit excursions might occur, but air quality will remain high.	An LNG terminal at Anderson Bay would be operated under its own air permit, with additional stringent state and federal requirements for potential natural gas releases to the atmosphere. Pump stations for a gas pipeline would operate under the same rules.	Emissions from oil field facilities will remain within regulatory standards mandated by the regulations. Minor permit excursions might occur, but air quality will remain high.	A potential exists for recreational facilities to add minimally to the cumulative impact.	Negligible impact.	Possible, unidentified but relatively small regulated discharge.	L	H	H	M	L
Phy5 **Changes to water quality from wastewater discharges.**	Discharges of domestic and non-domestic wastewater from TAPS facilities may cause minor changes in local water quality, but these changes are within regulatory standards. Minor permit excursions might occur.	Gas commercialization will have the potential to add new point-source discharge sites, but regulated discharges will avoid creating densities of wastewater discharges high enough to exceed state water quality standards for receiving waters. A possible LNG terminal at Anderson Bay near the VMT will produce waste water, but there should be no oily ballast water to treat.	Because individual oil-field, oil-field-support-service, and tourist facilities on the North Slope must operate under strict regulatory controls, releases of processed effluent from individual wastewater treatment systems should not be an issue. There is a potential, however, for an adverse cumulative impact resulting from many individual and separate permitted discharges to land and water.	Growing tourism will have the potential to add new point-source discharge sites, and these will have to be regulated to avoid creating densities of wastewater discharges high enough to exceed state water quality standards for receiving waters.	Relatively small regulated discharges could add to existing discharges.	Possible, unidentified but relatively small regulated discharge.	L	M	H	M	M

Table 4.5-9.
Physical cumulative effects summary: Proposed action.

Table 4.5-8. *Criteria for ranking potential cumulative effects on physical resources.*

	High	Moderate	Low
Magnitude	The effect would alter a physical resource in a way that would degrade its value to the point that it could not be used for subsistence, recreational, or commercial purposes, or would endanger human health. For example, both a series of large-volume marine oil spills *and* the destruction of a single fish stream by silt-laden runoff from multiple project sites could be in this category, although they might differ in geographic scope	The effect would indisputably alter a physical resource, but still allow the resource to be used for subsistence, recreational, or commercial purposes without endangering human health. For example, the construction of multiple access roads into a formerly roadless area would alter it physically, but would still allow the area to be used safely for subsistence, recreational, or commercial purposes, although some of these uses might be diminished and others enhanced. With moderate effects, users with different purposes typically tend to disagree about the extent of resource degradation.	The effect would visibly or measurably alter a physical resource without removing its value for subsistence, recreational, or commercial purposes, and without endangering human health. For example, ponding alongside gravel roads and pads built to support a variety of projects would alter the physical characteristics of an area without diminishing its overall value for subsistence, recreational, or commercial purposes, and without endangering human health.
Geographic Scope	The effect would occur on a statewide basis, or throughout a defined region such as the ANS, central TAPS study area, or PWS. For example, construction of a natural gas pipeline in the BLM Utility Corridor, aligned roughly parallel to the existing TAPS pipeline, would qualify as *high* in geographic scope.	The effect would occur at the borough or community level, or on a limited portion of the ANS, Central TAPS study area, or VMT/PWS. For example, establishment of a new production unit in the Prudhoe Bay oil fields would be considered *moderate* in geographic scope.	The effect would be site-specific or occur at a few isolated locations. For example, expansion of the Williams refinery at North Pole, with associated facility modifications at the North Pole Metering Station, would be rated as *low* in geographic scope.
Frequency and Duration	The effect would be continue indefinitely. For example, construction and operation of compressor stations for a natural gas pipeline would be in this category.	The effect would occur intermittently. For example, the recurring but infrequent release of black smoke from flare stacks would be ranked as *moderate*.	The effect would most likely occur only once, if at all. For example, a 500-year flood event on the Yukon River could occur more than once during the project life, but this is unlikely.
Intensity	*Evaluated based on magnitude, geographic scope, and frequency/duration, using the criteria defined above.*		
Probability	Probability greater than 0.6.	Probability in the 0.3 to 0.6 range.	Probability of less than 0.3.

tion, and significant restoration of the TAPS ROW will not occur until 2034 or later. It can be assumed that restoration techniques and mitigation measures used after 2034 could be more advanced than today and could reduce enduring terrestrial impacts. From 2004 to 2034, impacts to the terrestrial environment would be mitigated to allow continued use of the land, with focus on erosion control, stabilization, and revegetation.

As described in Section 4.3.1, the terrestrial environment affected by TAPS has generally stabilized, and major long-term changes to the terrestrial environment are not anticipated. Future impacts would be influenced most by construction of a new gas pipeline. Although the proposed TAGS or ANGTS would consist of a buried pipeline, there would still be a need for material sites, gravel access roads, gravel pads to support compressor stations, and gravel workpads in locations where winter construction techniques would not be feasible (BLM and USACE, 1988). Based on over 20 years of operating history of the ANS fields and TAPS, integrity of the terrestrial environment would be only temporarily disrupted by a new project and would quickly stabilize.

The magnitude of this potential cumulative effect is low when judged against the criteria on Table 4.5-8 since future activities related to North Slope development or to gas commercialization will visibly or measurably alter the terrestrial environment but will not remove their resource value. Geographic scope will be high if a gas commercialization project other than GTL goes forward but moderate if future effects are caused only by ANS development or a GTL project. Frequency and duration would be high because effects will remain at least until 2034. The overall intensity ranking is moderate based on the low magnitude of the effect and the uncertainty of a gas disposition project. The probability of continued activity on the North Slope or a gas disposition project affecting integrity of the terrestrial

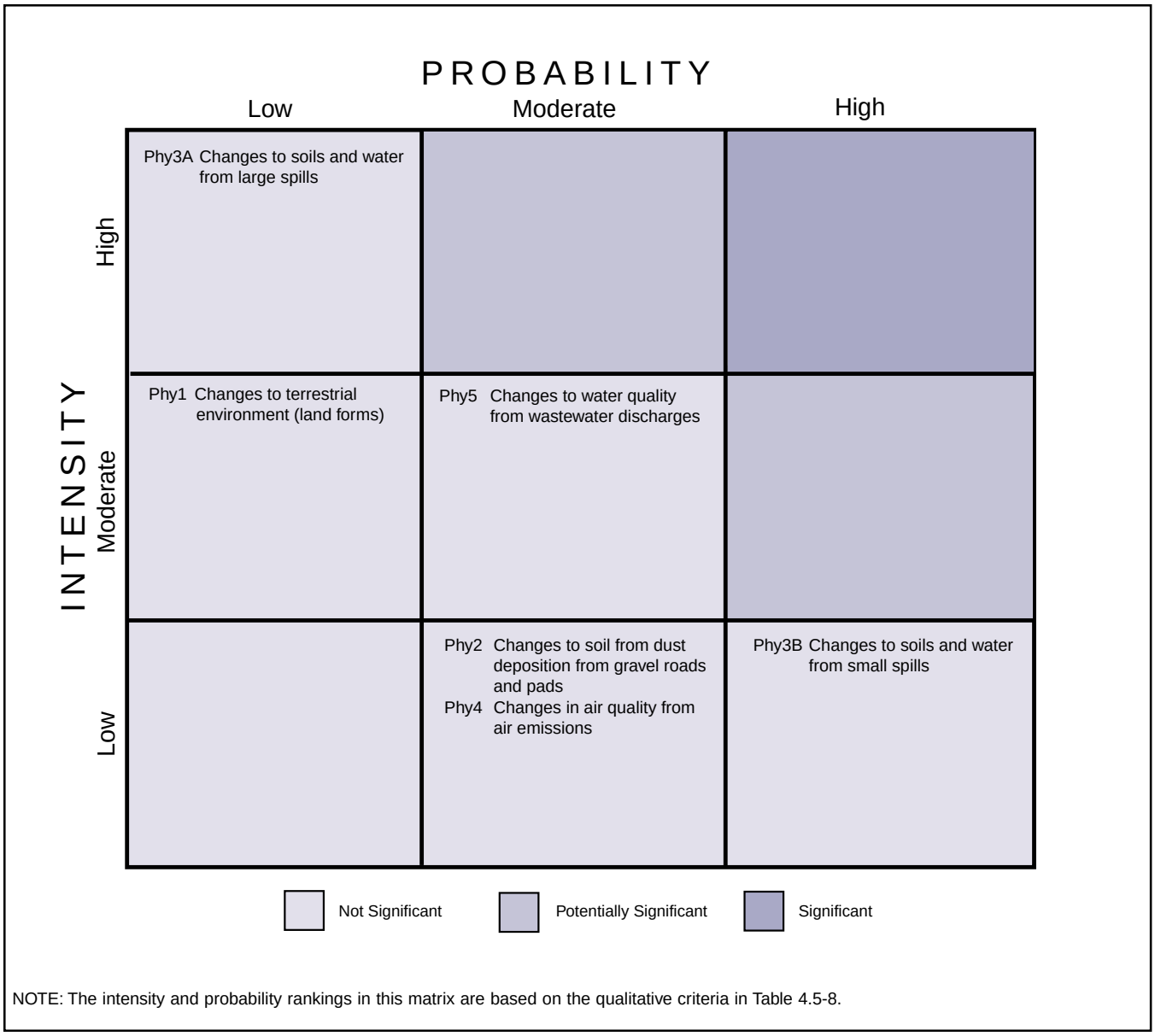


***Figure 4.5-6**. Ranking matrix of potential cumulative impacts on physical environment (proposed action).*

environment is low based on the current status of land forms affected by TAPS and the ANS oil fields after over 20 years of operating experience.

Phy2. Changes to soil from dust deposition from gravel roads and pads.

The dust-shadow effect has been well documented along more heavily used gravel roads in the Prudhoe Bay oil field (see review by Auerbach et al., 1997; also Walker and Everett, 1987; and Walker, Cate, et al., 1987). Dust shadows also occur in places along the Dalton Highway (Montgomery, 1999, pers. comm.; Schmidt, 1999, pers. comm.; Shoulders, 1999, pers. comm.), although it has been well documented only for roads with heavy traffic on the North Slope (Walker, 1999, pers. comm.). In the proposed action, the dust-shadow effect will continue as at present, producing localized changes in microsite conditions such as moisture, albedo, and soil pH. Such changes will be confined largely to the locations where they presently occur, unless a major new development leads to one or more new roads that support traffic loads comparable to the Prudhoe Bay Spine Road or the Dalton Highway (Walker, 1999, pers. comm.). The establishment of new production units on the North Slope could lead to such an outcome if traffic on the connecting roads is frequent enough to produce heavy dust deposition, but thermokarsting, if it occurs at all, would be

limited to the heaviest dust zones (Walker, 1999, pers. comm.). A gas disposition project could result in increased traffic along the Dalton Highway to support construction but would not result in a large increase in traffic beyond the construction period.

This potential cumulative effect is ranked as low in magnitude, because any local thermokarsting would not affect current or traditional activities on the North Slope or endanger health. Geographic scope is also low, because thermokarsting would be site-specific, occurring in only a few isolated locations where roadside dusting was particularly heavy. Frequency/duration is high, because the effect would continue for as long as heavy vehicle and equipment traffic was sustained. Intensity is low, because existing thermokarsting along roads on the North Slope has not been shown to have an adverse effect on any resource or function. Probability is moderate, because although the effect has been documented, major increases in vehicle and equipment traffic on the North Slope are not foreseen.

Phy3. Contamination of soils or water from spills (Phy3A, large spills; Phy3B, small spills).

Spills can be caused by natural events, integrity failures of a system, or accidents. The impact of spills on soils and water depends on the size of the spill, product spilled, location, and effectiveness of the cleanup and remediation. A spill on undisturbed soils will have a significantly different environmental impact than a spill contained on a gravel pad. Spills can occur where contact with water is unlikely or where the spill can contact both land and water or water alone. Cleanup of spills is required by state and federal regulations, along with remediation actions as appropriate. Impacts can result from cleanup itself. Spill cleanup and disruption of normal use can vary from a day or less to several years depending on severity. Spill impacts are generally not long-lasting or of environmental consequence after cleanup and remediation.

It is possible that a climatic or geological event could damage the structural integrity of TAPS, resulting in a major spill (**Phy3A**). Earthquakes, flooding, wildfires, lightening strikes, and glacial changes have all occurred more than once in the vicinity of the TAPS ROW without adverse effects on the pipeline. Of these events, only flooding has threatened the pipeline because of the danger of washouts to VSMs, buried sections of pipeline, and valve housings. Risk from flood damage is mitigated through river training structures and, increasingly, through management of stream-channel configurations near pipeline crossings. Along the entire 800-mile route, gate and check valves are built into the pipeline to limit the volume of crude oil that would be released in the event of a leak. In addition, containment dikes or structures are located at critical locations along the pipeline. Nevertheless, a major spill is possible, and response equipment is maintained in a constant state of readiness at all pump stations and at strategic locations along the route. Residents of local communities such as Rampart and Stevens Village are an integral part of the program and, along with Alyeska personnel, receive repeated training in oil spill response. Thus, a combination of mitigative engineering design and response preparedness minimizes the effect of any spill that might occur.

The seismic history of the PWS region and the southern portion of TAPS demonstrates the potential for a high-magnitude earthquake. Special design features for the pipeline mitigate the risk of a pipeline failure. The VMT was designed to meet this contingency, specifically through secondary containment of the large-volume crude oil storage tanks on the terminal site and emergency shutoff valves, among other measures. Nevertheless, a large earthquake or other type of event could result in the loss of stored crude oil and fuel products to the waters of Port Valdez. A cumulative effect would result in the event of similar losses from the Petro Star refinery, other industrial and commercial facilities and, potentially, a future LNG terminal constructed at Anderson Bay.

On the North Slope, loss of structural integrity of facilities belonging to TAPS, to one or more production units, or to oil-field support services and structures could cause a major spill leading to a cumulative effect. Although TAPS facilities and oil-field production units, and other industrial and commercial operators function under strict regulatory and proprietary controls, a major spill of crude oil, fuels or — in the case of GTL-based gas commercialization — GTL products will be possible. Other gas commercialization alternatives are unlikely to create a major oil spill risk.

Besides concerns about natural events, maintaining structural integrity to avoid pipeline failure receives a major expenditure of effort, time, and funding by Alyeska. Thousands of preventive maintenance procedures are conducted and documented every year in this regard. The potential for pipeline corrosion is regularly monitored by automated and manual procedures. These include using instrumented “pigs” that travel through the pipeline and monitor wall thickness and condition, and annual corrosion inspections of above-ground and buried portions of the pipeline scheduled to ensure that the entire pipeline is examined on a recurring basis. Other preventive maintenance includes the regularly scheduled installation of cathodic protection devices. Similar controls are in place to mitigate the effect on pipeline structural integrity of damage caused

by metal fatigue from pressure cycles and vibrations. A significant security and surveillance program protects the system from terrorist threat. Section 4.2 provides more detailed discussion of methods used to mitigate these threats.

The magnitude ranking of a major spill is high, because human health could be endangered, resource values could be reduced, and the commercial viability of areas impacted by a spill would be reduced until completion of cleanup and site rehabilitation. Geographic scope is moderate, because a large spill or series of spills could affect site-specific but moderately large onshore areas or potentially a portion of the nearshore marine environment if the spill is on water. Because the VMT/Valdez area has a very large oil-spill response capability, a large spill at the VMT or in PWS would likely be contained and would not disperse widely in a manner similar to the *Exxon Valdez* spill.

Frequency/duration is ranked as low, because such an event would occur at a very low frequency, if at all, and duration of impact would be relatively short. Based on the high magnitude ranking and moderate geographic scope, the intensity of this potential effect is high. Probability is low, because large oil spills have not occurred in the North Slope oil fields and have been infrequent along TAPS and the tanker routes.

Small spills (**Phy3B**) can be caused in several ways. Some valves on North Slope pipelines and TAPS have been found to leak small amounts of crude oil into their secondary containment structures. Valve leaks occur on any pipeline. The risk is minimized through mitigation measures such as ensuring that pipeline valves are placed in secondary containment structures and conducting regular and comprehensive valve monitoring. See Section 4.2 for a discussion of management controls that reduce and control the risk of minor leaks from operations and maintenance activities.

Because of the continuous monitoring of TAPS and production unit pipelines, such leaks seldom enter the surrounding environment, and they involve very small quantities of oil and are corrected. Still, there is a potential cumulative effect associated with TAPS and oil-field production pipelines. If gas commercialization employs GTL technology, GTL products would be added to the inventory of fluids carried by TAPS, and the total volume of liquids transported by TAPS would increase. Some TAPS valves have released small quantities of crude oil into their secondary containment structures. In a few isolated cases — e.g., Check Valve 92 — larger quantities have been released to the surrounding environment, but the areal extent of effects have been relatively small.

The great majority of spills associated with TAPS and with the North Slope oil fields involve small releases of fuels or lubricants. Most of these spills are to gravel pads, but some occasionally contact soil and/or water. There is a cumulative effect when spills from TAPS, North Slope production units, oil field services, tourism and potentially, future gas commercialization are factored together, although each spill is site-specific and separately reported and cleaned up.

In general, spills at the VMT consist of fuel products and are contained and removed before contacting soil or water. In some cases, soils in the VMT industrial complex have been contaminated by fuel spills, and these sites have been remediated. The potential for a cumulative effect of VMT spills with spills from the Petro Star refinery, other industrial and commercial facilities along Port Valdez, and a future LNG marine terminal at Anderson Bay is small but present. Furthermore, occasional crude oil and fuel spills occur during tanker berthing at the VMT, and LNG tanker operations at Anderson Bay could add to this effect. In both cases, however, released hydrocarbons would be immediately contained by the preventive booming placed around all berthed tankers at either terminal.

The magnitude of this potential cumulative effect is ranked low because the small quantities involved would not alter the physical environment to the extent that it would degrade its resource value in terms of subsistence, recreation, or commercial use, or endanger human health. Geographic scope would also be low, because the site-specific small spills would not interact with one another to create a wider effect. Frequency/duration would be moderate, because the effect would occur intermittently, at different locations, during the lifetime of the proposed action. Therefore, the intensity of this potential cumulative effect is low. There is a high probability that individual small spills will continue to occur.

Phy4. Changes in air quality from air emissions.

Air emissions from Alyeska pump stations and North Slope oil-field facilities are regulated by ADEC under State of Alaska Air Quality Regulations (18 AAC 50), with overview authority retained by the EPA under the Clean Air Act. Individual facilities are regulated by ADEC air quality operating permits that prescribe types and quantities of stationary emission sources; place limits on air pollutant emissions; require that any modifications to or replacements of existing sources, or startup of new sources, receive advance approval from ADEC; require regular reporting of facility emissions to ADEC; and establish monitoring, record keeping, and reporting requirements. Certain mobile or portable emissions sources are also regu-

lated by permit.

The construction of new facilities that would create new emission sources requires additional permitting by ADEC under Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act. This is a complex and lengthy process requiring emission-control technology evaluations and ambient-air impact-modeling. New Source Performance Standards (NSPS) also apply to major new stationary sources of air emissions. As new oil and gas production units are developed on the North Slope, their facilities will be subject to these requirements. PSD permitting, in particular, takes into account the emissions that will be added by a facility to permitted air emissions already in effect. Gas commercialization and other future oil field developments will be subject to these controls, and the cumulative volume and mix of emissions will be regulated by ADEC to minimize air pollution.

Atmospheric emissions from the VMT consist primarily of steam, hydrocarbon, and particulate output from the powerhouse. A tanker vapor recovery system designed to collect hydrocarbon vapors associated with tanker loading and divert them to the powerhouse fuel stream has recently been installed to reduce emissions. Powerhouse stack emissions are controlled by an ADEC operating permit and must meet federal and state air quality standards. An LNG terminal at Anderson Bay would be operated under its own ADEC permit, with additional stringent state and federal requirements for potential natural gas releases to the atmosphere. Moreover, the new terminal would have to meet PSD and NSPS increment provisions of the Clean Air Act that would be based on pre-existing VMT emissions. The volume and constituents of the emissions from a new terminal would be permitted only after extensive analysis and modeling to assure that the cumulative total would meet National Ambient Air Quality Standards.

If gas commercialization proceeds using GTL technology, the TAPS pipeline would be operated as a batch line carrying North Slope crude oil and GTL products in alternating batches. This mode of operation might require more frequent use of large breakout tanks for the temporary storage of crude oil or GTL products to allow the alternating transport of these materials to be precisely scheduled and coordinated, and to minimize pressure fluctuations in the pipeline. Opacity exceedances are sometimes associated with the diversion of crude oil to the breakout tanks. These unavoidable transient events are permitted, provided they are reported to the ADEC within 24 hours of the incident, and they are mitigated through careful nomination and regulation of crude oil flow through the pipeline and through improved flare nozzle design. If the pipeline is operated as a batch line, there may be a potential for a cumulative effect involving opacity incidents if flow diversions to breakout tanks become more frequent. Because most TAPS opacity incidents not involving tankers occur at Pump Station 1, this effect is discussed here in the context of the North Slope. It should be noted that opacity events occasionally occur at other pump stations.

Based on the existing regulatory structure, the magnitude of this potential cumulative effect is ranked low, because the new permitted facilities will not reduce air quality to the point where human health or subsistence, recreational, or commercial activities are endangered. Geographic scope is high because airborne emissions are involved. Frequency/duration is also high because emissions would continue for the life of the proposed action. Overall intensity is moderate on the basis of low magnitude but high geographic scope and frequency/duration. The probability that planned and regulated air emissions will adversely affect human, wildlife, and plant populations is considered low.

Phy5. Changes to water quality from wastewater discharge impact

Domestic and non-domestic wastewater discharges from Alyeska and oil-field facilities are regulated by State of Alaska water quality standards (18 AAC 70), ADEC wastewater disposal permits (18 AAC 72), and federal permits issued by the EPA under the National Pollutant Discharge Elimination System (NPDES) (40 CFR 122). Because individual oil-field, oil-field-support-service, and tourist facilities on the North Slope and the TAPS pump stations must operate under these regulatory controls, releases of processed effluent from individual wastewater treatment systems is not at issue. There is a potential, however, for an adverse cumulative effect resulting from many individual and separate permitted discharges to land and water from future compressor stations associated with a natural gas pipeline, along with tourist facilities or other industrial, commercial, or military activities. Because all individual releases of domestic (pathogen-containing) and non-domestic (industrial and construction-related) wastewater from facilities and construction sites must meet permit conditions and state water quality standards, it is unlikely that such a cumulative effect — involving multiple effluents — would occur. Furthermore, the density of facilities and their point-source effluent releases on the North Slope and along TAPS is presently too low to allow a synergistic effect that exceeds state water quality standards, and it is unlikely that the number and density of facilities will increase in the foreseeable future. Gas commercialization and growing tourism will have the potential to add new point-source

discharge sites, and these will have to be regulated to avoid creating densities of wastewater discharges high enough to exceed state water quality standards for receiving waters.

Biologically processed ballast water is released to a permitted and monitored Port Valdez mixing zone from the VMT Ballast Water Treatment Facility (BWTF). As with other wastewater discharges, the BWTF effluent is prescriptively regulated, and permit excursions in the past have been minor in terms of levels and duration. It is appropriate to assume that associated future projects will be similarly regulated. With gas commercialization, there is a potential for a new marine terminal to be built at Anderson Bay, near the existing VMT. Because the vessels involved with the second terminal would be LNG tankers, oily ballast water will not be an issue, and domestic wastewater would presumably be held in storage tanks for periodic removal to the City of Valdez wastewater treatment system.

Since state and federal water quality regulations will continue to be effective for controlling wastewater discharges, the magnitude of this potential cumulative effect is low. Geographic scope is moderate, because individual wastewater treatment systems and isolated, low-density point-source discharge points will continue to be dispersed within developed areas of the North Slope and along TAPS. Frequency/duration is high, because wastewater discharges will occur throughout the life of the proposed action and other actions not related to TAPS. On the basis of these rankings, the overall intensity is ranked as moderate. It is expected that this issue will increase in importance with continuing North Slope development. At the same time, existing regulatory controls will mitigate the potential for cumulative wastewater discharges to degrade surface water and groundwater resources of the North Slope. Thus, the probability of an adverse cumulative effect is moderate.

Proposed Action: Physical, Cumulative Effects Summary

In summary, none of the potential physical cumulative effects is considered significant by this analysis because:

- TAPS pipeline and related facilities already exist;
- Major changes to the pipeline system or to the affected physical environment are not expected during the ROW renewal period;
- New surface disturbance areas associated with TAPS will be small and isolated;
- Future North Slope development and potential gas commercialization projects would not cause significant disturbance to the physical environment, with the exception of the transitory construction disturbance.
- Pump stations, potential compressor stations, and marine terminals (VMT and LNG) would be widely separated, and their emissions would be relatively small and strictly regulated; and
- There would be no unavoidable adverse effect on the physical environment that would not be mitigated to the fullest extent technically feasible.

With continued regulatory compliance by TAPS and any associated future project, potential cumulative effects on physical resources are not expected to become significant issues during the life of the proposed action.

4.5.3.2 Proposed Action: Biological Resources

By M.A. Cronin, R.G.B. Senner, S.R. Johnson, L.L. Moulton, H. Whitlaw, W. Ballard, D.W. Funk, staff of LGL Alaska Research Associates, Inc., and staff of Alaska Biological Research, Inc.

This section follows the procedure described in Section 4.5.1 to analyze potential cumulative effects of the proposed action on biological resources. Section 4.5.2 discusses past, present, and reasonably foreseeable future actions, in addition to the continued operation of TAPS, that could affect the environment. These actions include two main categories: (1) expansion and further development of existing and other ANS oil fields and (2) commercial development of Alaska's substantial natural gas reserves. It is assumed that ANS oil-field developments will expand and that either a GTL project using the existing TAPS pipeline or a new natural gas pipeline will be implemented if the proposed action is selected.

Other past, present, and reasonably foreseeable future actions not directly related to the petroleum industry were also examined. Other industries, such as mining, may increase operations and affect the environments of concern. It is assumed that the NMDS installation will be built at Ft. Greely. Because tourism and outdoor recreation are increasing in Alaska, the potential effects of increased public access to areas under discussion were also considered.

The extent and nature of effects from future actions are necessarily speculative. For the future ANS developments and natural gas projects, information from the past operation of the ANS oil fields and TAPS was used to infer future effects. Past impacts from public access were also used to infer future effects. The assessment of potential impacts from activities of other industry in the future is constrained because the nature, location, or extent of operations are unknown, and this category is described in general terms.

The analysis also considered information on past, present, and future regulation and mitigation measures that influence effects. For example, tanker operations in Prince

William Sound presently include the SERVS tanker escort system, and will include double-hull tankers in the future. These measures greatly reduce the probability of a large oil spill from a tanker.

The impacts of the proposed action in the TAPS ROW, presented in Section 4.3.2, were consolidated into general impacts for the assessment of cumulative effects. We maintained the categories of vegetation and wetlands, fish, birds, terrestrial mammals, marine mammals, and threatened and endangered species, used in the assessment of impacts of the proposed action (Section 4.3). For vegetation the impacts fall under the following categories:

- Revegetation;
- Drainage and water flow issues;
- Thermokarst;
- Air pollution;
- Oil, fuel, and chemical spills;
- Fire and fire management;

For fish, birds, and mammals, the general categories of impacts are:

- Obstructions to movement;
- Disturbance and displacement;
- Habitat loss/alteration/enhancement;
- Mortality;
- Hunting, trapping, fishing, and recreational effects.

For the effects of oil, fuel, and chemical spills on birds and marine mammals, large spills and small spills are ranked separately because of the different magnitude of impact from each. Criteria for ranking potential cumulative effects on biological resources are shown in Table 4.5-10. Rankings were done for the intensity and probability of an impact, considering the proposed action and the other actions identified above. The intensity ranking was composed of sub-rankings for magnitude, geographic scope, and frequency/duration of an impact. The probability ranking was based on the probability that an impact would occur. For each category, rankings of high, moderate, or low were given.

The basic question in developing the ranking criteria was about the unit of impact. Impacts could be considered at the level of individual organisms, populations, species, or communities, and it is important to clearly state the unit that an action will impact. Because fish and wildlife are generally managed as populations and plants as communities, effects at these levels were emphasized in the criteria for magnitude. Impacts that change a population size, geographic range, or carrying capacity were deemed important and were ranked high or moderate. Impacts that do not change the size of a population, range, or carrying capacity were ranked low in magnitude. Because there are few examples in the study areas of direct cause-effect relationships between human activity and fish or wildlife population sizes, subjective terms and professional judgement were used in ranking magnitude. Thus, an impact's magnitude was ranked high if it changed the population size, range, or carrying capacity "substantially," and as moderate if changes were "measurable." The judgement of whether a population has changed according to these terms will vary among people. However, for most populations and communities, a consensus on impacts can be reached, and appropriate mitigation and regulation implemented.

Geographic scope was ranked according to the extent of impact. Impacts occurring throughout the entire range (ANS, TAPS ROW, and Valdez/PWS) were ranked high, those occurring primarily in one of the three major regions were ranked moderate, and those occurring at a limited number of sites were ranked low in geographic scope. The frequency/duration rankings considered how often, and for how long an effect would occur. An effect's frequency/duration was ranked high if it is continuous, moderate if it occurs intermittently, and low if it is infrequent. The magnitude, geographic scope, and frequency/duration were considered together for a single intensity ranking for each effect. The probability ranking reflects whether an effect is likely to occur. The rankings and their justifications are described in the text below, and summarized in a table identifying the contribution of each action to each cumulative effect and showing the rankings for each effect (Table 4.5-11). Figure 4.5-7 provides a graphical representation of the distribution of the rankings of the cumulative biological effects associated with the proposed action.

Proposed Action: Vegetation and Wetlands

By D.W. Funk and R.G.B. Senner

With the exception of the Beaufort Sea and Prince William Sound marine environments, the area under consideration is covered by indigenous terrestrial and wetland vegetation interrupted by gravel pads and roads, pipelines and other facilities. New construction or maintenance activity that is not on existing gravel pads and roads, or on ice pads and roads, will therefore require site-specific removal of vegetation or additional fill placement in wetlands. Because the North Slope is almost entirely covered by tundra wetlands and because wetlands occur abundantly along the TAPS ROW, wetland removal or alteration is an important issue in considering the cumulative effects of petroleum operations in both study areas (Senner, 1989). The following potential effects on vegetation and wetlands would be associated with continuing oil-field development on the

Table 4.5-10. *Criteria for ranking potential cumulative effects on biological resources.*

		High	Moderate	Low
INTENSITY		*Evaluated in the context of magnitude, geographic scope, and frequency/duration, using the criteria defined below.*		
	Magnitude	The effect would change substantially the size or geographic range of a fish or wildlife population or the distribution of a plant community, or the habitat carrying capacity.	The effect would change measurably the size or geographic range of a fish or wildlife population or the distribution of a plant community, or the habitat carrying capacity	The effect would be limited to a small number of individuals and would not measurably change the size or geographic range of a fish or wildlife population or the distribution of a plant community or the habitat carrying capacity.
	Geographic Scope	The effect would occur throughout the entire terrestrial or aquatic environments of concern.	The effect would occur primarily within one of the major study areas, the Alaska North Slope study area, or the central Trans Alaska Pipeline System study area, or the Valdez Marine Terminal/Prince William Sound study area.	The effect would be site specific at a few locations.
	Frequency & Duration	The effect would be continuous and of indefinite duration.	The effect would occur intermittently.	The effect would occur infrequently or only once.
PROBABILITY		*Evaluated in the context of professional judgment and past occurrence of impacts.*		

North Slope and with maintenance along the TAPS ROW, in combination with other construction projects such as a natural gas pipeline, installation of an NMDS site at Ft. Greely, or new campgrounds, visitor centers, service facilities, or other recreational amenities along the Richardson and Dalton Highways.

Bio1. Wetland and vegetation loss from gravel placement and mining, and dust fallout at roads, pads, and facilities.

The proposed action, with other future actions, will destroy vegetation under gravel pads and roads, and at material sites. The proposed action by itself would produce little further loss of vegetation from gravel mining or placement, unless a major pipeline reroute was required. All required facility pads and access roads are already in place, and there are no plans to add or expand pipeline facilities to the extent that new pads or roads would be needed. Oil-field development on the North Slope has similarly affected vegetation through the placement of gravel fill and the development of gravel mines. Development of new North Slope oil fields will add incrementally to the effects of gravel placement on vegetation. Most new developments have a substantially reduced footprint and are often roadless (or nearly so), markedly reducing the effects of gravel placement on vegetation, and reducing the number of gravel mines required. Construction of a natural gas pipeline would require extensive gravel mining and fill placement for burial of the new pipeline and for construction of compressor station pads and access roads. Routing of the pipeline will largely determine the contribution of such a project to the cumulative impact of gravel mining and placement. Use of existing pads, access roads, stream crossings, and material sites where feasible would help reduce the cumulative increase in impacts. Construction of a GTL facility, the NMDS site at Ft. Greely, other industrial developments such as mines, and campground and recreational facilities along the Dalton and Richardson Highways all could contribute incrementally to the cumulative effect of gravel placement on vegetation. These developments would probably be limited to a relatively small area and would have only site-specific effects.

Within 30 feet of roads and pads, dust and gravel may smother vegetation, resulting in a shift to weedy species and reduced plant photosynthesis; decreases in some common moss, lichen, and shrub species; and development of barren areas. The “dust-shadow” effect has been well-documented along more heavily used gravel roads in the Prudhoe Bay oil field and along the Dalton Highway (Auerbach et al., 1997; Walker and Everett, 1987; Walker, Webber, et al., 1987). For the proposed action, the dust-shadow effect will continue as at present, causing localized changes in plant species composition by changing microsite conditions such as moisture, albedo, and soil pH. Such

BIOLOGICAL CUMULATIVE EFFECTS SUMMARY: PROPOSED ACTION

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
VEGETATION AND WETLANDS											
Bio1 **Wetland and vegetation loss from gravel mining and placement, and dust fallout at roads, pads, and facilities.**	Little or no additional gravel placement will occur, and similar levels of traffic are expected on roads and pads causing only limited impacts from dust.	Gravel placement at facility sites and road dust from construction and facility use are likely. Substantial quantity of gravel fill will be required for a buried gas pipeline. Dust will increase from road traffic for construction and operation.	Well-documented dust shadow effect along heavily traveled roads. Substantial placement of gravel fill for roads, pads and facilities has occurred. Placement of gravel fill for new roads, pads and facilities, but newer fields have a substantially reduced footprint and are often roadless.	Will contribute to dust shadow along the Dalton Highway.	Gravel placement at facility sites and road dust from construction and facility use are likely.	Gravel placement at facility sites and road dust from construction and facility use are likely.	M	M	H	M	H
Bio2 **Changes to natural drainage patterns causing changes to wetlands and vegetation.**	Few new changes to drainage patterns will be required. Maintenance activities for culverts and low water crossings may have some localized effects.	Potential for localized drainage issues depending on GTL facility siting. Pipeline construction will have potential for numerous site-specific changes in natural drainage that may cause localized habitat change and loss of wetlands.	Numerous site-specific changes in natural drainage patterns have occurred, resulting in localized habitat change and loss of wetlands. New facilities with a smaller footprint are carefully sited along natural drainage lines. Some site-specific changes in drainage patterns that result in altered habitat.	No impact.	Potential localized drainage issues depending on facility siting.	Potential localized drainage issues depending on facility siting.	L	M	H	M	H
Bio3 **Changes in plant community structure resulting from thermokarst.**	Small amounts of additional subsidence along the TAPS ROW may occur, but impacts to new areas will be negligible.	Minor localized thermokarst may occur depending on GTL facility siting. For pipeline, potential for thermokarst from impoundments and cross-drainage problems and clearing of vegetation to cause localized habitat loss and changes in plant communities. Minor localized thermokarst may occur depending on facility siting.	In heavily developed areas, about 3% of the total area may be affected resulting in habitat loss and alteration. In heavily developed areas, thermokarst is probably increasing, resulting in habitat loss and alteration. Future developments will have localized thermokarst impacts resulting in small amounts of habitat loss and changes, depending on the size and location of the development.	No impact.	Minor localized thermokarst.	Minor localized thermokarst depending on the size and location of the development.	L	M	H	M	H
Bio4 **Detrimental effects on plants from air pollution.**	Little or no impact on plants from air pollution will occur.	Project should have little or no impact on plants from air pollution.	Future developments are unlikely to have detrimental impacts on plants from air pollution.	Increased public access is unlikely to impact air pollution levels.	Project will probably have little or no impact on plants from air pollution.	Potential for some impacts on local plant communities depending on the type of industry.	L	L	M	L	L
Bio5 **Alteration of the natural fire regime.**	No additional impact on fire or fire suppression will occur, and the natural fire regime will not be affected.	GTL project is unlikely to have any impact on the natural fire regime. Potential increase in fire suppression during construction and operation of pipeline, but unlikely to affect the natural fire regime.	Development is unlikely to have any impact on the natural fire regime.	May increase number of human caused wildfires but is unlikely to have any effect on the natural fire regime.	Potential increase in fire suppression during construction and operation but is unlikely to affect the natural fire regime.	Potential increase in fire suppression during construction and operation.	L	L	L	L	L
Bio6 **Vegetation destruction and alteration from oil, fuel, and chemical spills.**	Minor fuel and oil spills likely, but most contained on workpads, some potential for a major spill.	Minor fuel and oil spills likely, but most will be contained on workpads. For pipeline, minor fuel and oil spills likely but most will be contained on workpads. Major spill possible but unlikely for GTL and LNG.	Most spills have been and will be contained on workpads, localized areas of tundra have been killed requiring remediation. No major spills on tundra have occurred, but major spill possible but unlikely.	Minor fuel and oil spills mostly confined to roadways.	Localized fuel, oil and chemical spills mostly confined to work areas.	Localized fuel, oil and chemical spills mostly confined to work areas.	L	L	M	M	L
Bio7 **Introduction of exotic vegetation from revegetation of disturbed areas.**	Minor revegetation along the TAPS ROW is possible in localized areas and may introduce some exotic species.	Possible minor revegetation following GTL facility construction on the North Slope and at Valdez. Revegetation of some construction sites along the pipeline route are likely following construction.	Some revegetation of construction and spill impacted sites will likely occur in the future.	Low level introduction of weedy species.	Revegetation of construction impacts at missile defense site is likely to occur.	Revegetation of mined sites and construction impacts are likely to occur.	L	L	M	L	H
FISH											
Bio8 **Obstruction of fish movements in freshwater rivers and streams.**	Some obstruction to movement of freshwater fish will occur at low water crossings and culverts. This is a chronic impact along the TAPS ROW.	No impact from GTL. For pipeline, new areas will be affected, depending on the route chosen. Construction and increased vehicle traffic for maintenance will add to this impact. Inspection and monitoring will keep impacts of short duration.	Some impacts have occurred and may occur, but design and mitigation minimize them. Newer developments have a smaller footprint and fewer roads decreasing impacts.	No impact.	Some impacts possible depending on siting of facility and the road corridors required for the development.	Some impacts possible depending on siting of facility and the road corridors required for the development.	M	M	H	M	H
Bio9 **Obstruction of fish movements in the marine environment due to causeways and docks.**	No impact on marine fish movements will occur.	No impact.	Some impacts have occurred at West Dock, but populations have not been affected. Present development at Northstar will have no impact. Future developments should have minimal impacts because of limited use of structures, careful siting, and mitigation.	No impact.	No impact.	No impact.	L	L	M	L	L
Bio10 **Alteration of marine habitats.**	No impacts on marine habitats will occur.	No impact.	Minor impacts may have occurred, but have been within discharge and regulatory standards. Minor impacts may occur at Northstar and future developments, but will be within discharge and regulatory standards because of strict regulations.	No impact.	No impact.	No impact.	L	L	M	L	M
Bio11 **Alteration of freshwater fish habitats.**	Maintenance activities along the TAPS ROW may alter freshwater fish habitats in localized areas.	No impact from GTL. New areas may be impacted by pipeline construction and increased vehicle traffic for maintenance, depending on pipeline route chosen. Inspection and monitoring will keep impacts limited.	Some impacts may have occurred, but populations have not been affected. Some impacts may occur, but mitigation will limit impacts.	There may be minor impacts from erosion from off-road vehicles.	Potential for small impact from gravel placement for construction of facilities depending on siting of facility.	Potential for small impact from gravel placement for construction of facilities depending on siting of facility.	M	H	M	M	H

Table 4.5-11.
Biological cumulative effects summary: Proposed action.

BIOLOGICAL CUMULATIVE EFFECTS SUMMARY: PROPOSED ACTION

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
FISH (CONT'D)											
Bio12 **Effects of oil, fuel, and chemical spills on fish.**	Most spills are contained on the work pads. There is potential for some spills to reach freshwater habitats and impact local fish populations. There is also potential for a large spill into fresh water that would have major impacts on fish, but this has not occurred in the past and is unlikely to occur.	Most spills will be small and contained on gravel, but there is the potential for a major spill that could impact fish.	Most spills will be small and contained on gravel. A large marine spill could occur from subsea pipeline and impact fish.	Possible small spills from vehicles that could impact fish in small areas.	Most spills will be small and contained, but there is the potential for a large fuel spill.	There is the potential for fuel spills, the size, and impact on fish depending on the extent and location of operations.	H	H	L	M	L
Bio13 **Effects on fish populations from increased recreational fishing.**	TAPS ROW renewal will be accompanied by continued public access from roads and workpad.	No impact from GTL, beyond future operation of TAPS. New access from pipeline route will increase fishing pressure on local populations.	No impact.	Increased fishing pressure from existing and new access points may impact local stocks.	No impact.	Increased fishing pressure from new access to remote areas may result.	M	H	H	H	H
BIRDS											
Bio14 **Obstruction of bird movements by roads, causeways, pipelines, and other structures.**	Continued TAPS operation will not block movements of birds.	No impact from GTL. As the gas pipeline will be buried, no impact will occur, except during construction.	Limited impacts have occurred on geese, but habituation has removed the impact. Limited impacts may occur, but mitigation and habituation will make them minor.	No impact.	No impact.	No impact.	L	L	L	L	L
Bio15 **Disturbance and displacement of birds by traffic, aircraft, and other activities.**	Continued TAPS operation will not appreciably disturb or displace birds.	Small impacts may result from new facilities on the ANS and at VMT for GTL. As the gas pipeline will be buried, little impact will occur, except during construction.	Some disturbance and displacement has occurred in the ANS oil fields but there have been no population level impacts. Impacts will be minor because of the small footprint of new developments and other mitigation.	Increased public access may have small impacts near the road system.	Local disturbances may occur at the NMDS site during construction.	Local impacts may occur at specific sites.	L	L	M	L	H
Bio16 **Birds use of man-made habitats including gravel pads, causeways, artificial islands, and pipelines.**	Birds will continue to use TAPS structures for nesting, perching, and foraging.	No impact.	Birds use oil field structures for nesting, perching, and foraging and may use new developments on and offshore.	No impact.	Birds may use new developments at the NMDS site for nesting, perching, and foraging.	Birds may use new developments for nesting, perching, and foraging.	L	M	H	M	H
Bio17 **Loss of bird habitat from roads, pipelines, and other facilities.**	Continued TAPS operation will not appreciably alter bird habitat.	Small impacts may occur from new facilities on the ANS and at VMT for GTL or along the pipeline corridor, particularly during construction.	Habitat has been altered by gravel and facilities, but there are no population-level impacts. Small amounts of habitat will be altered, but impacts to bird populations will be minor.	No impact.	Small amounts of habitat will be altered, but impacts to bird populations will be minor.	Small amounts of habitat will be altered, but impacts to bird populations will be minor.	L	M	H	M	H
Bio18 **Early vegetation green-up and habitat use by birds due to deposition of dust from roads.**	Birds will continue to use habitats with early green-up along TAPS. Positive impacts have occurred where birds use areas of early green-up to feed in the spring	No impact from GTL. New roads for gas pipeline may expand this impact to new areas.	Positive impacts. Birds aggregate in areas of early green-up to feed and replenish fat reserves before nesting. Positive impacts may occur near new roads.	Increased traffic on unpaved roads may increase this impact.	No impact.	Positive impacts may occur near new roads.	M	M	M	M	H
Bio19 **Bird habitat changes caused by water impoundments.**	Some impoundments have affected bird habitats along the north end of the Dalton Highway.	Small impacts may occur from new facilities on the ANS. No impact from gas pipeline.	Some impoundments have affected and may affect bird habitats and have resulted in changes in species using habitats.	No impacts.	Some impacts may occur depending on facility location and design.	Some impacts may occur depending on facility location and design.	M	M	M	M	H
Bio20 **Mortality of birds from highway vehicle road-kills.**	Small numbers of birds may be killed by continued operation of TAPS.	No impact. Some mortality may be associated with increased road traffic for gas pipeline.	No impact.	Road kills of birds will increase with increased traffic, particularly in early green-up areas.	No impact.	Some mortality may be associated with increased road traffic, depending on the extent and location of developments	L	M	L	L	M
Bio21 **Incidental bird mortality at facilities.**	Small numbers of birds may be killed during continued operation of TAPS.	Bird mortality could result at facilities.	Bird mortality could result at facilities.	No impacts.	Bird mortality could result at facilities.	Bird mortality could result at facilities.	L	M	L	L	M
Bio22 **Increased predation on birds.**	Continued TAPS operation will not increase numbers of predators with good garbage management.	No impact from GTL. Impacts possible, particularly during pipeline construction. Good garbage and food management can mitigate this impact.	Impacts have occurred in the past, particularly predation on waterfowl and shorebird eggs. Some predators still abundant and the impact continues, but improvements to garbage management are mitigating the impact.	Potential impacts could occur, depending on garbage management by the public.	Potential impacts could occur, depending on garbage management.	Potential impacts could occur, depending on garbage management by the public.	M	H	H	H	M

Table 4.5-11 (Cont'd).
Biological cumulative effects summary: Proposed action.

BIOLOGICAL CUMULATIVE EFFECTS SUMMARY: PROPOSED ACTION

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
BIRDS (CONT'D)											
Bio23A (large spills) Bio23B (small spills) Injury or death of birds from oil, fuel, or chemical spills.	Spills from TAPS are small and infrequent but may kill birds on land or in rivers and lakes.	GTL or fuel spills from tankers could impact birds.	Generally, no impact. Offshore pipeline or fuel spill could impact birds.	Small fuel spills could impact small numbers of birds.	Fuel spills could impact birds.	Fuel spills could impact birds, depending on the extent and location of developments.	H	H	L	H	L
							Bio 23A (Large Spills)				
							L	L	M	L	L
							Bio 23B (Small Spills)				
Bio24 Increase in bird hunting from increased access.	Bird hunting is expected to continue with TAPS operation.	No impacts for GTL, since no hunting allowed in North Slope oil fields. With a pipeline, bird hunting may increase with new access, depending on restrictions.	Access via Deadhorse airport may have increased hunting pressure on ANS outside oil fields where hunting is allowed. No hunting allowed in North Slope oil fields.	Impacts will increase with increased public access.	Possibly increased hunting will result from new military personnel.	Impacts will increase with increased public access, depending on the location and extent of development.	L	M	M	M	M
TERRESTRIAL MAMMALS											
Bio25 Obstructions of mammal movements by roads, pipelines, and facilities.	Continued operation of TAPS will not obstruct mammals' movements.	No impact from GTL. As the gas pipeline will be buried, little impact will occur, except during construction.	Some wildlife movements may have been impeded, but no population-level impacts have occurred. Some wildlife movement deflection may occur, but crossing of roads and pipelines occurs with proper design and no population level impacts are expected.	No major changes from past operation of TAPS, but increased vehicle traffic that deflects wildlife movements may occur on highways.	No impacts are expected except possibly during the construction phase.	Depending on the extent and location of activity, vehicle traffic or new roads may deflect wildlife movements.	L	M	M	M	M
Bio26 Disturbance and displacement of large mammals by human activities.	Continued operation of TAPS will have minimal disturbance or displacement of mammals.	No impact from GTL. As the gas pipeline will be buried, little impact will occur, except during construction, and at pumping facilities.	Some disturbance and displacement of calving caribou on the ANS have occurred, but no population-level impacts. Some disturbance and displacement of calving caribou may occur with new developments, but timing of activity and mitigation will prevent population-level impacts.	Increased public access in PWS, the TAPS ROW, and the ANS may result in increased disturbance of terrestrial mammals. The level of this impact is not expected to be very high.	No impacts are expected except possibly during the construction phase.	Depending on the extent and location of activity, vehicles, aircraft, or other human activity may disturb and displace terrestrial mammals.	L	H	M	M	M
Bio27 Reduced habitat quality for terrestrial mammals caused by fragmentation and alteration of habitat.	Continued operation of TAPS will not destroy or alter habitats for caribou or other ungulates.	No major changes will occur, although new facilities and pipelines on the ANS and VMT may add to this impact. With a buried gas pipeline, little impact will occur, except during construction, and at pumping facilities.	Mammalian habitats have been altered by TAPS and ANS oil fields, but no population-level effects have occurred. New developments incorporate measures to minimize habitat alteration and footprint of development.	No impacts.	Minor impacts may occur at the development site.	Impacts may occur at development sites, depending on the location and extent of projects.	L	H	M	M	M
Bio28 Mortality of terrestrial mammals from highway vehicle roadkills.	Some roadkills may result from continued operation of TAPS, but this impact has not been large in the past.	No impact from GTL. Increased traffic on existing roads or new roads associated with a gas pipeline could result in increases in roadkills.	Occasional roadkills have occurred in the ANS oil fields. Present developments at Badami, Alpine, and offshore have few roads, and no main road connections to the major oil field areas so roadkills will be rare or none. Future developments at NPRA and offshore will have few roads, and no main road connections to the major oil- field areas so roadkills will be rare or none.	Increased public access will result in increased numbers of roadkills on public highways.	Traffic associated with new military developments could result in increased roadkills.	This impact depends on the amounts of traffic associated with new industry activity.	L	H	L	M	H
Bio29 Effects on predators from anthropogenic food sources and habitat enhancement.	TAPS operations have not allowed access to anthropogenic food sources in the recent past and will not in the future.	No impact from GTL. Potential impacts during pipeline construction phase, and at pipeline pump stations could include improved nutrition, but mortality of nuisance animals and hunter kills. Mitigation measures and proper management will minimize impacts.	Predator populations have probably been enhanced by anthropogenic food in the ANS oil fields. However, mortality from hunters also has occurred. Recent mitigation and management actions may have reduced this impact. Present and future developments have strict control of anthropogenic food sources and minimum impact.	Increased public access could provide anthropogenic food for predators and increase mortality.	This impact could occur and depends on the control of anthropogenic food by the NMDS.	This impact could occur and depends on the control of anthropogenic food by other industries and regulators.	M	H	H	H	M
Bio30 Mortality, injury, or disturbance of terrestrial mammals from oil, fuel, or chemical spills.	It is very unlikely that spills from TAPS operations will impact terrestrial mammals.	No impact.	No impact has occurred, but there is the potential for land spills to impact small numbers of terrestrial mammals.	No impact.	No impact.	No impact.	L	H	L	L	L
Bio31 Increased hunting of terrestrial wildlife from increased access.	Continued TAPS operations will not increase hunting and trapping.	No impact from GTL. New access on pipeline route could increase hunting pressure.	Access provided from Deadhorse airport has increased hunting pressure on ANS. No impact from future development.	Increased access from TAPS roads, Dalton highway, and facilities has increased hunting pressure. Regulatory changes maintain populations to meet objectives.	Increased military personnel could add to hunting pressure.	New human presence in rural areas could increase hunting pressure.	M	H	H	H	H

Table 4.5-11 (Cont'd).
Biological cumulative effects summary: Proposed action.

BIOLOGICAL CUMULATIVE EFFECTS SUMMARY: PROPOSED ACTION

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
MARINE MAMMALS											
Bio32 **Disturbance and displacement of marine mammals by petroleum-related operations.**	TAPS operations will not disturb marine mammals. Tanker traffic in Prince William Sound could have a small impact.	No impact from GTL. Offshore Beaufort Sea route for gas pipeline could disturb marine mammals during construction and maintenance operations. Increased LNG tanker traffic in PWS could disturb marine mammals.	Offshore exploration has disturbed some marine mammals. Development at Northstar may disturb marine mammals, although mitigation and monitoring have been instituted. Seismic exploration will disturb limited numbers of marine mammals and development at Liberty and other offshore locations could disturb marine mammals, although mitigation will reduce impacts.	Increased public access in PWS may disturb marine mammals.	No impact.	No impact.	L	H	M	M	M
Bio33A (large spills) **Bio33B (small spills)** **Mortality, injury, disturbance, or alteration of habitats for marine mammals from oil, fuel, or chemical spills.**	Spills from TAPS will not impact marine mammals. Past spills have had an impact in Prince William Sound, but populations have recovered.	GTL spills in PWS could impact marine mammals. No impact from pipeline, but LNG spills could impact marine mammals.	Past spill of ANS oil into PWS from the *Exxon Valdez* resulted in mortality of sea otters and seals and potential impacts on whales. Spills from Northstar could impact marine mammals. Spills from Liberty and other offshore developments could impact marine mammals.	No impact.	No impact.	Spills near the coast could impact marine mammals.	H	H	L	H	L
							Bio33A (Large Spills)				
							L	L	L	L	L
							Bio33B (Small Spills)				
THREATENED / ENDANGERED SPECIES											
Bio34 **Collisions of eiders with onshore or offshore structures.**	No impact from TAPS	No impact.	Possibly few instances where this impact occurred or will occur.	No impact.	No impact.	No impact.	L	L	L	L	L
Bio35 **Disturbance of Spectacled and Steller's eiders on the North Slope from noise and activities from oil-field operations.**	Operations at Pump Station 1 and TAPS on the ANS may disturb some eiders.	No impact.	Some disturbances of eiders probably have occurred but no effect on the population. Some disturbances of eiders may occur but will be minimized by regulation.	No impact.	No impact.	No impact.	L	L	M	L	M

Table 4.5-11 (Cont'd).
Biological cumulative effects summary: Proposed action.

INTENSITY \ PROBABILITY	Low	Moderate	High
High	Bio23A Bird mortality or injury from ***large*** spills Bio33A Impacts of ***large*** oil spills on marine mammals	Bio22 Increased predation on birds Bio29 Impacts on predators from anthropogenic food sources	Bio13 Impact on fish populations from increased recreational fishing Bio31 Impacts on terrestrial mammal populations from increased hunting
Moderate	Bio6 Vegetation change from spills Bio12 Impact on fish from spills	Bio24 Increased bird hunting because of increased access Bio25 Obstruction of mammal movements by facilities Bio26 Disturbance/displacement of mammals by human activities Bio27 Decrease in habitat quality for terrestrial mammals because of habitat fragmentation/alteration Bio32 Disturbance/displacement of marine mammals by activities	Bio1 Wetland change from gravel mining/ placement and dust Bio2 Wetland change/loss from water flow changes Bio3 Plant community changes from thermokarst Bio8 Fish movement obstructions in freshwater streams Bio11 Alteration of freshwater habitats Bio16 Bird use of man-made habitat* Bio17 Loss of bird habitat from facilities Bio18 Bird use of dust shadow vegetation* Bio19 Bird habitat changes from impoundments* Bio28 Roadkills of mammals
Low	Bio4 Plant damage from air pollution Bio5 Alteration of natural fire regime Bio9 Fish movement obstructions in marine water from causeways Bio14 Bird movement obstructions from facilities Bio23B Bird mortality or injury from ***small*** spills Bio30 Impacts of oil spills on terrestrial mammals Bio33B Impacts of ***small*** oil spills on marine mammals Bio34 Eider mortality from collision with facilities	Bio10 Alteration of marine habitats Bio20 Roadkills of birds Bio21 Incidental bird mortality at facilities Bio35 Disturbance of Spectacled and Steller's eiders from noise	Bio7 Exotic plants introduced by revegetation Bio15 Disturbance/displacement of birds from traffic and activities

*Beneficial effect

Not Significant | Potentially Significant | Significant

NOTE: The intensity and probability rankings in this matrix are based on the qualitative criteria in Table 4.5-10.

Figure 4.5-7*. Ranking matrix of cumulative impacts on the biological environment (proposed action).*

changes will be confined largely to the locations in which they presently occur, unless a major new development leads to one or more new roads that support traffic loads comparable to the Prudhoe Bay Spine Road or the Dalton Highway (Walker, 1999, pers. comm.). Dust shadows may be increased by the addition of roads, facility pads, and greater traffic loads associated with gas commercialization on the North Slope. Construction of a natural gas pipeline would increase traffic loads on the Dalton Highway, contributing to the effect in the Central TAPS study area. Other industry, an NMDS site at Ft. Greely, and recreational use would contribute modestly to dust effects in the areas of concern. The dust shadow affects a limited amount of habitat, but will continue as long as heavy traffic occurs on gravel roads.

The magnitude of this effect is moderate, the geographic scope is ranked moderate, and the frequency/duration is ranked high, for an overall intensity of moderate. The probability of these impacts occurring is high. Magnitude is moderate because careful siting of facilities and the smaller footprints of new developments limit the amount of vegetation affected by gravel placement and dust. Proper siting restricts the potential to substantially alter the distribution of a plant community. Geographic scope is ranked moderate because impacts occur on the ANS and along the TAPS route. Frequency and duration are high since gravel placement destroys vegetation directly under the road or pad, and dust effects will continue as long as traffic volumes remain the same or increase. The probability of at least some gravel placement being required for the proposed action and potential future actions is high.

Bio2. Changes to natural drainage patterns causing changes to wetlands and vegetation.

The effects of roads, pads, and other facilities will include the drying up of some areas due to restriction of sheet-drainage flow volume or duration, and also to the flooding of some wetlands. In localized areas along the TAPS ROW, road and pad construction has influenced flow patterns during spring runoff — which has in turn resulted in flooding and the loss of some habitats, including wetlands. These effects are site-specific and typically affect a small area for a small part of the year, although some impoundments may last throughout the life of the project. Further wetland losses or alterations from TAPS maintenance projects are likely to be minor and site-specific, and will be managed routinely through the Army Corps of Engineers Section 404 nationwide permitting process. Future oil development, gas commercialization, other industry, tourism/recreation, and military activities, along with current TAPS-related activities, may result in cumulative effects.

Similar effects to natural drainage patterns have occurred with development in the North Slope oil fields. A major new North Slope oil field requiring permanent gravel roads and pads for production facilities would incrementally increase the area affected by changes in drainage patterns. The construction of a natural gas pipeline would also contribute to these types of effects on wetlands, because trenching for, and burial of, the pipeline and gravel placement for compressor stations and access roads would cover wetland sites and affect natural drainage patterns. Although these effects would be directly attributable to the gas pipeline, they would add cumulatively to wetland disturbances related to the proposed action. If a natural gas pipeline is routed approximately parallel to the TAPS alignment, impacts can be minimized by using the existing TAPS workpad, access roads, stream crossings, and material sites when feasible. In locations where this is not an option, winter construction with temporary ice roads and pads will be an important additional mitigative measure to ensure that new gravel mining and fill sites are minimized. Other activities near the TAPS ROW that may alter natural drainage patterns include the NMDS installation at Ft. Greely and the establishment of campgrounds and visitor service facilities along the Richardson, Steese, Elliot, and/or Dalton highways. These developments would probably have only small-scale, site-specific impacts on drainage patterns but would contribute incrementally to habitat disturbance from changes in drainage patterns.

Residual ice (late melting) along ice roads or ice pads also influences drainage and affects tundra vegetation. Winter construction employs temporary ice roads and pads to avoid fill placement on vegetation and wetlands underlain by permafrost soils. The slower melting of the ice relative to adjacent tundra decreases the growing season for plants beneath the ice road or pad. Additionally, when the ice used for these structures melts during spring, water temporarily accumulates along the melting edges. In general, these effects have not been identified as a significant drawback to winter construction, because of the mitigative advantages afforded by this construction technique. The North Slope producers use winter construction to build exploratory roads and well pads, to expand existing oil fields, and to develop new satellite fields. This technique is also used occasionally by Alyeska when cross-country access from the workpad to repair sites is required, although existing access roads usually suffice. If a natural gas pipeline is built, it is likely that winter construction will be used extensively. However, any temporary adverse effects of late melt-

out or meltwater on vegetation would be greatly offset by the advantage of avoiding gravel fill. Effects of a shorter growing season would typically last only for that year and would have no long-term impacts. Because most of the affected microsites would be perennially wet environments, the additional meltwater would not have a significantly adverse effect and would not persist beyond a single season.

For this impact magnitude is ranked low, geographic scope moderate and frequency/duration high giving an overall intensity ranking of moderate. The probability of this impact occurring is ranked high. Magnitude was ranked low because impacts from changes in drainage patterns do not appreciably change the distribution of a plant community. Geographic scope was ranked moderate because localized problems associated with drainage have occurred in both the ANS and along the TAPS ROW. Frequency/duration was ranked high because drainage problems and impoundments tend to persist from year to year. These impacts have been a reoccurring site-specific problem along TAPS and in the ANS, making the probability of the impact high.

Bio3. Changes in plant community structure resulting from thermokarst.

Permafrost is sensitive to changes in surface conditions that alter the energy balance and increase heat flow into the ground. Even small disturbances to the plant cover and soil moisture regime can increase the depth of the active layer and melt ice-rich permafrost, causing thermokarst or settlement of the ground after thawing (MacKay, 1970; Webber and Ives, 1978; Brown and Grave, 1979; Lawson, 1986; Jorgenson, 1986; Walker, Webber, et al. 1987). Thermokarst has resulted from a variety of disturbances along the TAPS ROW, but primarily from the formation of impoundments and cross-drainage problems. A limited amount has also been associated with terrain adjacent to buried sections of the pipeline at MP 19, 574, and 734. Thermokarst was mitigated in these areas by filling sinkholes with gravel (Thomas and Ferrel, 1983). VSMs on slopes at MP 687 and 717 have also been exposed to limited thermokarst confined to the workpad. Thermokarst from impoundments, icings, and dust are likely to persist and cause small amounts of additional settlement. However, few new thermokarst areas will be created by the proposed action. Maintenance work may cause some minor impacts associated with clearing of vegetation along the ROW.

In heavily developed portions of the Prudhoe Bay oil field, thermokarst has resulted from impoundments and construction-related disturbances. Walker et al. (1986) indicated that 3 percent of the total area was affected and that the area of impact was increasing with time. Walker, Webber, et al. (1987) suggested that a cumulative loss of habitat was occurring from thermokarst-related impacts. However, Noel et al. (1996) suggested that at least a portion of the area being impacted was from thermokarst occurring because of natural processes associated with the thaw-lake cycle (Billings and Peterson, 1980).

Thermokarst in the heavily developed portions of the ANS oil fields will continue to increase in area. New developments are designed with minimal footprints, are often roadless, and carefully consider drainage patterns in facility siting. These design improvements have generally been successful at limiting the area affected by thermokarst. However, additional developments on the North Slope will contribute incrementally to the area affected by thermokarst, but the impacts will be substantially less than in the early development of the Prudhoe Bay oil field.

Construction of a GTL facility on the North Slope would have minimal localized effects on thermokarst that would depend on the site chosen. Increased thermokarst impacts from construction of a natural gas pipeline would depend greatly on the route chosen. A route using existing workpads, access roads, stream crossings, and material sites to the greatest extent possible would limit additional thermokarst. Development of other industry and the NMDS site at Ft. Greely may also have some localized thermokarst impacts depending on the size and the location of the facilities and would cause some incremental increase in thermokarst impacts.

The magnitude of thermokarst impacts is ranked low, geographic scope is ranked moderate, and frequency/duration is ranked high, for an overall intensity of moderate. The probability of thermokarst impacts occurring is high. The magnitude of thermokarst impacts is ranked low because impacts will occur in limited areas and will not appreciably alter plant community distribution. The geographic scope is ranked moderate since effects are site-specific but occur in the ANS oil fields and the along the TAPS ROW. However, the frequency/duration is ranked high since thermokarst impacts will remain and probably progress once they occur. The probability of these impacts is high, since current thermokarst areas will remain and probably increase in size even with no new development.

Bio4. Detrimental effects on plants from air pollution.

The TAPS pump stations, facilities on the ANS, and the VMT currently produce emissions to the atmosphere. Studies of plant response to emissions have not been conducted along TAPS, but studies at ANS facilities, which have

larger permitted discharges, show no adverse impacts to vegetation at pollutant concentrations at or above those likely to be experienced near TAPS facilities (Kohut et al., 1994). The proposed action would not increase the number of pump stations or facilities along the TAPS route. Construction of a gas pipeline or an NMDS site at Ft. Greely, and other industry along the TAPS route would produce some incremental increase on pollutant emissions. Any impacts from these pollutants would in most cases be very localized and unlikely to result in detectable changes in the vegetation.

Magnitude and geographic scope are ranked low and frequency/duration is ranked moderate, giving an overall intensity rank of low. The probability of impacts from air pollutants on plants occurring is ranked low. Magnitude and geographic scope are ranked low because potential impacts are limited to a few small areas. Emissions do occur from pump stations and the VMT and would occur intermittently from other developments along the TAPS route making frequency/duration moderate.

Bio5. Alteration of the natural fire regime.

The Alaska Interagency Fire Management Plan provides for a full range of suppression responses that vary from aggressive control that extinguishes the fire to surveillance (ADNR, 1999b). Decisions on fire suppression are at the discretion of the federal or state agency involved. Suppression action is based on the fire's threat to human life, inhabited property, designated physical developments, and structural resources such as National Historic Landmarks, high-value natural resource areas, and other high-value areas such as identified cultural and historical sites. The current operation and maintenance of TAPS do not directly affect fire-suppression decisions. The proposed action would not increase human habitation or infrastructure along the pipeline route and would not increase the likelihood of suppression action occurring.

Construction of a gas pipeline along the TAPS route would increase the likelihood of suppression action during construction phases and may increase the number of personnel at facilities along the pipeline. Future developments on the North Slope would also potentially increase fire suppression actions, but the likelihood of a wildfire in tundra is low. Construction of an NMDS site at Ft. Greely would also potentially increase fire suppression, as would other industry developments such as mines. These actions would increase infrastructure and human habitation and therefore could increase the likelihood of fire suppression actions being taken.

Fire is a natural force in the Alaskan Interior, and most forest communities have been extensively influenced by recurring fire (Dyrness et al., 1986). There has been considerable debate on the effect of fire suppression on the natural fire cycle. In general, Alaska is thought to still be in a "wilderness fire" stage in which fire suppression has had no pronounced effect on the natural fire cycle. The proposed action and the anticipated future developments are unlikely to alter wildfire patterns or responses except on a very localized scale.

Increasing the number of people and facilities in an area increases the potential for human-caused wildfires. The proposed action would not increase the likelihood of human-caused fires, because there would be no increase in facilities or personnel. However, construction and operation of a natural gas pipeline, a missile defense site, other industrial developments, and increased usage for recreation and tourism could potentially increase the number of human-caused fires.

Magnitude, geographic scope, and frequency/duration are all ranked low, for an overall intensity ranking of low. The probability of the impact occurring is also low. Magnitude, geographic scope, and frequency are ranked low because wildfires and wildfire suppression decisions would occur on a site-specific basis and would occur infrequently if at all. The probability of impacts to the natural fire regime is extremely low.

Bio6. Vegetation destruction and alteration from oil, fuel, and chemical spills.

Oil, fuel, and chemical spills reported along the TAPS ROW have generally been confined to the workpad and have been small leaks of refined product. Only a few of these spills significantly impacted vegetation. Oil, fuel and chemical spills will probably occur along the TAPS ROW during the 30-year period of the proposed action. As in the past, most of these spills will occur on the workpad with no impacts to adjacent vegetation. In accordance with spill response plans, any spills contacting vegetation will be quickly contained, cleaned and remediated. Spills reaching vegetation are expected to be rare. However, there is some inherent risk of a large-scale spill occurring during transportation of large volumes of oil. Continued operation of TAPS would result in the continued likelihood of spills and would contribute to cumulative effects of spilled oil in the Alaskan environment.

Future ANS development would also contribute to the cumulative effects of oil and fuel spills. Tundra vegetation may be exposed to oil in the event of a pipeline leak, or a leak or blowout at the production pads or facilities. In addition, coastal wetlands or salt marsh habitats could be af-

fected by an offshore spill that reaches the shoreline. For pipelines, small spills will most likely be contained on the gravel pads. Leaks in the elevated portion of a pipeline could expose the tundra to oil. During winter these will be on top of snow and will be cleaned with minimal impact to tundra vegetation. Spills occurring during summer will penetrate the tundra mat, killing the vegetation, but oil will not penetrate beyond the active layer. The contaminated area would be cleaned and revegetated. Few oil spills have occurred on tundra during the development and operation of the Prudhoe, Kuparuk, and Milne Point oil fields, and there is no reason to expect that this will change with future developments. However, future development on the North Slope could cause an incremental increase in the effects of spilled oil on vegetation.

Other future developments, including construction of a gas pipeline, GTL facility, an NMDS site at Ft. Greely, and mine construction, could also contribute to spills of fuel, oil, and chemicals. Most of these impacts would occur during construction phases and would primarily involve spilled fuel, although in some mining operations, chemical spills could also occur. These impacts could also incrementally increase the cumulative impacts of spills.

Spill impacts are ranked as low magnitude, low geographic scope, and moderate frequency/duration for an overall intensity rank of moderate. The probability of spills impacting vegetation is ranked low. Spills are given a low magnitude and low geographic scope ranking because they occur at specific locations and would impact vegetation in a localized area. Spills will probably occur intermittently over the period of the project and are therefore ranked as moderate for frequency/duration. Intensity is considered moderate despite the low rankings of magnitude and geographic scope because there is the potential for a large spill. The probability of spill impacts on vegetation occurring was ranked low, because while the probability of some spills occurring is high, few of the spills that do occur will contact vegetation.

Bio7. Introduction of exotic vegetation from revegetation of disturbed areas.

Seed mixes used for revegetation of construction sites, roads, pads, and other areas could include nonindigenous species of grasses and other plants. However, the introduction of exotic plants with seed application has been reduced as greater quality-control measures have been developed for producing seed mixtures for construction sites in arctic and subarctic environments. The result of introducing exotics on the North Slope and along the TAPS ROW has usually been benign and has not led to large-scale replacement of indigenous plant species. However, in some cases these introduced plants have slowed the reformation of natural plant communities and successional patterns on revegetated sites. Site-specific revegetation will continue on the North Slope and in the Central TAPS study area in conjunction with limited excavations for pipeline inspection and maintenance. New construction of oil fields, a natural gas pipeline, GTL facility, the Ft. Greely NMDS installation, or public use facilities such as campgrounds will create greater potential for introduction of exotic plant species, since all these actions will involve some site-specific revegetation.

The magnitude and geographic scope of this impact are low, and frequency/duration is moderate, giving an overall intensity ranking of low. The probability of this impact occurring is high. Magnitude and geographic scope were ranked low because revegetation would be site-specific and occur at a few locations. The frequency/duration of the impact is moderate because it is intermittent, because construction of projects will have different schedules.

Proposed Action: Fish

By L.L. Moulton and R. Fechhelm

Bio8. Obstruction of fish movements in freshwater rivers and streams.

Drainage structures, such as culverts and low water crossings of the TAPS workpad, may impede fish migration (BLM and USACE, 1988) and obstruct fish passage (Brna, 1999, pers. comm.). This impact was addressed for the TAPS ROW in Section 4.3.2.3. The impacts occur intermittently at some, but not all, stream crossings, and they are generally mitigated through regulation, monitoring, and corrective action.

This impact may occur in ANS oil fields, although proper design and maintenance of road and pipeline river crossings at most locations have resulted in little or no impact there. This will also be the case for present and future ANS oil fields. The GTL project will have no impact. A gas pipeline will likely have impacts similar to those for TAPS. New roads, workpad, and buried pipeline crossings for a gas project will impact new areas outside the TAPS ROW. Increased public access could result in more vehicles crossing streams along TAPS and increase this impact. The NMDS will have no impact. Other industry may increase this impact depending on location, extent, and level of mitigation.

The magnitude of this impact is moderate because impeding fish migration can lead to reduced spawning upstream from the impact site and affect a population. The

geographic scope is moderate because it occurs along the TAPS ROW. The frequency/duration is high because it has been a continuous impact for TAPS. The overall intensity is moderate. The probability is high, because it is a continuing maintenance issue throughout the TAPS route.

Bio9. Obstruction to fish movements in the marine environment due to causeways and docks.

This impact does not occur along TAPS, but may occur in the marine environment of the Beaufort Sea. There has been little or no impact on fish movements from docks or causeways at the VMT or in Prince William Sound. Relative to the extensive distributions and coastal movements of marine and anadromous species, any additional VMT structures would likely impact an insignificant number of individuals and a small geographic area.

On the ANS, this impact was a concern at West Dock and the Endicott Causeway, although impacts were only realized at West Dock. In general, breaching and other design features have minimized impacts. Under certain meteorological conditions, structures along the Beaufort Sea mainland coast can block the movements of diadromous fishes, particularly juveniles (Fechhelm, 1999). Diadromous species are freshwater fish that overwinter in North Slope rivers but disperse into low-salinity coastal waters during the summer to feed. Because many of these species avoid high-salinity, marine conditions, they tend to remain nearshore where they forage up and down the coast within a narrow band of warm, low-salinity water (Craig, 1984). Causeways can impede coastal movement either by directly blocking fish or by modifying nearshore water conditions to the point where they might become too cold and saline for these species. However, current construction practices and mitigation efforts have shown that breaching can alleviate blockage (Fechhelm, 1999).

The location of causeways relative to coastal topography, local bathymetry, and freshwater drainages also is critical in determining their impact to the nearshore migration corridor (Niedoroda and Colonell, 1990). For example, West Dock was constructed at the eastern end of an extensive brackish-water lagoon system (Simpson Lagoon) through which fish disperse and migrate. The causeway extends seaward enough into the marine environment beyond the 2-meter (m) isobath to exacerbate coastal mixing processes that sometimes block the movements of those fish. In contrast, the entire Endicott Causeway was constructed inside the 2-m isobath and does not protrude into deeper marine waters. The onshore encroachment of marine water is further impeded by the freshwater discharge of the Sagavanirktok River (Niedoroda and Colonell, 1990). As a result, cells of upwelled marine water that develop at the Endicott Causeway are restricted to the seaward tip of the causeway's western leg and do not reach the mainland shore, where it might otherwise disrupt fish migrations (Hachmeister et al., 1991; Gallaway et al., 1991).

The impact of causeways obstructing the movements of marine fishes (i.e., fish with their entire life history in marine waters) would be small. The marine species that dominate the nearshore zone are found throughout the Arctic and are abundant and widely distributed along the Beaufort Sea coast (Morrow, 1980; Griffiths et al., 1998). Relative to the extensive and continuous distribution of these marine species, even a worst-case causeway effect would be of limited geographic scope, affecting only a small fraction of the population. Further, the most abundant marine species found in nearshore coastal waters during summer are benthic Arctic flounder and fourhorn sculpin (Griffiths et al., 1998). Given their sedentary nature, it is doubtful that they undergo extensive alongshore migrations.

Proper siting for any future causeway construction along the ANS Beaufort Sea coast is the most important consideration regarding fish movements. In addition, breaching may be appropriate relative to site location and hydrography. Other structures constructed at offshore facilities and artificial islands would not affect diadromous fish habitat and would have a limited influence on marine species. A GTL project, a gas pipeline, increased public access, an NMDS and other industry activity will not have an impact.

The magnitude of this impact is low, the geographic scope is low, and the frequency/duration is moderate, for an overall intensity of low. The probability that the impact will occur is low. The magnitude is low, assuming that future causeway construction includes proper siting and adequate design. Documented instances of causeway blockage (Fechhelm et al., 1999) suggest that causeways have had no detectable effect on stocks after nearly 20 years of study (Moulton, 1997). The geographic scope is low because the impact occurs at only a few sites in the Beaufort Sea and only in the immediate vicinity of the structure (Niedoroda and Colonell, 1990). The frequency/duration is moderate because of the intermittent nature of the impact.

Bio10. Alteration of marine habitats.

This impact does not occur along the TAPS ROW, but may occur in the marine environments of the Beaufort Sea and Prince William Sound. In the ANS oil fields, offshore construction discharges and offshore trenching may alter marine habitat and influence planktonic and benthic marine invertebrates and fishes (USACE, 1984, 1999). This impact could also occur at the VMT in Prince William Sound. Af-

fected areas would likely be more turbid than normal, and this turbidity could affect faunal respiration and vision. Because ANS construction is in the winter with darkness and thick ice cover, phytoplankton photosynthesis is not likely to be affected. Heavy downstream sedimentation could smother the benthos. In general, species occupying these areas are adapted to dynamic conditions and react to short-term fluctuations in water quality and habitat either by enduring and functioning under those conditions or moving out of the impact zone. This has been the case with past ANS offshore developments. An exception is the Boulder Patch community that lies several kilometers seaward of the Sagavanirktok River delta. The Boulder Patch is a community of epilithic flora and fauna that inhabit an isolated area of rock substrate in Stefansson Sound (Dunton and Schonberg, 2000). Organisms occupying the Boulder Patch are at risk from localized impacts because they are immobile, occupy a relatively small geographic area, and are an isolated community that cannot easily be repopulated from surrounding stocks. Offshore construction and trenching in this area would require special consideration.

A GTL development, a gas pipeline, public access, and an NMDS would have no impact. Other industry could have an impact only if it included offshore operations.

The magnitude of this impact is low, the geographic scope low, and the frequency/duration moderate, for an overall intensity of low. The probability of this impact is moderate. The magnitude is low because even under a worst-case scenario in which benthos (excluding the Boulder Patch community) were covered and destroyed, the numbers of individuals would be small relative to the population, and they would likely be quickly replaced from nearby stocks. The geographic scope is low because offshore construction and trenching discharges would be restricted to few specific sites in the Beaufort Sea. The frequency/duration of this impact is moderate because of the intermittent nature of offshore construction projects. The probability of this impact is moderate because offshore construction is likely to continue.

Bio11. Alteration of freshwater fish habitats.

The impacts associated with freshwater habitat alteration were addressed for the TAPS ROW in Section 4.3.2.3. These impacts include sedimentation and loss of spawning beds and overwintering areas near pipeline and road crossings and during pipeline construction and maintenance (BLM and USACE, 1988). TAPS operations include erosion control, restoration, and monitoring that minimize this impact.

These impacts could occur on the ANS, although they have not been a large problem and have been adequately mitigated. An additional impact on the ANS has been removal of fresh water from lakes for construction of ice roads and pads and other operations. Design and mitigation are included in these operations to minimize impacts on fish. Present and future ANS oil-field developments will also have these impacts, but regulation minimizes them.

A GTL development would have no impact. A gas pipeline would have impacts similar to those of TAPS, including construction and maintenance operations. Inspection and monitoring will limit impacts. Public access will have little impact unless there is increased erosion of stream banks from off-road vehicles. An NMDS will have no impact unless facilities are constructed near lakes or rivers. Other industry could have impacts depending on their location and extent.

The magnitude of this impact is moderate, the geographic scope high, and the frequency/duration moderate, for an overall intensity of moderate. The probability of this impact is high, because it is a continuing maintenance issue throughout the route. The magnitude is moderate because the impact can change a population size or spawning or wintering range. The geographic scope is high because the impact can occur along the TAPS ROW or across the ANS. The frequency/duration is moderate because the impact occurs intermittently.

Bio12. Effects of oil, fuel, and chemical spills on fish.

Oil, fuel, or chemical spills are a primary concern for TAPS and related operations. The impact of freshwater spills was addressed for TAPS in Section 4.2.3.3. Most spills along TAPS have been small and restricted to gravel pads at facilities or roads. Large spills into fresh water have not occurred, but if one occurs in the future, it could impact fish.

Large marine spills, such as EVOS, can potentially have large, but short-term, impacts on fish. Such spills can cause mortality and injury to plankton, marine invertebrates, and fish (USACE, 1999). Direct mortality of fish due to oil is seldom seen outside of the laboratory, and impacts on fish in natural environments have been largely inferred (Neff and Stubblefield, 1995). The EVOS probably had some impacts on fish, including pink salmon and herring, but there is not a consensus on the extent and duration of impacts on these species (Wells et al., 1995; Rice et al., 1996). However, populations and habitats had largely recovered as of 1995. Even during the *Exxon Valdez* oil spill, the concentration of oil in water was not sufficiently high to cause fish mortalities (Neff and Stubblefield, 1995).

Past oil spills along TAPS and in the ANS oil fields have

been mainly confined to land but could leak into watersheds and impact fish. Future operation of TAPS and construction of a gas pipeline, NMDS, or other industrial activity carry the risk of small-scale spills of oil, fuel and chemicals from vehicles and machinery. However, industry and agencies have established rigorous criteria for the environmentally safe operation of machinery. These include such measures as regular inspection of facilities and equipment and deployment of containers to catch oil drips from parked vehicles.

Present and future ANS oil-field developments may have an impact, particularly in the marine environment. The potential for spills from subsea pipelines and other sources on offshore developments in the Beaufort Sea has been assessed previously (USACE, 1999). Impacts of spills in solid ice or broken ice in this region may be particularly difficult to clean up.

A GTL development could increase the risk of impacts related to the increased volume of liquids transported through TAPS and in tankers. A gas pipeline, an NMDS, and other industry activities have potential impacts from fuel spills that may enter fresh water, depending on facility locations. Increased public access could result in some small spills from highway vehicles, off-road vehicles, and boats.

The magnitude of this impact is high, the geographic scope high, and the frequency/duration low for an overall intensity of moderate. The probability of this impact is low. Spills will occur, but they will not necessarily impact fish. The magnitude is high because large spills can impact a population or range. The geographic scope is high because spills may occur on the ANS, TAPS ROW, or in Prince William Sound. The frequency/duration is low because spills that reach water occur infrequently, and impacts are of limited duration.

Bio13. Effects on fish populations from increased recreational fishing.

The impact of sport fishing along the TAPS ROW is addressed in Section 4.3.2.3. Increased access has resulted in decreases in some fish populations. Overharvest can occur when regulations and enforcement are inadequate. Developments in remote areas, such as the TAPS ROW, can allow access to previously unavailable harvest opportunities (BLM, 1972). The problem is magnified in northern areas because productivity is low and populations are more susceptible to excessive harvest.

This impact has not occurred in the ANS oil fields or Beaufort Sea, although some sport fishing occurs there. There is increasing public access into Prince William Sound, where sport fishing could impact populations. Sport fishing and commercial fishing are managed by the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service.

Present and future ANS development and a GTL development will have limited impacts because there is no public access to the oil-field operating areas. However, expansion of oil development on the ANS and in the Beaufort Sea could result in increased access for recreation (BLM, 1976). An NMDS will have little to no impact. Increased public access from existing roads and airfields, along with access to new areas with a gas pipeline and other industry activity, will add to this impact. Depending on the level of regulation and enforcement of sport fishing harvest, some areas could have reductions in fish populations. This impact is regulated by the state and federal agencies, and is not under the control of industry.

The magnitude of this impact is moderate, the geographic scope high, and the frequency/duration high, for an overall intensity of high. The probability of this impact is high. The magnitude is moderate because sport fishing can lead to reductions in a local stock, but not widespread populations. The geographic scope is high because this impact can occur along the TAPS ROW, in Prince William Sound, and potentially on the ANS. The frequency/duration is high because the impact will occur regularly in accessible areas.

Proposed Action: Birds

By S.R. Johnson and M.A. Cronin

Bio14. Obstruction of bird movements by roads, causeways, pipelines, and other structures.

There has been concern that roads, causeways, pipelines, and other facilities could obstruct movements of birds (USACE, 1984). This impact was discussed for the TAPS ROW in Section 4.3.2, and impacts were negligible.

A major concern expressed before construction of the Endicott Development Project was that the road and causeway would obstruct traditional movements of flightless molting and brood-rearing geese nesting in the Sagavanirktok River delta. Some of the geese were initially reluctant to cross the new road, but they eventually habituated to the road and traffic and moved across the road to brood-rearing habitats (Johnson, 2000a). Although long-term monitoring studies indicated that some individual birds and family groups may avoid heavily used roads (Bur-

gess et al., 1992), most evidence indicates that geese and most other waterfowl have habituated to roads and traffic in the North Slope oil fields.

Present and future ANS oil-field developments may include new roads that may obstruct bird movements to some extent. However, after years of research, there has been no evidence of population-level impacts on birds due to blockages by roads and causeways. Concerns were also expressed that proposed near-the-ground flexible pipelines (i.e., not elevated pipelines) on the North Slope could obstruct movements of molting and brood-rearing waterbirds. Recent research showed that geese initially avoided a simulated near-the-ground pipeline, but they eventually became habituated to the pipe and moved around and under it (Olson and MacLean, 1999).

A GTL development would likely have small impact because there will be only a few new facilities on the ANS and the VMT. A gas pipeline could result in more impacts during the construction phase over a wider geographic area. Because the gas pipeline will be buried, impacts will be restricted to the construction corridor during the construction period. Continued or increased public access, military activities, and other industry activities likely would have no impact.

The magnitude of this impact is low, the geographic scope low, and the frequency/duration low, for an overall intensity of low. There is a low probability that this impact will occur for birds. The low magnitude is because the impact will be on small numbers of birds. The geographic scope is low because the impacts are site-specific. The frequency/duration is low because the impact is infrequent.

Bio15. Disturbance and displacement of birds by traffic, aircraft, and other activities.

Breeding, postbreeding, molting or brood-rearing birds exposed to oil-field or pipeline operations, aircraft or vehicle traffic, and other human activity could be disturbed and displaced from local habitats and/or subject to increased energy demands. Such disturbances and displacements in the TAPS ROW have been site-specific and intermittent, have affected small numbers of birds, and have not limited populations (See Section 4.3.2).

Operations in the ANS oil fields have caused some disturbance and displacement, but no population-level impacts have been documented (reviewed in Truett and Johnson, 2000). Noise, activity, bright lights, and constant human presence associated with construction and operations at the VMT may disturb and displace some birds. However, the number of birds displaced is likely small, the impact is only at the VMT, and most birds have probably habituated to the facilities.

Present and future ANS developments may have limited impacts, but the smaller size of new facilities will result in less impact than in the past. GTL development will have localized impacts at the new ANS and VMT facilities. A natural gas pipeline could disturb and displace birds during the construction phase. Increased public access may have local and minor impacts. The NMDS will have local impacts during the construction phase. Other industry activity will have impacts depending on the location and extent of development.

The magnitude of this impact is low, the geographic scope low, and the frequency/duration moderate, for an overall intensity of low. The probability of this impact was judged high. The magnitude is low because of the small number of birds affected, because no population-level effects have been documented previously, and because none are anticipated in the future. The geographic scope is low because of the localized impacts. The frequency/duration is moderate because of the intermittent nature of the impacts. A high probability exists that birds will be disturbed and displaced to some extent.

Bio16. Bird use of man-made habitats including gravel pads, causeways, artificial islands, and pipelines.

Habitat alteration can result in both beneficial and negative impacts on birds. The negative impacts are discussed in the next subsection (Bio17). Several studies have documented positive impacts of TAPS on birds (see Section 4.3.2). Raptors perch and nest on oil-field and pipeline structures (Schmidt, 1999, pers. comm.; Ritchie, 1991), and swallows and other birds nest on structures at several TAPS pump stations (Shoulders, 1999, pers. comm.). Similarly, Pollard et al. (1990) and Rodrigues (1992) documented extensive bird use of gravel pads and adjacent disturbed sites in the North Slope oil fields. Another beneficial impact is that offshore artificial drilling islands provide new habitat that will attract birds (USACE, 1999). This positive effect was documented on the Endicott Causeway, which was colonized by Common Eiders. In addition, molting Oldsquaws aggregate on the leeward side of the causeway. This occurred during the first summer after completion of the causeway despite construction and operational activities.

Present and future oil and gas development on the ANS, particularly offshore in the Beaufort Sea, may involve the construction of more offshore islands, which would likely provide more nesting and molting habitat for birds. This could enhance local bird productivity and increase local bird populations. A GTL project would likely have no im-

pact. A gas pipeline would likely have no impacts, unless offshore gas production included island habitat. Public access would have no impact. An NMDS and other industry activity might create habitats attractive to birds.

This impact is beneficial. The magnitude is low, the geographic scope is moderate, and the frequency/duration is high, for an overall intensity of moderate. The probability of birds using man-made habitats is high. The magnitude is low because few individuals are impacted. The geographic scope is moderate because the impact occurs at specific sites along TAPS and across the ANS. The frequency/duration is high because the impact is continuous.

Bio17. Loss of bird habitat from roads, pipelines, and other facilities.

There is concern that pipeline and oil-field development — including roads, pads, and other structures — removes vegetation and decreases available habitat (BLM, 1972; USACE, 1984). This impact was discussed for the TAPS ROW in Section 4.3.2, and both beneficial and negative impacts have occurred. The beneficial impacts were discussed in the previous subsection (Bio16).

In the ANS oil fields, about 8,800 hectares (ha) of tundra habitats have been covered with gravel (Gilders and Cronin, 2000). However, there is no evidence this has had population-level impacts. Studies suggest that birds displaced by gravel fill move to adjacent tundra habitats (TERA, 1990). Other studies in the Sagavanirktok River delta indicated that Snow Geese continued to use adjacent habitats after construction of the Endicott road and causeway (Johnson, 1991, 1998, 2000a; Wilkinson et al., 1993). Some birds preferentially use gravel habitats for nesting or other activities (Johnson, 2000b).

Present and future oil and gas development on the North Slope will result in continued habitat alteration, although new developments have smaller footprints, and relatively smaller impact than in the past. A GTL development will have small impacts at a few facilities. A gas pipeline will have some impacts during the construction phase, but revegetation of the buried pipeline should make the impact short-term. Public access will have no impact. An NMDS will have local, site-specific impacts. Other industry impacts will depend on the location and extent of activities.

The magnitude of this impact is low, the geographic scope moderate, the frequency/duration high, for an overall intensity of moderate. The probability of this impact is high. The low magnitude is because a small number of birds and small areas are impacted. The geographic scope is moderate because the impact is primarily on the ANS. The frequency/duration is high because the habitat alteration is generally long-term.

Bio18. Early vegetation green-up and habitat use by birds due to deposition of dust from roads.

Road dust and associated early spring green-up may cause local redistributions of waterfowl and shorebirds (BLM, 1989). This impact was discussed for the TAPS ROW in Section 4.3.2. Impacts are generally beneficial by providing birds more forage early in the spring. This impact occurs along unpaved roads, but it also occurs naturally along river floodplains. The impact is annual in early spring and many birds are affected. The positive effects on the energy balance of local bird populations has not been studied, but they are likely beneficial.

Road dust from vehicle traffic on the Dalton Highway drifts downwind onto adjacent snowfields and the dark-colored dust decreases albedo, increases heat absorption, and stimulates early snowmelt and green-up. Areas of early green-up are attractive feeding places for migrating waterfowl and shorebirds in early spring when most tundra habitats are still snow-covered. Most waterbirds are food-stressed in spring after long migrations, and areas of early green-up provide good feeding areas. As long as roads remain unpaved, road traffic associated with future North Slope oil development, potential gas commercialization, other industry activities, and tourism and recreation will likely maintain dust shadows along the Dalton Highway and side roads. The GTL project will have no impact because no new roads will be built. A gas pipeline with new gravel roads will expand this impact to new areas. Present and future ANS oil-field development will expand this impact to new areas, although new roads will be limited compared to past operations. Increased public access on unpaved roads will increase this impact, while an NMDS will have no impact. Other industry activities may have impacts depending on their extent and location.

The magnitude of this impact is moderate, the geographic scope is moderate, and the frequency/duration is moderate, for an overall intensity of moderate. The probability of this impact occurring is high because it has been extensively documented and is likely to occur in the future. The magnitude is moderate because it affects many birds over the ANS oil fields and along the Dalton Highway and may enhance carrying capacity and population sizes. The geographic scope is moderate because it occurs primarily over the northern part of the TAPS ROW and in the ANS oil fields. The duration/frequency is moderate because it occurs intermittently in the spring.

Bio19. Bird habitat changes caused by water impoundments.

Construction of roads and gravel pads sometimes results in blockage or rerouting of water flow, particularly during spring snowmelt. Since culverts sometimes do not thaw before spring runoff or are not effective, temporary or permanent water impoundments can occur in areas where there was previously no standing water. In other cases, wetlands may dry up because they do not receive enough water. This issue was addressed for the TAPS ROW in Section 4.3.2.4., and impacts may occur along the north end of the Dalton Highway. The impacts of most impoundments are site-specific, are usually temporary, and have not affected population sizes.

The impacts of impoundments on birds and their invertebrate prey have been studied extensively in the ANS oil fields over the several past decades (Noel et al., 1996). Most man-made impoundments are site-specific and temporary, and most are mitigated by replacing culverts and reestablishing traditional drainage patterns. In the few instances where impoundments have become permanent, the diversity of bird species using them for feeding and nesting was similar to that in natural wetlands. Although some birds, such as tundra-nesting passerines and shorebirds, may be displaced by impoundments, other species, such as loons, waterfowl, and some shorebirds (mainly phalaropes) frequently use impoundments. Overall, the numbers of birds using impoundments is similar to or higher than the numbers using natural wetlands. This impact could be beneficial or negative, depending on the species considered. Mitigation and remediation can reverse the effects of impoundments.

Present and future ANS oil-field development could create new impoundments, although the extent of new roads will be substantially less than in previous developments. A GTL project may create some impoundments depending on where facilities are sited on the ANS. A gas pipeline could create impoundments if roads or workpads accompany the buried pipeline. Public access should have no impact as long as culverts are not blocked. The NMDS may have some site-specific impoundments depending on design. Other industry activities may cause impoundments depending on their extent and location.

The magnitude of this impact is moderate, the geographic scope moderate, and the frequency/duration moderate, for an overall intensity of moderate. The probability of the impact is high. The magnitude is moderate because the impact could measurably alter the population sizes of some birds — either a beneficial increase or a negative decrease in population. The geographic scope is moderate since the impact occurs in the ANS oil fields and northern TAPS ROW. The frequency/duration is moderate because it occurs intermittently, mainly in spring and summer.

Bio20. Mortality of birds from highway vehicle roadkills.

Birds may be killed by vehicles. This impact is more likely for birds using early green-up areas in dust shadows along the TAPS ROW (Shoulders, 1999, pers. comm.; Schmidt, 1999, pers. comm.). This impact was addressed in Section 4.3.2.4 and may affect small numbers of birds.

This impact could occur in ANS oil fields, although it has not been reported as a problem there. It is unlikely to be a problem with present or future ANS oil fields or a GTL project. A gas pipeline could include more roads and traffic that could result in some roadkills. Increased public access could also cause some roadkills of birds, while an NMDS is unlikely to cause an impact. Other industry activities could cause roadkills depending on their location and extent.

The magnitude of this impact is low, the geographic scope moderate, and the frequency/duration low, for an overall intensity of low. The probability this impact will occur is moderate. The magnitude is low because small numbers of birds are affected, while the geographic scope is moderate because it can occur along the length of the TAPS ROW. The frequency/duration of the impact is low because it is occurs infrequently and seasonally.

Bio21. Incidental bird mortality at facilities.

Birds may be accidentally killed at industrial facilities — for example, some birds (e.g., cliff swallows) may nest at TAPS pump stations, may fly into pump station structures, or may be sucked into compressor intakes. Structures and bright lights at the VMT may attract birds during inclement weather (Senner, 1999, pers. comm.). The number of birds killed is small, and the impacts are restricted to the immediate vicinity of the VMT. Collisions normally occur during spring and fall when birds are migrating through the area. This minor impact was addressed for the TAPS ROW in Section 4.3.2.4.

In the ANS oil fields, there is some anecdotal evidence for bird mortality at nearshore structures such as Endicott and at the seawater treatment plant at the end of the West Dock causeway. Bird mortality at such structures, however, has been intermittent and local, and has involved only a few individuals. Present and future ANS oil-field development could cause this sort of bird mortality. It has been postulated that lights at offshore facilities such as Northstar may attract migrating birds that could then collide with struc-

tures (USACE, 1999).

A GTL development will involve a few structures that could add to this impact, and a gas pipeline would have compressor stations that could add to this impact. Public access would not add to this impact, while the NMDS may have structures that could add to this impact locally. Other industry activity could cause this impact depending on the types of facilities used.

The magnitude of this impact is low, the geographic scope moderate, and the frequency/duration low, for an overall intensity of low. The probability this impact will occur is moderate. The magnitude is low because a small number of birds are affected, while the geographic scope is moderate because the impact can occur at specific sites on the ANS, along TAPS, or at the VMT. The frequency/duration is low because it occurs infrequently.

Bio22. Increased predation on birds.

Predators such as gulls, ravens, foxes, and bears may be attracted to human activity because of access to garbage and other food. This could increase predation on birds (BLM and MMS, 1998). This impact was addressed for TAPS in Section 4.3.2.4, and was thought to be minor because of good garbage and food management at Alyeska facilities.

Increased predator populations due to access to human food has been a problem in the ANS oil fields. High predator populations in the ANS oil fields could also be due to natural factors such as high prey availability and natural den sites. Because of the availability of supplemental food at the North Slope Borough Landfill and in dumpsters throughout the ANS oil fields, populations of predators such as bears, foxes, gulls, and ravens have increased over the past three decades. Although there is no definite cause-effect relationship between human food and predator numbers, predators have adversely affected nesting success of ground-nesting birds, especially colonial nesting Snow Geese, and possibly some ducks and shorebirds. Recent improvements in garbage management and cessation of intentional feeding of predators should result in mitigation of this impact in present and future ANS oil fields.

A GTL project will likely have stringent garbage management at its few facilities and little to no impact. A gas pipeline could have an impact, especially if garbage and feeding at construction camps are not managed properly. Increased public access could increase this impact, although hunting and trapping of the predators could balance increases due to supplemental feeding. An NMDS and other industry could have an impact if anthropogenic foods are not managed properly.

The magnitude of this impact is moderate, the geographic scope is high, and the frequency/duration is high, for an overall intensity of high. The probability is moderate. The magnitude is moderate because increased predator numbers have affected bird populations in the ANS oil fields. The geographic scope is high because it may occur over the ANS and could occur with new gas development and increased public access. The frequency/duration is high because it has occurred over several years on the ANS.

Bio23. Injury or death of birds from oil, fuel, or chemical spills (Bio23A, large spills; Bio23B, small spills).

Oil spills have a potentially large impact on birds, particularly in marine environments, because spills may kill or injure birds or reduce forage species and contaminate habitat. This issue was addressed for the TAPS ROW in Section 4.3.2.4, and impacts were infrequent and of low magnitude. Likewise, for past ANS oil-field operations, oil spills have been small and site-specific, with little or no impact on birds. This includes the offshore developments at Endicott and numerous offshore exploration sites.

Present and future ANS oil-field development will include more offshore development with the potential for marine oil spills (USACE, 1999). Oil pipelines will be used for both the Northstar and Liberty developments in the Alaskan Beaufort Sea, and fuel barges are used for supply. Depending on the time of year and volume of an oil spill, either no birds or several thousand birds could be affected by a spill in the Beaufort Sea (USACE, 1999). Small, infrequent spills are more likely than large catastrophic spills. Small spills that are not contained on the facility pad could have site-specific impacts, and in such cases, few birds would likely be affected. Since most marine birds are absent for over half the year, the duration of impacts from a spill in the Beaufort Sea would be considerably less than in more southern latitudes where birds are present all year. However, oil may persist in the cold arctic environment longer than at warmer latitudes.

The *Exxon Valdez* oil spill in Prince William Sound in 1989 impacted many birds. Marine birds were killed and habitat was contaminated. Birds may die by ingesting oil from the water or from their feathers when they preen. They may also drown after losing buoyancy when their feathers become oil-soaked (reviewed in Rice et al., 1996; Wells et al., 1995). The experience with EVOS indicates that although many thousands of birds were killed and extensive bird habitat was contaminated, fewer long-term population-level impacts were detected than originally thought (Day, Murphy, et al., 1995; Wiens, 1996; Wiens et al., 1996). Today, several bird species have either recovered or are in the

process of recovering, and most habitats are recovered. According to EVOS Trustees, of the 10 bird species thought to have been affected by the EVOS, one has completely recovered (Bald Eagle), three are nearly recovered (Black Oystercatcher, Common Murre, Marbled Murrelet), and six are considered to have not yet recovered (Common Loon; Pelagic, Red-faced, and Double-crested cormorants; Harlequin Duck; and Pigeon Guillemot). For at least some species, such as Common Murres, factors other than EVOS — e.g., a wide-scale oceanographic regime shift — may be affecting recovery (Agler et al., 1999). For one species, the Kittlitz's Murrelet, not enough information is available to determine its present status.

Wiens et al. (1996) and others (Day et al., 1995; Wiens, 1995, 1996) who studied habitat use by seabirds documented that within two years of EVOS, the marine bird community showed few effects related to the spill. Initially, bird species that were most significantly affected by oiling were those that feed near or on shore, that either breed on the beach, or that winter or are full-year residents in the area. However, even those species showed little evidence of continuing impacts after mid-summer 1990 (Wiens et al., 1996, p. 838). The findings of Wiens et al. (1996), Wiens (1995, 1996), and Day, Murphy, et al. (1995) corroborate research by others (Harrison and Buck, 1967; Chabreck, 1973) which shows that avian communities often make rapid recoveries following oil spills.

Present and future oil transport through Prince William Sound is now safer than before EVOS because of the implementation of the SERVS vessel escort system. In addition, the use of double-hull tankers in the future will add further protection against spills.

A GTL project will add more volume of liquids through TAPS and more tanker trips through Prince William Sound, although the product is lighter and probably less persistent than crude oil. A gas pipeline will not add to this impact, with the exception of potential of LNG spills or accidents and fuel spills from tankers. Public access will not add to this impact unless small spills into rivers and lakes impact small numbers of birds. The NMDS has the potential for site-specific land spills of fuels, while other industry activity could result in fuel spills the extent of which is dependent on location and volume.

For a large spill (**Bio23A**), the magnitude of this impact is high, the geographic scope is high, and the frequency/duration is low, for an overall intensity of high. The probability of large oil spills impacting birds is low. The magnitude is high because population-level impacts may occur from large spills, although populations may recover. The geographic scope is high because of the potential for spills from the Beaufort Sea to Prince William Sound. The frequency/duration of large spills is low because they have been infrequent, and the implementation of the SERVS escort vessels and double-hull tankers will further reduce the probability of marine spills.

For small, operational spills (**Bio23B**) , the magnitude of impact is low, the geographic scope is low, and the frequency/duration is moderate, for an overall intensity of low. The probability of small oil spills impacting birds is low. The magnitude is low because of the small volumes involved, and the scope is low because such spills usually affect only a small area. The frequency/duration of small spills is moderate because they happen more frequently but are usually quickly cleaned up.

Bio24. Increase in bird hunting from increased access.

Increased access along the Dalton Highway in recent years may have resulted in increased harvests of some bird species. This impact was addressed in Section 4.3.2.4 for the TAPS ROW, and impacts are minor.

In the ANS oil fields, this impact does not occur because of the prohibition on hunting there. This will continue to be the case with present and future ANS oil fields and a GTL project. A gas pipeline and other industry activity may bring more workers to remote areas and could increase hunting pressure depending on location and extent of development. However, it is likely that firearms will be prohibited from gas-pipeline construction sites and facilities (as with Alyeska facilities today) and that hunting will be prohibited from the ROW of a gas pipeline, as with the TAPS ROW. Increased public access will result in the greatest impact through sport hunting, while an NMDS may bring more military personnel who hunt, although hunting may be prohibited on the military site. Industry does not control this impact, which is regulated by state and federal agencies.

The magnitude of this impact is low, the geographic scope is moderate, and the frequency/duration is moderate, for an overall intensity of moderate. There is a moderate probability this impact will occur. The magnitude is moderate because small numbers of birds are affected. The geographic scope is moderate because it is primarily along the TAPS ROW. The frequency/duration is moderate because of the intermittent nature of the impact.

Proposed Action: Terrestrial Mammals

By W. Ballard, M.A. Cronin, H. Whitlaw

Bio25. Obstruction of mammal movements by roads, pipelines, and facilities.

There have been concerns that road and pipeline construction, operation, and maintenance could interfere with the movement of caribou and other wildlife in the North Slope oil fields and along the TAPS ROW (FWS, 1970; BLM, 1972; USACE, 1999). As discussed in Section 4.3.2.5, TAPS has not seriously obstructed wildlife movements, although individual animals are sometimes deflected.

In the ANS oil fields, elevated pipelines and adjacent roads may impede caribou movements to some extent (Cronin et al., 1994). Single pipelines elevated >1.5 m adjacent to roads with low levels of vehicular traffic (<5 vehicles per hour) generally do not impede caribou movements (Cronin et al., 1994; Lawhead et al., 1993; Curatolo and Murphy, 1986; Smith and Cameron, 1985). Elevated pipelines and adjacent roads with moderate to heavy levels of vehicle traffic (>15 vehicles per hour) may impede caribou movements, although this depends on several factors (Lawhead, 1997; Johnson and Lawhead, 1989; Cronin et al., 1994). For example, caribou crossing success tends to increase with insect abundance and decrease with caribou group size (Pollard et al., 1996a; Cameron et al., 1995; Cronin et al., 1994; Johnson and Lawhead, 1989; Curatolo and Murphy, 1986; Smith and Cameron, 1985). Studies indicate that gravel ramps are not necessary to allow caribou movement through the oil fields (Cronin et al., 1994; Johnson and Lawhead, 1989). Cronin et al. (1994) concluded that neither elevated pipelines (<10 parallel pipes) nor roads alone posed significant barriers to the movements of caribou. New oil fields have lower road and pipeline densities than older oil fields, and nearly all pipelines are elevated >1.5 m (Cameron et al., 1995; Cronin et al., 1994). Therefore, although the early unelevated pipelines may block some caribou movements, recent mitigation measures (primarily elevating pipelines) have been effective in allowing movements of caribou (Lawhead, 1997; Cameron et al., 1995; Cronin et al., 1994).

Wildlife movements are not obstructed in the Prince William Sound area, except for possible interference of local movements of black bears by the VMT.

Present and future ANS oil-field development could cause some obstruction of movements, as in the existing oil fields. However, elevated pipelines and limited roads will limit this impact. A GTL development would have little or no impact because only a few new facilities would be built on the ANS and VMT. A natural gas pipeline would be buried and have no impact, except during construction. A new marine terminal and LNG plant at Anderson Bay on the south side of Port Valdez could create an additional obstruction to movements of terrestrial mammals in the vicinity. The NMDS would have very localized impacts in the area of development. Increased public access could result in more highway traffic and increased obstruction of wildlife movements. The impact from other industry activity depends on extent and locations.

The magnitude of this impact is low, the geographic scope moderate, and the frequency/duration moderate, for an overall intensity of moderate. The probability is moderate that roads and pipelines will obstruct wildlife movements. The magnitude is low because this impact has not affected population sizes or ranges, and mitigation measures limit the impact. The geographic scope is moderate because the impact is primarily in older oil fields of the ANS, and the frequency/duration is moderate because the impact occurs intermittently.

Bio26. Disturbance and displacement of large mammals by human activities.

There has been concern that operations in the ANS oil fields, along TAPS, and at the VMT could disturb and displace terrestrial mammals. This could include impacts from aircraft, ground vehicles, and other human activities (BLM and MMS, 1998; BLM, 1972, 1976; USACE, 1999; FWS, 1970; BLM and USACE, 1988). Disturbance by humans can elicit short-term impacts on individuals (Colescott and Gillingham, 1998; Andersen et al., 1996; Tyler, 1991; Horejsi, 1981), although there is evidence for habituation (Reynolds, 1998; Harting, 1987; Miller and Gunn, 1984). As discussed in Section 4.3.2.5, TAPS construction and operation have generally not caused any appreciable disturbance or displacement of wildlife.

Extensive assessments have been conducted on the impacts of the ANS oil fields on caribou (Ballard et al., 2000). Disturbance of other terrestrial mammal species in the oil fields has not been investigated as intensively, but is probably minor compared to that postulated for caribou. Most work has been on the distribution and behavior of caribou relative to infrastructure and human activity. Pre- and post-development data in the Milne Point and Kuparuk oil fields suggest that cow caribou with calves are sometimes displaced 1 to 6 kilometers (km) from oil-field roads with traffic during the calving period (Dau and Cameron, 1986b; Cameron et al., 1992; Cronin et al., 1994; Lawhead, 1988; Nellemann and Cameron, 1998, 1996). In addition, surveys in the 1990s found that the area of most concentrated calving (in both density and absolute numbers) by the western segment of the CAH has shifted south of the Kuparuk field since the late 1980s (Lawhead and Cameron, 1988; Lawhead and Johnson, 2000; Murphy and Lawhead, 2000). Some researchers have interpreted this shift as progressive

abandonment of the Milne Point and Kuparuk calving area (Nellemann and Cameron 1996, 1998). Displacement of caribou from the oil fields during the post-calving (July-August) period has also been suggested (Cameron et al., 1995). It also has been suggested that these impacts result in declines in nutritional status and productivity of caribou (Cameron 1995, Wolfe et al. 2000).

Despite this potential displacement, there is no evidence of impacts on the herd. Although there may be displacement of some calving caribou from roads with traffic, not all animals are so affected. Some cows with calves occur within 1 km of the roads, and many caribou return to the calving areas within the oil fields each year. In addition, calving-period surveys of the Milne Point oil field during the 1990s show displacement from roads in only some years (Olson and Noel, 2000). The combined data from all sources indicate that displacement of calving caribou from roads with traffic is not absolute in either space or time. During the post-calving season, caribou regularly occur in, and move through, the North Slope oil fields, and no displacement from infrastructure occurs (Pollard et al., 1996a; Cronin, Ballard, et al., 1998). In fact, oil-field infrastructure, including roads, gravel pads and buildings, are regularly used as insect-relief habitat (Pollard et al., 1996b; Noel et al., 1998). Most importantly, there is no evidence of adverse population-level effects, as the herd has grown during the period of oil-field development. There are no consistent differences in herd numbers or productivity indices in developed and undeveloped areas, and the ADF&G management objectives for the herd are being met (Cronin, Amstrup, et al., 1998; Cronin et al., 1997; Cronin et al., in press).

Besides ground facilities and operations, aircraft may disturb wildlife. The effects of aircraft overflights on wildlife vary among species, populations, environmental variables, and habitat types, and are dependent on flight altitude and aircraft type. Helicopters and low-flying jet aircraft are generally more disturbing to individuals than light fixed-wing aircraft (Maier et al., 1998; Côte, 1996; Bleich et al., 1994; McKechnie and Gladwin, 1993; Murphy et al., 1993; Harting, 1987; Davis et al., 1984; Miller and Gunn, 1984; Valkenburg and Davis, 1984; Fancy, 1982; also see Section 4.3.2.5). Some terrestrial mammals on the North Slope and along TAPS may be habituated to aircraft disturbance (McLaren and Green, 1985; Davis et al., 1984; Miller and Gunn, 1984; Valkenburg and Davis, 1984). Some individuals of most terrestrial mammal species on the North Slope are likely to have short-term responses to aircraft disturbance, but mitigation in the form of flight altitude-limits reduces impacts. Avoidance of seasonally sensitive areas (e.g., muskoxen calving areas on the Arctic Coastal Plain during April to mid-June) also reduces adverse effects (Reynolds, 1998).

Present and future North Slope oil-field development may add a degree of disturbance and displacement during the calving period, as in the existing oil fields. However, mitigation such as restricting timing of activity and locating facilities away from calving areas can minimize the impacts. A GTL development would have little impact because only a few new facilities would be built on the ANS and VMT. A natural gas pipeline would be buried and would have no impact, except during the construction phase. The NMDS would have very localized impacts in the area of development. Increased public access could result in more highway traffic and increased disturbance of wildlife. Year-round human presence (recreational vehicles, ATVs, and snowmachines) along the TAPS ROW will cause noise which could disturb wildlife. However, wildlife observations collected during Alyeska Security flights indicate the year-round presence of terrestrial mammals in the vicinity of the ROW. The future impacts from public use of the ROW and nearby areas depend on the nature and extent of use. The impact from other industry activity depends on the extent and location of development.

The magnitude of this impact is low, the geographic scope high, and duration/frequency moderate, giving an overall intensity of moderate. The probability of this impact is moderate. The magnitude is low because the only change to a population has been a possible shift of a portion of the calving range of the Central Arctic caribou herd (the majority of the original range is still used by numerous caribou). No population-level changes are anticipated from future impacts. The geographic scope is high because impacts may occur along the TAPS ROW from public access, with gas pipeline construction, and in new ANS oil fields, although mitigation should minimize the extent. The frequency/duration is moderate because the impact in the ANS oil fields is for only a few weeks during calving and in other areas will be intermittent.

Bio27. Reduced habitat quality for terrestrial mammals caused by fragmentation and alteration of habitat.

There has been concern that pipeline and oil-field development may alter and fragment wildlife habitats (USACE, 1984). This was discussed for the TAPS ROW in Section 4.3.2.5, and no substantive impacts are expected.

Regarding past oil-field operations on the ANS, this impact is related to those of obstructions to movement, and disturbance and displacement (Bio25 and Bio26). It has been suggested that oil-field development has fragmented

calving habitat in the ANS oil fields, resulting in the loss of some areas and overuse in others (Nellemann and Cameron, 1996; Cameron et al., 1992). Nellemann and Cameron (1996) concluded that this resulted in the overuse of forage. Nellemann and Cameron (1998) further concluded that reductions in foraging habitats during calving might explain a southwesterly shift in calving activity. Reduced availability of forage could reduce productivity and energetically stress female caribou entering the winter (Whitten and Cameron, 1985; Cameron et al., 1992; Nellemann and Cameron, 1998).

As described previously, there is no evidence of adverse population-level effects, as the Central Arctic Herd has grown during the period of oil-field development and there are no consistent differences in herd numbers or productivity indices in developed and undeveloped areas (Cronin, Ballard, et al., 1998; Cronin et al., 1997; Cronin et al., in press). The scientific literature on ungulates suggests that population density and animal movements are more likely to affect a caribou herd than oil-field infrastructure and operations (Cronin et al., 1997; Cronin et al., in press).

It is also apparent that caribou use the ANS oil-field infrastructure (including gravel pads, roads, and buildings) as insect-relief habitat (Noel et al., 1998; Pollard et al., 1996a, b; Lawhead et al., 1993). In this case, habitats have been enhanced.

Other terrestrial wildlife populations such as grizzly bears, muskoxen, and foxes have also increased during oil-field development. This is not due to habitat alteration, but probably due to protection from hunting and access to anthropogenic food sources.

Present and future North Slope oil-field development may add a degree of habitat alteration for caribou, as in the existing oil fields. However, the decreasing size of developments' footprint will result in small amounts of affected habitats. A GTL development would have little impact because only a few new facilities would be built on the ANS and at the VMT. A natural gas pipeline would be buried and would have no impact, except during construction. A new marine terminal and LNG plant at Anderson Bay on the south side of Port Valdez would change some habitats locally. The NMDS would have localized impacts as well. Increased public access would not alter habitats appreciably. The impact from other industry activity depends on extent and locations.

The magnitude of this impact is low, the geographic scope high, and duration/frequency moderate, for an overall intensity of moderate. The probability of this impact is moderate. The magnitude is low because there have been no population-level changes. The geographic scope is high because habitats could be altered along TAPS and across the ANS. The frequency/duration is moderate because the impact occurs seasonally and infrequently.

Bio28. Mortality of terrestrial mammals from highway vehicle roadkills.

Improved access and increased traffic via the Dalton Highway and other roads may result in increased road kills. This impact was addressed for the TAPS ROW in Section 4.3.2.5. There are some roadkills associated with TAPS, but they are infrequent compared to those in other parts of Alaska. In 1996, the Alaska Department of Transportation (ADOT) reported that highway segments with the most moose/vehicle accidents were near cities and towns. No highway segments with high vehicle/moose accidents were on the Richardson or Dalton Highways (ADOT, 1996).

Roadkills have not been a problem in the ANS oil fields, although there may be occasional mortalities of caribou or bears. The same trend is likely with present and future ANS oil-field developments and a GTL project. A gas pipeline may increase traffic on highways, particularly during construction. This is unlikely to impact large numbers of animals. Increased public access may increase the numbers of roadkills from Valdez to the ANS, while the NMDS is unlikely to have an impact. Other industry activity may cause roadkills, depending on the location and extent of developments.

The magnitude of this impact is low, the geographic scope high, and the frequency/duration low, for an overall intensity of moderate. There is a high probability that this impact will occur to some extent. The magnitude is low because of the small numbers of animals affected. The geographic scope is high because it occurs from Valdez to the ANS. The frequency/duration is low because of the infrequent occurrence of roadkills.

Bio29. Effects on predators from anthropogenic food sources and habitat enhancement.

Improper garbage disposal and food availability may attract wildlife, especially bears and foxes, and could result in mortality of the animals. The intentional feeding of wildlife, and the use of anthropogenic food sources (i.e., garbage) was a problem during TAPS construction, and some bears were killed in the vicinity of the TAPS ROW between 1971 and 1979 (Follmann and Hechtel, 1990). As discussed in Section 4.3.2.5 the general consensus among biologists is that animal feeding and garbage management by Alyeska personnel are no longer problems within the TAPS ROW. However, increasing recreational use of remote areas along the TAPS ROW and the ANS may cause an impact

(McCarthy and Seavoy, 1994; Follmann and Hechtel, 1990; Miller and Chihuly, 1987; Milke, 1977; see Section 4.3.2.5). Bears may occur around the VMT and access anthropogenic food from public sources in Valdez.

In the ANS oil fields, use of anthropogenic food by bears is problematic (Shideler and Hechtel, 2000). Bears with access to anthropogenic food in oil fields (primarily garbage in dumpsters and the landfill) have high cub survival in relation to other Arctic Coastal Plain bear populations. The anthropogenic food sources may be beneficial to the population in terms of increasing productivity. However, these benefits are offset by relatively high subadult and adult mortality (Shideler and Hechtel, 2000). Of 10 deaths reported from the ANS, only one was killed by a vehicle collision in the oil fields (Shideler and Hechtel, 2000). Two bears died of apparent natural causes, and the remaining 7 were legally harvested or killed in defense of life and property outside the oil fields. Shideler and Hechtel (2000) suggest that bears which had become habituated to the presence of humans in the oil fields were more vulnerable to being killed by humans when they moved out of the oil fields.

Arctic foxes also access garbage, use facilities for den sites, and may have increased in numbers in the ANS oil fields. Disease outbreaks, including rabies, may occur as the population density of foxes increases. Ninety-nine arctic foxes were killed for scientific purposes (i.e., disease testing) during winter 1994 as a result of an attack on two oil-field workers by a rabid arctic fox (Ballard et al., 2000). Rabies was detected in one fox, and exposure to rabies without active infection in four others.

In addition to affecting the predators themselves, the increased predator populations resulting from access to anthropogenic foods may negatively affect bird and mammal prey populations. As discussed in **Bio22**, fox and bear predation on Snow Geese on the ANS occurred several times in the 1990s. It is also possible that bears may prey on caribou calves in the oil fields.

It is important to note that management practices, including fencing the landfill, use of bear-proof dumpsters, strict prohibition of wildlife feeding, and worker education have reduced this impact on the ANS over the last few years. This impact will decline in the future because present and future ANS oil-field operations will have strict prohibitions of feeding wildlife and will have procedures to limit wildlife access to garbage. A GTL project will be managed according to ANS oil field or VMT regulations with minimal impact. A gas pipeline could have impacts during construction and operations, but will also be managed to minimize wildlife access to anthropogenic foods. Increased public access in the TAPS ROW may allow predators access to anthropogenic foods, with associated increases in populations and increases in hunting mortality. This may be mitigated by public information programs. The NMDS could have an impact, although garbage and feeding management, as with the oil-industry projects, should be enacted. The impact from other industry activity depends on extent, locations and extent of regulation.

The magnitude of this impact is moderate, the geographic scope high, and the frequency/duration high, for an overall intensity of high. The moderate magnitude is due to potential changes in numbers of animals. The high geographic scope is because it may occur on the ANS, TAPS ROW, and at the VMT. The high frequency/duration is because it has occurred regularly. There is a moderate probability that this impact will occur to some extent.

Bio30. Mortality, injury, or disturbance of terrestrial mammals from oil, fuel, or chemical spills.

It is thought that oil and fuel spills from onshore and offshore activities and marine transportation could result in mortality of small numbers of terrestrial animals (USACE, 1999). Cleanup activity could also disturb and displace animals, and change habitats.

There are no data to suggest that oil spills have killed or otherwise impacted terrestrial mammals on the ANS or TAPS ROW. Cleanup of land spills could cause some disturbance and destroy vegetation in the affected area, but this has not occurred to any extent in the past.

The large oil spill from the *Exxon Valdez* in Prince William Sound may have affected some terrestrial mammals. The major cleanup effort for EVOS undoubtedly disturbed terrestrial mammals to some extent. There is no evidence that cleanup activities and the associated human presence for EVOS or other cleanups have adversely affected terrestrial mammal populations. The only terrestrial mammal species of concern during the restoration effort was the river otter, which uses coastal habitats that may have been oiled. There is some evidence of exposure to oil (Duffy et al. 1996), but river otters are now considered recovered from the spill. No other evidence exists that EVOS or other spills in Alaska have adversely affected terrestrial mammal populations.

A GTL project could increase the risk of a spill by virtue of the additional volume of liquids being transported by TAPS and in tankers. However, the GTL product is more volatile and less persistent than crude oil. A gas pipeline will have minimal impact, largely confined to small spills of refined products during construction and operation of the pipeline and facilities. Present and future ANS oil-field

development could include land spills from ANS pipelines, but impacts on terrestrial mammals will be minimal. Increased public access, the NMDS, and other industry activity should have little or no impact.

The magnitude of this impact is low, the geographic scope high, and the frequency/duration low, for an overall intensity of low. The probability of this impact is low. The magnitude is low because of the small numbers of animals that would be affected. The geographic scope is high because spills may occur in the ANS, TAPS ROW, or Prince William Sound. Based on the impact of past spills on terrestrial mammals, the frequency and duration are low. Based on the low frequency of past oil spills and the prevention measures implemented since EVOS, the probability is low that future spills will impact terrestrial mammals.

Bio31. Increased hunting of terrestrial wildlife from increased access.

Increased access to, and human presence in, remote areas will increase hunting and trapping pressure that may impact wildlife populations (BLM, 1976). This impact was discussed for the TAPS ROW in Section 4.3.2.5. In general, adaptive management in response to increased hunting and trapping has minimized the population-level impacts along the TAPS ROW.

Hunting is not allowed in the ANS oil fields, although access to adjacent areas from the Dalton Highway and the Deadhorse airport has increased pressure on wildlife populations. Game harvests have increased in Game Management Unit 26 (Arctic Coastal Plain); however, ADF&G management objectives are being met for most populations, and bag limits and seasons have been adjusted to allow for maximum sport-harvest opportunities without adversely affecting populations. This impact is regulated by the state and federal agencies, and is not under the control of industry. Smith (1999) concluded that although use of the Dalton Highway Corridor Management Area has increased since 1991, populations of moose, caribou, brown bears, and wolves have not been adversely affected. Hunting has not reduced populations below management objectives.

Present and future ANS oil-field development and a GTL project will not increase this impact. A gas pipeline may increase access to remote areas and increase harvests, particularly during construction. The NMDS and other industry activity may also increase the numbers of hunters in remote areas.

The magnitude of this impact is moderate, the geographic scope high, and the frequency/duration high, for an overall intensity of high. The probability that this impact will occur is high. The magnitude is moderate because hunting pressure can change a population size. The geographic scope is high because the impact occurs from the ANS to Prince William Sound. The frequency/duration is high because the impact occurs every year.

Proposed Action: Marine Mammals

By R.G.B. Senner and J. Burns

The potential for cumulative effects on marine mammals is a concern in both the Beaufort Sea and Prince William Sound. There are no marine mammals along the TAPS ROW itself, but the ANS oil-field developments and tanker traffic in Prince William Sound could affect these species. Marine mammals in these areas are described in Section 3.2.7.5.

The central Alaskan Beaufort Sea supports the bowhead whale, the belukha whale, and several species of seals, all of which are important subsistence resources for the Iñupiat people. In addition, polar bears range widely on the drifting ice pack, and pregnant females den on sea ice or sometimes along snow-laden coastal river terraces or stream banks from late October or November until late March or early April. Marine mammal populations in Prince William Sound include a diversity of cetaceans (whales, porpoises, dolphins), pinnipeds (seals and the Steller sea lion), and the sea otter. All marine mammals, including polar bears, are protected under the Marine Mammal Protection Act of 1972, and any activity that might disturb them requires a federal permit. The bowhead whale, humpback whale, and Steller sea lion are listed as endangered and federally protected under the Endangered Species Act of 1973.

There are two basic ways in which the proposed action could affect marine mammals: disturbance and displacement, and oil spills. In the Beaufort Sea, petroleum exploration and production activities have the potential to disturb migrating bowhead whales and belukhas in the spring and fall, and ringed seals that pup on shorefast ice near Prudhoe Bay. Female polar bears and cubs in maternity dens can be similarly disturbed. In Prince William Sound, the primary concern relates to potential oil or fuel spills, but noise produced by vessel traffic, including tankers and cruise ships, can also disturb marine mammals. Both types of disturbance have received increasing attention because of the *Exxon Valdez* oil spill and because some Alaskan marine-mammal populations (including the Steller sea lion and the harbor seal) have declined since the mid-1970s.

Bio32. Disturbance and displacement of marine mammals by petroleum-related operations.

Arctic oil and gas exploration and production, including

the outer continental shelf of the Beaufort Sea, have occurred and would continue with the proposed action. There is a potential for marine mammals — including endangered bowhead whales, seals, and polar bears — to be disturbed and/or displaced by noise and movement from seismic exploration, vessel traffic, low-flying aircraft, and construction of causeways, artificial islands, and undersea pipelines. All such activities are regulated by the U.S. Minerals Management Service, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Alaska Department of Fish and Game. Regulations require avoidance of sensitive periods such as the autumn bowhead-whale migration and sensitive locations such as known polar-bear maternity dens. Bowhead whales have not been present in nearshore waters of the Alaskan Beaufort Sea where petroleum exploration has been conducted during the winter, spring, and summer. Activities such as seismic exploration, module transport, and artificial-island construction are conducted in the nearshore Beaufort Sea when whales are not present. Long-term monitoring and research have allowed for design of mitigation of these impacts. On-ice seismic exploration has locally displaced individual ringed seals in winter and during the spring molting season (Frost and Lowry, 1988; Link et al., 1999; Lawson and Williams, 1999). Agencies and industry monitor the locations of ringed-seal breathing holes and subnivean lairs during activities conducted on sea ice so that these locations can be avoided. Information on potential noise effects on seals during open-water periods has not been systematically collected, but there is no evidence that seals have experienced population-level effects as a result of industrial activity in the Alaskan Beaufort Sea.

Noise from tanker traffic and other vessels could disturb and displace marine mammals in Prince William Sound. Marine mammals, including killer whales, seals, the Steller sea lion, and sea otters, are known to react in various ways to moving vessels. There is evidence that killer whales use calls, passive listening, and echolocation to communicate with one another and to locate prey (Ford, 1989; Saulitis, 1993). Vessel noise could interfere with normal sound transmission and reception, thus disrupting social communication and foraging (Ford et al., 1994). It has been suggested that noise and other disturbance from increased vessel activity associated with EVOS cleanup activities led to avoidance of some usual foraging areas by killer whales (Saulitis, 1993). In a review of reports on whale/vessel interactions, Richardson, Greene, et al. (1995) concluded that reactions to vessels vary among individual whales of the same species and that vessels in some cases caused temporary avoidance and displacement, but that long-term avoidance of specific areas was not indicated by evidence.

Anthony (1995) documented short-term behavioral reactions by sea otters to vessel traffic in Port Valdez. These responses, which variously included avoidance, attraction, flight, cessation of previous activity, and assumption of alert posture, lasted for a few minutes, after which otters typically resumed their previous activity. The frequency of otter responses to vessels increased with vessel size and proximity; most responses occurred less than 50 m from vessels and in reaction to vessels greater than 30 m in length. Only about one-third of the encounters of sea otters with vessels elicited a response, and otters did not avoid the tanker lane or VMT vicinity.

Vessel noise from crude oil tankers transiting Prince William Sound would continue under the proposed action, and GTL or LNG development would increase tanker traffic. Increased public access, including tour ships and recreational boats, would add to the traffic. Present and future offshore operations in the Beaufort Sea will include vessel traffic, open-water and on-ice seismic exploration, exploratory drilling, and construction of islands, facilities, and subsea pipelines. Regulation and mitigation can minimize impacts from these actions. The development of a gas (not LNG) pipeline and the NMDS would have no impact. Other industry could have impacts if it occurs in the offshore area or involves marine vessel traffic.

The magnitude of this impact is low, the geographic scope high, the frequency/duration moderate, for an overall intensity of moderate. The probability of this impact is moderate. The magnitude is low because available evidence suggests impacts would be limited to transient responses by individual animals and would not alter populations. The geographic scope is high, because the impact could occur throughout tanker lanes in Prince William Sound or in the Beaufort Sea. The frequency/duration is moderate because of the intermittent nature of the impacts. The probability this impact will occur is moderate.

Bio33. Mortality, injury, disturbance, or alteration of habitats for marine mammals from oil, fuel, or chemical spills (Bio33A, large spills; Bio33B, small spills).

Under the proposed action, the marine transport of crude oil from the VMT through Prince William Sound would continue. Offshore exploration and production will also continue in the Beaufort Sea. There is the potential for large or small crude oil or fuel spills in both regions.

Oil spills can kill or injure marine mammals through the inhalation and ingestion of hydrocarbons and through the fouling of fur and skin, resulting in acute toxicity, hypothermia, and loss of buoyancy. Chronic toxicity can result

from sublethal exposure to hydrocarbons from spills, ballast water releases, and contaminated prey animals in the food chain.

Oil spills have not impacted marine mammals in the Beaufort Sea. Small spills during exploration operations have occurred, but none have been of enough magnitude to be of concern. The large *Exxon Valdez* oil spill resulted in considerable mortality of sea otters, seals, and possibly other species in Prince William Sound (Wells et al. 1995; Rice et al. 1996). Estimates of the numbers of seals and sea otters killed by EVOS vary, but there is general agreement that many seals were exposed to oil (Lowry et al., 1994), and that a substantial portion of the sea otter population was killed. There is also agreement that seals and sea otters exhibited short-term avoidance of spill cleanup activities. The overall Prince William Sound sea otter population has recovered from the spill, although there may be local areas with lingering effects. The sea otters in Prince William Sound are also impacted by subsistence harvest and killer whale predation (see Table 4.3-12). There is speculation that killer whales died as a result of EVOS because 14 whales were missing from one pod after the spill. However, five other pods that were observed in heavily oiled water did not suffer losses (Dahlheim and Matkin, 1994).

Present and future ANS offshore operations may result in spills of crude or refined oil into the Beaufort Sea which could impact marine mammals. A large crude-oil spill could also occur from a tanker in Prince William Sound. However, preventive measures now in effect as a result of the Oil Pollution Act of 1990 (OPA 90) and independent actions by Alyeska have reduced the probability of a large marine spill. These measures include the SERVS vessel escort system, improved response capabilities, and future use of double-hull tankers. Spills of refined fuel from commercial shipping, gas commercialization, marine transportation of petroleum products, or tour ships could also occur.

The impact of a spill would depend on the quantity of fuel, location, and time of year. A GTL development would use tankers as in the current crude oil operations and increase the volumes of hydrocarbons transported by tankers. The GTL product is lighter and more volatile than crude oil and would likely have less impact on most organisms. A gas pipeline would not impact marine mammals if it stayed on land. For an LNG operation in Valdez, tanker traffic would increase, but only the ships' fuel would pose a spill threat. LNG poses potential danger from explosion, but not the physical oiling threat that crude or fuel oil poses. Increased public access into Prince William Sound could increase the numbers of small fuel spills, but impacts on marine mammals would be small. The NMDS would have no impact. Other industry activities could increase the potential for fuel spills if they were near the marine environment.

For large spills (**Bio33A**), the magnitude of this impact is high, the geographic scope is high, and the frequency/duration is low, for an overall intensity of high. The probability of this impact is low. This is particularly true with the new spill prevention measures in Prince William Sound, and the careful design and regulation in the Beaufort Sea. The magnitude is high because a large marine spill could substantially change a marine-mammal population size. The geographic scope is high because there is the potential for spills in the Beaufort Sea or Prince William Sound, while the frequency/duration is low because large spills occur infrequently.

For small, operational spills (**Bio33B**), the magnitude of impact is low, the geographic scope is low, and the frequency/duration is low, for an overall intensity of low. The probability of small oil spills impacting marine mammals is low. The magnitude is low because of the small volumes involved, and the scope is low because such spills usually affect only a small area. The frequency/duration of small marine spills is low because they happen infrequently and are usually quickly removed.

Proposed Action: Threatened and Endangered Species

By S.R. Johnson and M.A. Cronin

Bio34. Collisions of eiders with onshore or offshore structures.

After breeding, Spectacled Eiders move to the nearshore Beaufort Sea before starting migration during late summer (Petersen et al., 1999). Construction and operations both offshore and onshore could involve the use of cranes and other tall structures with which flying birds could collide at night or in fog. Bird collisions have been documented intermittently at other tall structures on the North Slope, such as the seawater treatment plant on West Dock. The placement of strobe lights on tall structures has been shown to reduce bird collisions. Typically, only a few birds are involved in collision incidents, mainly during spring and fall migration. As future oil and gas development occurs on the North Slope, more tall structures are likely to be constructed and some bird collisions may occur. The probability of future bird collisions with tall structures (buildings, equipment, powerlines) depends on whether mitigation measures (low profile of new structures, strobe lights) are effective. The impacts will be site-specific, infrequent in nature, and involve very few birds. Other future operations

in areas other than the ANS will not have an impact.

The magnitude of this impact is low, the geographic scope low, and frequency/duration low, for an overall intensity of low. The probability of this impact is low. The magnitude is low because only a few birds are impacted. The geographic scope is low because the impact is limited to a few sites in offshore ANS areas, and the frequency/duration is low because the impact occurs infrequently.

Bio35. Disturbance of Spectacled and Steller's eiders on the North Slope from noise and activities from oil-field operations.

Some oil-field facilities, such as gas compressor stations (e.g., GHX-1), produce loud noises that have disturbed and displaced a few non-breeding Spectacled Eiders (Anderson et al., 1995). Other activities in oil fields, especially those that involve humans in close proximity to nests or broods, may disturb and displace Spectacled and Steller's eiders. The few documented disturbances and displacements have been site-specific and intermittent (Anderson et al., 1995) and in some cases have resulted in positive impacts (Warnock and Troy, 1992). Future oil and gas development on the North Slope will result in more facilities producing loud noises and more human activity that could disturb and displace eiders. However, monitoring and mitigation for eiders accompany new developments and will minimize impacts.

The magnitude of this impact is low, the geographic scope is low, and the frequency/duration is moderate, for an overall intensity of low. The probability of this impact is moderate. The magnitude is low because a small number of birds will be impacted. The geographic scope is low because the impact is limited to specific sites on the ANS. The frequency/duration is moderate because the impact would occur intermittently.

Proposed Action: Biological Cumulative Effects Summary

In summary, two potential biological cumulative impacts met the significance criteria of high intensity and high probability: Bio13, Impacts on fish populations from recreational fishing, and Bio31, Impacts on terrestrial mammal populations from increased hunting. Both impacts can be mitigated by regulation and enforcement by the appropriate agencies. Note, however, that other impacts could be biologically significant, depending on chance events (e.g., oil spills) or mitigation (e.g., maintenance of low water crossings). This approach acknowledges that all of the impacts identified in this report could occur. In many cases, preventive or mitigation measures will minimize impact.

4.5.3.3 Proposed Action: Social Resources

By L.D. Maxim, O.S. Goldsmith, M. Galginaitis, C. Gerlach, P. Bowers, C. Wooley, R. Niebo

This section addresses the potential cumulative effects of the proposed action with respect to economics, sociocultural features, and subsistence. This analysis considers the effects of the renewal of the TAPS ROW along with the continued operation of the ANS oil fields, the VMT, and the associated marine transportation link. These facilities were treated as a group in the economic analysis, because the econometric models employed for prediction of these effects were linked, and it was not feasible to undertake this analysis on a facility-by-facility basis. Because the economic effects of the proposed and no-action alternatives were assessed using an integrated state economic model, the discussion contained in Sections 4.3 and 4.4 covers cumulative effects and only a summary of these findings is presented here.[7]

Other reasonably foreseeable petroleum-related activities that could interact with the alternatives to produce cumulative effects are discussed briefly in Section 4.5.2. The starting point for this analysis was an inventory of the potential direct and indirect effects presented in Sections 4.3.3 and 4.4.3, respectively. These issues were distilled from pertinent EISs, other published literature, and interviews. These were compared with the numerous impact issues predicted for other past, present, and reasonably foreseeable future actions tabulated from the EISs, EAs, environmental reports, and other relevant documents. Using the screening criteria shown in Table 4.5-12, the potential for cumulative effects was assessed in qualitative terms. Many issues were deleted, whereas others were retained for more detailed description and analysis. This section provides a summary of potentially important effects, with abbreviated discussions of others.

Potential cumulative effects were grouped into six broad effects categories (Table 4.5-13 and Figure 4.5-8):

- **Economic:** Many of the potential effects and issues are fundamentally economic. These include revenues derived from oil and gas operations in Alaska, direct and indirect employment, personal income, and other fiscal effects of oil and gas development and other actions. Consolidated economic issues are relevant in several contexts, including effects on the national as

[7]The economic analysis in Sections 4.3 and 4.4 does not consider the economic impacts of possible projects to commercialize natural gas produced on the North Slope (discussed in this section). Therefore, the incremental economic effects of these projects should be added to those estimated in Sections 4.3 and 4.4.

well as state and local economies.

- **Social Change:** Other issues are usefully grouped under the heading of *social change*. Industrial development, among other factors, helps to create and/or accelerate social changes, particularly in areas previously insulated from the modern industrial economy. For example, an influx of new workers, who may bring with them different lifestyles and customs, is one manifestation of social change. New entrants contribute to the demand for housing and various government services and may place strains on limited infrastructure. Also, large income changes resulting from oil and gas employment and/or revenues (an economic effect) may also hasten the process of social change — with both beneficial and adverse consequences. Wage and salary employment for Alaska Natives — an issue itself in terms of employment opportunities or lack thereof in the oil and gas industry — may contribute to social change and can have complex effects on subsistence. Social changes brought about by wage and salary employment, availability of advanced communications (e.g., telephones, television, radio, the Internet), and other elements of modern industrial society can make it more difficult for Alaska Native individuals and communities to retain their traditional culture and language.
- **Subsistence:** The choice of a traditional lifestyle based on the skillful harvesting and use of wildlife, fish, and plant resources is essential to many Alaskans. Subsistence harvesting is important in economic terms alone (Section 3.3). However, subsistence has even more important cultural and social dimensions. Adverse effects on subsistence may occur from oil spills, access limits resulting from oil and

Table 4.5-12. *Criteria for ranking potential cumulative effects on social resources.*

	High	Moderate	Low
INTENSITY	*Evaluated in the context of magnitude, geographic scope, and frequency/duration, using the criteria defined below.*		
Magnitude: *Visual/Recreational*	Visual/recreational effects are termed high if degraded to a point that resources could no longer be used for recreational purposes and/or the visible landscape(s) were altered for many years. One or more large-volume oil spills in the same geographic area could have this potential.	Visual/recreational effects are termed moderate if the affected areas could still be used for the intended purposes, albeit with some loss of value(s). Significant, but time-limited effects (e.g., those occurring from an isolated large oil spill) are included in this category.	Visual/recreational effects are termed low if these do not attain the threshold for moderate.
Magnitude: *Land-Use and Related*	Land-use effects would be high if widespread and significant effects on planned land use would occur, leading to an irretrievable (or at least very long-term) commitment of resources inconsistent with other possible uses. Land-use effects from creation of the TAPS pipeline route would be termed high. However, construction of a natural gas pipeline is moderate, even though the area affected is comparable, because of the pre-existence of TAPS. Potential destruction of many cultural sites would also be termed high.	Effects on land use are termed moderate if effects entail an irretrievable (or at least long-term) commitment of resources, but are not large in extent or not novel (e.g., construction of a pipeline in a pre-existing utility or transportation corridor).	Effects on land use are termed low if they do not reach the threshold for moderate.
Geographic Scope	The effect would occur at the national and/or state level.	The effect would occur primarily within one of the major study areas (Alaska North Slope, Central TAPS, or Valdez/PWS).	The effect would be site-specific at a few locations.
Frequency & Duration	The effect would be nearly continuous and last more than 10 years.	The effect would occur intermittently and/or last longer than 2 years but less than 10 years.	The effect would occur infrequently and last less than or equal to 2 years.
PROBABILITY	*Evaluated in the context of professional judgment and statistical or econometric analysis.*		

SOCIAL RESOURCES CUMULATIVE EFFECTS SUMMARY: PROPOSED ACTION

POTENTIAL EFFECT	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
ECONOMIC											
Soc 1 **National economic effects.**	The proposed action does not generate national-level economic benefits by itself but rather enables continued operation of the ANS fields.	All gas commercialization options will have beneficial economic effects at the national level. Revenues to the federal government include royalties, lease bonuses, and federal income taxes. Revenues depend on the scale of operations, gas transportation costs, wellhead prices, lease rates, royalty rates, tax rates, and before tax profits. All options increase domestic energy self-sufficiency and reduce the trade deficit in energy. The scale of either the LNG or gas export pipeline alternative is about twice that for the GTL option.	ANS oil and gas operations and the pipeline have contributed approximately $40 billion in revenues to the federal government. This production accounts for approximately 20% of domestically produced petroleum. Based on economic projections, ANS will contribute a further $10.8 billion (1998 $) in revenues during the renewal period.	No impact.	Deployment of limited ABM system believed to have national security benefits.	No impact.	H	H	H	H	H
Soc 2 **State economic effects.**	Economic effects associated with TAPS include contributions to gross state product (GSP), direct and indirect economic benefits associated with purchases, and certain taxes.*	All gas commercialization options will have beneficial economic effects at the state and local levels. Revenues to the state government include royalties, severance taxes, and state income taxes. Revenues depend on the scale of operations, gas transportation costs, wellhead prices, royalty rates, severance tax rates, and before tax profits. To various degrees, all options contribute to local property tax revenues. The scale of either the LNG or gas export pipeline alternative is about twice that for the GTL option.	ANS production has contributed approximately $51 billion in revenues to the state. Continued operation of the ANS oil fields, TAPS, and the marine transportation system is expected to generate $14.2 billion (1998 $) in state revenues during the renewal period. Revenues to state are used for a wide variety of beneficial purposes.	No impact.	Economic effects positive, but of much less significance than oil and gas development.	No impact.	H	H	H	H	H
Soc 3 **Local government economic effects.**	Continued operation of TAPS will generate income for local communities in Alaska in the form of property taxes.	To various degrees, all gas commercialization options contribute to local government revenues. For example, property taxes would be paid on permanent facilities. Property taxes for the export pipeline option depend on the specific route.	ANS production has contributed $4.4 billion in revenues to local governments and is projected to contribute another $2.2 billion during the renewal period.	No impact.	Economic benefits (e.g., construction activity and local payroll) could partially compensate for closure of other facilities at Fort Greely.	No impact.	H	M	H	H	H
Soc 4 **Employment effects.**	TAPS will continue to provide jobs in Alaska.	Both construction and operation and maintenance jobs would be created. Employment effects would be largest for the LNG option, because of facilities to be located in Valdez. Employment effects for the gas export pipeline depend on the route chosen. Employment effects for the GTL option are not likely to be substantial. The number of jobs created varies with the option.	Total employment, wage and salary employment, and real per-capita income will increase over the ROW renewal period as a result of continued operation of TAPS and associated ANS fields.	No impact.	Construction would require an average of 300 workers for 5 years. Operations would entail 360 direct and 108 indirect jobs.	No impact.	M	M	H	M	H
SOCIAL CHANGE											
Soc 5 **Social change effects.**	The proposed action will result in a modest decline in direct pipeline employment (operations and oversight) from approximately 2,600 at present to 1,800 in 2015.	All gas commercialization options entail some construction activity. The specific increment depends on the option selected and other factors (e.g., pipeline route). However, the influx of construction workers is likely to be smaller than for construction of TAPS. For example, the peak annual average construction employment for TAPS was 22,000, compared to a projected peak of 7,200 for TAGS.	The combined effects of the ANS fields, pipeline, VMT, and marine transportation segment on employment have been substantial. If the ROW is renewed, the continued operation of these facilities will result in only a very small increment in workforce. (There would be additional workers for one or more of the gas commercialization options were selected.) Cumulative effects associated with the proposed action are only one of many causes of social change.	No impact.	Construction of the NMDS facility will necessitate a small, temporary influx of workers.	No impact.	H	M	H	H	H
Soc 6 **Job opportunities for Alaska Natives.**	Alyeska's Native hire programs under the Alaska Native Utilization Agreement will continue under the proposed action.	Specific estimates of Alaska Native hire are not available for these options. However, all options will create additional jobs.	Operation of ANS fields past 2004 will ensure that employment opportunities for Alaska Natives in the oil and gas industry continue to exist.	No impact.	No impact.	No impact.	M	M	H	M	H
Soc 7 **Income potentially affecting social problems.**	The proposed action will have only modest effects on personal income.	Gas commercialization would have incremental effects on personal income. However, the linkage between income and social problems is not clear. Increased income provides resources for social programs.	Revenues to state and local governments from ANS developments have supported a variety of beneficial social programs. The North Slope Borough undertakes a variety of beneficial social programs.	No impact.	No impact.	No impact.	M	M	H	M	H

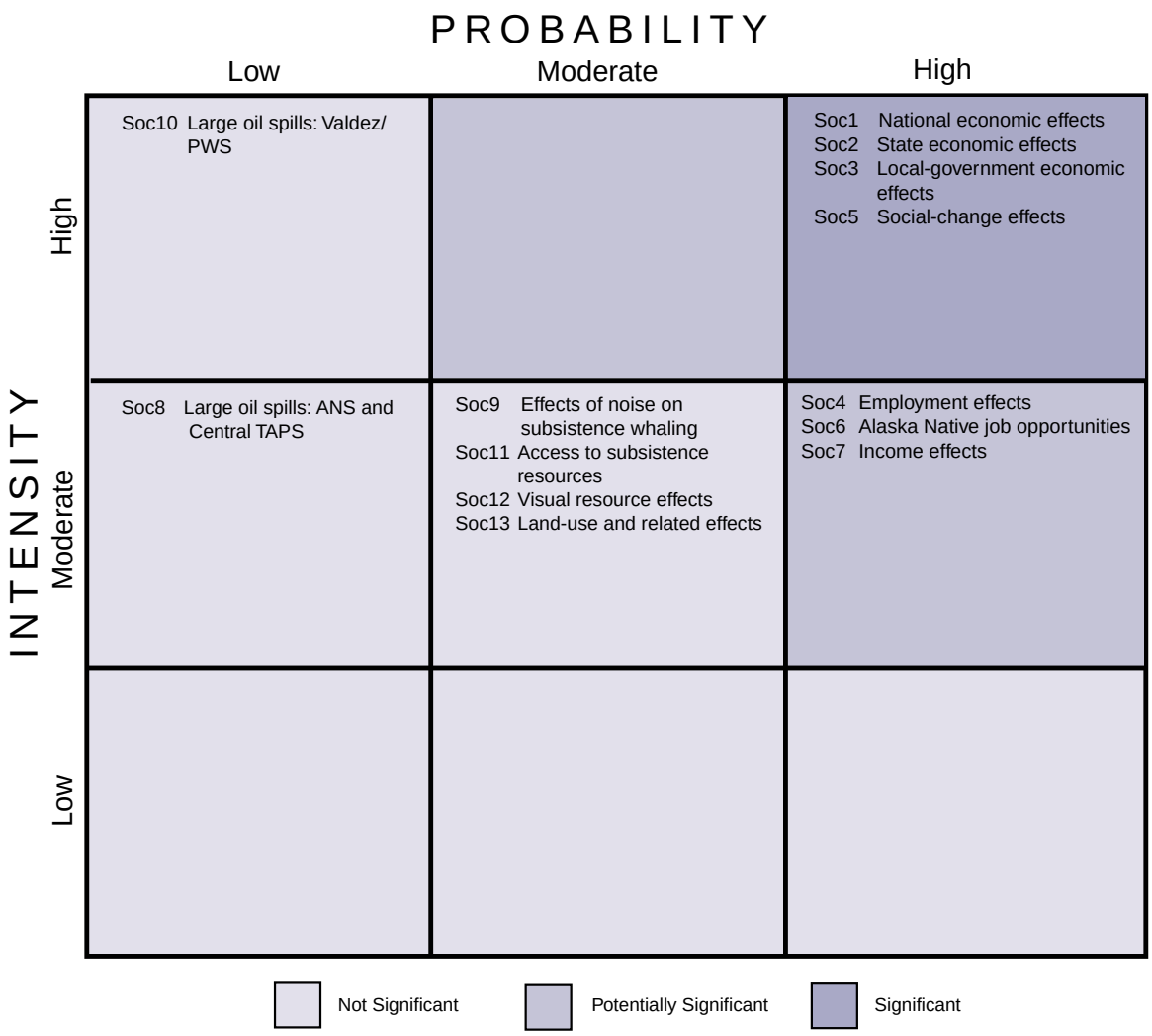
* The economic effects presented here include the effects of both the proposed action (pipeline alone) and other oil and gas production and development activities that are enabled by continued operation of TAPS. These are included in a linked economic model and presented in aggregate.

Table 4.5-13.
Social resource cumulative effects summary: Proposed action.

SOCIAL RESOURCES CUMULATIVE EFFECTS SUMMARY: PROPOSED ACTION

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
SUBSISTENCE											
Soc 8 **Large oil spills affecting quality of subsistence resources: ANS and Central TAPS.**	The proposed action could result in pipeline-related oil spills in the ANS or Central TAPS study areas. The effects of these spills depend on the amount spilled, location, and season. Historically, these effects have been small. The five largest pipeline spills to date has resulted in localized and temporary effects.	Oil spills are not associated with either the LNG or the export pipeline options. Implementation of GTL could increase spill volumes because TAPS throughput would be increased. Gas leaks are not likely to create significant adverse environmental effects, although fires and explosions could result.	Historically, most ANS oil spills were small and have had little affect on subsistence resources. Possible spill estimates based upon other ANS EISs have concluded that the probability of one or more large (>1,000 bbl) oil spills is high and could adversely affect subsistence resources for 1 to 5 years. Actual ANS data suggest the probability of a large spill is low.	No impact.	No impact.	No impact.	H	M	M	M	L
Soc 9 **Effects of noise on subsistence whaling.**	Continued operation of TAPS will have no direct effect on whaling.	Existing wells and other infrastructure are sufficient to support gas commercialization. Thus, no new exploration activities are required.	Additional offshore oil exploration and development activities may adversely affect subsistence whaling, but effects can be mitigated.	No impact.	No impact.	No impact.	M	L	L	M	M
Soc 10 **Large oil spills affecting quality of subsistence resources: Valdez/PWS.**	Pipeline and VMT spills are not likely to be large or result in significant effects.	The GTL option increases tanker traffic in Valdez and could increase PWS oil spills marginally. Potential LNG tanker traffic is small in comparison to oil tanker traffic. However, LNG accidents could affect marine mammals.	Continued operation of the marine transportation link is required to support ANS production. Analyses presented in this study indicate that the probability of one or more large (>1,000 bbl) oil spills ranges from 50% (best estimate) to 90% (no improvement from historical experience). Large oil spills could result in a material adverse effect on subsistence harvests.	No impact.	No impact.	No impact.	H	L	M	H	L
Soc 11 **Access to subsistence resources.**	Access to subsistence resources is unlikely to be materially affected by the proposed action.	Subsistence harvests could be adversely, although temporarily affected, by construction activity and increased competition for subsistence resources with construction workers. During the operational phase of these projects, effects are likely to be small.	Development of ANS oil fields has restricted access to subsistence resources on the North Slope in the past. Current regulations make provisions for subsistence users to access certain areas. Access to subsistence areas on the North Slope will continue to decrease as more oil fields are developed.	The opening of the Dalton Highway to general use provides greater access for tourists, recreation seekers, and hunters and anglers.	No impact.	No impact.	M	M	H	M	M
VISUAL/RECREATIONAL											
Soc 12 **Effects on visual/recreational resources.**	The proposed action is unlikely to result in any material effects on visual/recreational resources. Ground-impacting activities, including corrosion digs, river training structure repairs, and below ground valve inspections, could result in minor visual effects, as could oil spills.	All options result in incremental North Slope construction. New facilities do not occupy a large area, particularly in proportion to the present area of ANS industrial activity. Construction of a gas pipeline would result in temporary impairment of visual resources. However, once completed, the buried pipeline will have a small visual effect. For the LNG alternative, there will be additional visual effects associated with the LNG plant and marine terminal.	Historically, ANS development has substantially altered the visual character of this area. Reasonably foreseeable future projects will result in the geographic expansion of these visual effects. Improvements have reduced the size of the visual footprint of exploration and production facilities.	No impact.	Construction of this facility would result in an added visual effect.	No impact.	M	M	H	M	M
LAND USE AND RELATED ISSUES											
Soc 13 **Land use and related issues.**	No material effects on land use, wilderness, and cultural sites are foreseen. Oil spills could result in temporary changes to land uses and adverse effects on cultural sites.	Commercialization of ANS gas could have land use effects, depending on the option and (in the case of the pipeline options) the route chosen. For the LNG option, new facilities would be constructed in Valdez, affecting approximately 390 acres of land.	Land use has changed over time as ANS oil and gas production expanded. This trend would continue for the proposed action. Expansion of the land area used for oil and gas production could affect cultural resources in the area.	No impact.	Localized effects possible.	No impact.	M	M	M	M	M

Table 4.5-13 (Cont'd).
Social resource cumulative effects summary: Proposed action.



NOTE: The intensity and probability rankings in this matrix are based on the qualitative criteria in Table 4.5-12.

***Figure 4.5-8**. Ranking matrix of potential cumulative impacts on the social environment (proposed action).*

gas development, and competition for subsistence resources resulting from population growth and increased access by nontraditional users of subsistence resources.

- **Visual/Recreational:** Several issues are grouped in this general category. Industrial development changes the general appearance of formerly nonindustrial areas and can alter patterns of recreational use. Not all such effects are adverse. On the positive side, the TAPS pipeline and VMT are tourist attractions. Visible changes associated with petroleum development on the North Slope are of concern to some members of the public, and oil spills and associated cleanup activities can have temporary adverse effects on scenic vistas.
- **Environmental Justice:** Some of the potential cumulative effects associated with the proposed action have implications for "environmental justice," because they may have disproportionate effects on particular demographic groups. Some of these effects are beneficial. For example, the Alaska Permanent Fund Dividend (PFD), which is funded by oil and gas revenues, is distributed to all Alaskans who satisfy residency and other minimal requirements. Although the

dividend (for any given year) is a fixed amount per person, the impact of the PFD on household income is proportionately greater for larger families and for low-income families. Other effects of oil and gas development may have disproportionately adverse consequences. For example, an oil spill could disrupt subsistence harvests, with the potential to have greater effects on low-income and/or minority families that, by circumstance or choice, are dependent upon these resources to a greater degree than other residents. Environmental justice effects are reviewed in this section (see also Section 4.10), but this is not treated as a separate set of effects to avoid double counting.

- **Land Issues:** Included in this classification are topics related to changing land uses, land use conflicts, coastal zone management, and effects on wilderness. Potential effects of the proposed action on cultural resources are included in this category.

In the summary exhibits, these categories are disaggregated into selected component issues, which are evaluated in terms of a common rating scheme. At the conclusion of the discussion of each category or issue cluster, an overall evaluation of the intensity and probability of component effects is presented. This overall rating is based upon a judgement of the significance of each of the topics and issues together with the individual ratings.

Proposed Action: Economics

The economic effects of ANS development and of the construction and operation of TAPS, the VMT, and the marine transportation link from 1974 to the present have been both beneficial and substantial. In Section 3.3.1, these effects are discussed in national, state, and local contexts. The proposed action will allow the economic benefits of ANS petroleum development to continue throughout the ROW renewal period. Section 4.3.3.1 provides estimates of direct, indirect, and cumulative economic effects of TAPS for the period from 2004 to 2034. As noted in Section 4.3.3.1, the analysis of the economic effects of the proposed and no-action alternatives was based upon a constant real price for North Slope of approximately $16 per barrel (1998 dollars). Prices presently prevailing are substantially greater. It is not feasible to replicate this analysis in response to every crude oil price movement. However, the effect of any upward shift in crude oil prices is to magnify the economic effects projected here. Increased prices directly affect revenues from royalties and severance taxes, but also (if these prices continue) increase the effectiveness of marginal fields, which may increase the quantity of oil produced. For these reasons, the economic effects of the proposed action alternative are understated.

Soc1. National economic effects.

On the national level, ANS output presently accounts for about 20 percent of domestic oil production. This percentage will decline as ANS production and TAPS throughput decline, but it will remain significant (the Prudhoe Bay oil field is the largest oil and natural gas discovery in the history of North American exploration) (Gilders and Cronin, 2000). Crude oil self-sufficiency is not an option for the U.S., but each barrel produced domestically reduces the amount of oil that needs to be imported and therefore, the trade deficit. The proposed action will reduce this deficit by approximately $150 billion in 1998 dollars (based on world crude oil prices forecast by USDOE) from 2004 to 2033. ANS production will contribute approximately $10.8 billion to the federal government in the form of income taxes, lease payments, royalties, and bonuses. Application of the criteria shown in Table 4.5-12 indicates that the intensity of this effect is high, as is the probability that this will occur.

Additionally, continued operation of TAPS will necessitate the construction of new “Jones Act” double-hull tankers (estimated nine) to replace tankers retired from service because of OPA 90. Collectively, this amounts to an expenditure of $1.5 billion at U.S. shipyards for construction, and still more for periodic repair/maintenance. Since each of the tankers will generate approximately 1,000 shipyard jobs for 18 months, the total fleet purchase is estimated to support a total of 162,000 worker-months. Operation of Jones Act tankers requires U.S. seafarers. At the beginning of the ROW renewal period, tankers serving the ANS trade are estimated to employ 1,330 U.S. seafarers, declining to 530 by the end of the period.

Implementation of one or more of the three potential gas commercialization options would also have economic benefits at the national level. The federal government would receive royalties, lease bonuses, and federal income taxes. Additional domestic natural gas production would increase the degree of self-sufficiency and reduce the net balance of payments deficit in natural gas.

Soc2. State economic effects.

At the state level, the economic benefits of the proposed action (direct, indirect, and cumulative) would also be large. Projected state revenues from ANS oil production and pipeline operations under the proposed action total $14.2 billion. At the beginning of the ROW renewal period, these payments will account for 65 percent of total state general fund revenues, declining progressively to 18 per-

cent by 2025. To cope with oil and gas revenue declines, it is projected that Alaska will reimpose an income tax and reduce PFDs (which would be eliminated under the no-action alternative). These measures will reduce disposable personal income and slow job growth rates compared to historical norms, but will help to maintain public services.

Continued ANS production will provide statewide employment and income opportunities. Direct employment is not large in proportion to total state employment, but oil and gas economic activity generates substantial indirect (multiplier effect) activity and employment.

The above projections do not include the contribution of various gas commercialization options or the proposed NMDS installation at Fort Greely. These effects will add to those discussed above, as follows.

All natural gas commercialization options will provide income to the state in the form of royalties and severance taxes. Implementation of any of these options will increase the overall level of economic activity in the state through direct and indirect (multiplier) effects. Independent estimates of economic effects are not made in this analysis because the projects are not sufficiently characterized, no option has been selected, and future energy prices are uncertain. (Where appropriate, other estimates are included.) Nonetheless, there is little doubt that the economic benefits to the state will be large if any of the gas commercialization options prove viable.

As noted above, the capital cost for the LNG option including the GCF, pipeline, LNG plant, and LNG tankers is estimated to be $12 billion to $14 billion. Construction would require from 8 to 10 years and employ a peak work force of 10,500 (7,200 direct jobs and 3,300 indirect jobs). Upon completion, TAGS was projected to generate revenues of $188 million annually in property taxes and $189 million annually in royalties and severance taxes (BLM and MMS, 1998). These estimates depend upon the scale of operations, royalty and severance tax rates, transportation costs, and LNG prices at destination ports. TAGS was projected to generate 550 direct and 1,250 indirect jobs throughout its 30-year life (BLM and MMS, 1998).

The economic effects of the ANGTS pipeline depend, to some degree, upon the specific route chosen. Because the scale of operations (2 bcf/day) is the same as that for the LNG option, royalties and severance taxes are likely to be similar.[8] Property tax receipts, availability of gas for Alaskan communities (e.g., Fairbanks), purchases in Alaska, and employment opportunities for Alaskans are likely to depend on the specific route chosen for the pipeline.

The GTL option also provides economic benefits in the form of royalties and severance taxes. Because GTL liquids will use the present TAPS pipeline, the unit pipeline costs will decrease as fixed costs are spread over a larger number of barrels of throughput. Tariffs will also decrease (for all barrels shipped over TAPS), which will increase the net wellhead value of the crude oil.

Implementation of GTL, LNG, or the ANGTS pipeline will increase domestic supply and U.S. self-sufficiency in natural gas. As noted above, 2 bcf/day is equivalent to about 20 percent of present net imports, so implementing both the LNG and ANGTS pipeline options would have a significant effect on US net imports and the balance of trade.

The proposed action will provide Alaska with the opportunity to effect a gradual transition away from heavy dependence on one industry to a more diversified economy. Such changes are never easy, but they can be particularly difficult if the transition is abrupt.

Construction of the NMDS facility at Fort Greely will cost $626 million and require an average of 300 construction workers over a 5-year period; operation of the system could employ as many as 360 workers (U.S. Army Space and Missile Defense Command, 1999). During operation, employment will generate at least $9.7 million of direct income per year. Some 108 indirect jobs would also be created. In aggregate, these jobs would partially compensate for closure of other facilities at Fort Greely, and the NMDS installation might alleviate some of the economic hardship of base downsizing.

Application of the criteria given in Table 4.5-12 indicates that the statewide economic effects of the proposed action alternative are of high intensity and high probability.

Soc3. Local government economic effects.

The proposed action will provide revenues to local governments totaling an estimated $2.2 billion over the ROW renewal period. Revenue projections are particularly large for the North Slope Borough ($1.9 billion), but the continuing revenues will also be important for Valdez/Cordova ($126 million), Fairbanks ($51 million), and Anchorage ($25 million). These estimates do not reflect any allowance for property taxes on natural gas facilities, which would add to these totals. Application of the criteria identified in Table 4.5-12 indicates that the economic effects on local governments are of high intensity and high probability.

Soc4. Employment effects.

Selection of the proposed action alternative would have

[8]These quantities are computed on the net wellhead value, which is the sales price minus the transportation cost. Net wellhead values could differ among the gas commercialization options.

employment effects. These vary by location and are discussed below.

Alaska North Slope. Renewal of the TAPS ROW will maintain the existing sociocultural dynamics of the North Slope. The principal effects will be continued state and local revenues (Section 4.3.3.1) and earnings derived from probable operation and maintenance (O&M) contracts with Alaska Native regional corporations and their subsidiaries that provide services to Alyeska and the oil companies. Efforts to sustain and expand Alaskan and Alaska Native employment on TAPS-related O&M work are likely to continue. Under the proposed action, aggregate employment in the petroleum industry will increase only modestly from 2000 to 2010 and will remain constant thereafter (Section 4.3.3.1). Nonetheless, employment opportunities will continue to exist, as some growth is expected in North Slope oil-field operations (Table 4.3-17 in Section 4.3.3.1). A continued but declining revenue stream supporting government, community services, and Alaska Native corporations will provide benefits.

The NSB has a young population relative to other parts of Alaska and continues to grow at a more rapid rate than the state average. In fact, the increasing demand for employment caused by NSB population growth may exceed local employment opportunities afforded by renewal of the TAPS ROW. This may result in a net migration out of the borough. Whatever adverse effects are associated with declining crude production, however, are much smaller than would result if crude production were to cease abruptly.

Central TAPS. These effects are discussed in Section 4.3.3.1. Selection of the TAGS option would result in temporary economic benefits associated with construction activities and long-term benefits from property taxes and increased employment. Similar benefits would result if the Alcan route were chosen for the ANGTS pipeline.

Valdez/PWS. The proposed action contributes to a continuing growth in the level of jobs, employed resident workers, and maintenance of personal income in this study area. Valdez will continue to serve as the residential base for VMT employees and contractors, but will have little, if any, impetus for growth resulting from ongoing TAPS and shipping operations.

If TAGS were constructed, the LNG plant at Anderson Bay near Valdez would increase employment, economic activity, and local government revenues from taxes. A major new source of local employment since the *Exxon Valdez* oil spill has been the incorporation of local boat owners (mainly in the commercial fishing fleet) and trained spill response personnel from Valdez, Cordova, Tatitlek, and Chenega Bay into the Alyeska SERVS. The projected decline in revenues derived from petroleum property tax receipts (from $9 million in 2004 to $2 million in 2033) may cause adverse socioeconomic effects in Valdez (these effects would be more intense in the no-action alternative). Revenues from the LNG plant and marine facilities could partially offset this decline if the TAGS option were selected.

Selection of the GTL option is unlikely to increase revenues or employment in the Valdez/PWS study area. However, the additional throughput associated with the GTL option may extend the economic life of the pipeline, because lower TAPS tariffs could increase the economic attractiveness of marginal oil fields.

The ANGTS pipeline is not expected to have any effect on the Valdez/PWS study area, because none of the candidate routes for this pipeline approach this area.

Continued operation of the pipeline and of North Slope oil activity generates a large and stable level of basic sector employment. Because jobs in this sector are among the highest paid in the state, each job makes a large contribution to the economy. Wage and salary employment is projected (see Table 4.3-18) to grow modestly if the proposed action alternative is selected, as is real per-capita income. Using the criteria identified in Table 4.5-12, the intensity of employment effects is evaluated as moderate and the probability as high.

Summary: Economics

For the economic effects as a group, the effects are clearly beneficial, very substantial (high intensity), and almost certain to occur (high probability).

Proposed Action: Social Change

Examples of social change issues include potential cumulative effects associated with population changes (influx of new workers), demand for increased housing, the effect of wage and salary employment (and lack of same) on Alaska Natives, and concern over loss of cultural identity.

Soc5. Social change effects.

Significant social changes have occurred in many Alaskan communities. Industrial development, including construction of the North Slope oil-field infrastructure and TAPS, has been one of the factors contributing to this change (Coates, 1993; Cole, 1997). As noted in Section 3.3.2.1, other factors have included early Alaska Native contact with Euroamericans, mining booms such as the Klondike, World War II, the construction of the Distant Early Warning (DEW) line, Federal government policies (e.g., the Bureau of Indian Affairs), and changes in the

structure of government associated with statehood. Legislation, including ANCSA and ANILCA, also contributed to major changes in social organization and cultural value systems (Section 3.3.2.1). The increased availability of new communications technology (e.g., telephones, radio, television, and the Internet) provides many benefits but also contributes to cultural change. The increased availability of higher education is clearly a benefit, but it also introduces new values that may cause cultural stresses. Actual or perceived economies of scale in mass merchandising have led to the growth of shopping malls and major chain stores in larger communities; while convenient, this may have reduced the regional diversity of available products. Wage and salary employment reduces the time available for other pursuits, but the resultant income provides the means to purchase a wide variety of goods and services.

The institutions, policies, events, and trends identified above have helped to bring about social change. It should also be noted that many institutions and programs increase stability and cohesion. For example, many villages have programs (e.g., storytelling, traditional dance, crafts, boatbuilding, and Native language instruction) designed to promote elements of a traditional lifestyle.

There have been significant social changes for both Alaska Natives and non-Natives alike. The scope and depth of these social changes fully justifies an intensity evaluation of high. The probability of these changes continuing in the future is also high. This assessment is reflected in the ranking matrix of potential cumulative effects presented in Figure 4.5-8. This said, the contribution of the proposed action alternative is less clear — indeed it is likely that social change would continue regardless of the alternative.

Thus, to some extent, these cultural changes are *unavoidable* and may be *irreversible.* Whether or not many of these social changes are *undesirable* is a matter of personal or group perception. Some social changes can generally be considered beneficial. For example, almost 76 percent of the adult population of the NSB has graduated from high school, earned a general equivalency diploma, and/or attended an institution of higher education — a considerable increase compared to 1993 (NSB, 1999). The number of Iñupiat men and women from 18 through 26 years of age who have taken some college or university classes increased from 13.1 percent to 19.6 percent in 1993-99. Education is one of the benefits provided by rising incomes and programs provided by the NSB, funded in part by revenues from oil and gas activities on the North Slope.

Potential social effects of TAPS were foreseen by the Federal Task Force on Alaskan Oil Development in drafting the original EIS for TAPS (BLM, 1972). The EIS noted that economic activity might spur social change and discusses both positive and negative effects.

Several of the consolidated issues relate to the influx of new workers and population increases in general. A disruptive source of long-term change depends on the relative weakening of traditional stabilizing institutions through prolonged stress and disruptive effects (USACE, 1999). These changes already are occurring to some degree on the North Slope as a result of the cumulative effects of onshore oil and gas development, more dependence on a wage economy, higher levels of education, improved technology, improved housing and community facilities, improved infrastructure, increased presence of non-Natives, increased travel outside of the North Slope, and the introduction of television and the Internet (BLM and MMS, 1998; USACE, 1999).

The economic analysis of the proposed action provides projections of wage and salary employment overall and in the oil and gas sector in particular. Table 4.3-17 in Section 4.3.3.1 indicates that direct full-time employment with TAPS and ANS oil field operations is projected to increase from 11,601 in 2000 to 11,812 in 2015, a modest rise. Estimated total wage and salary employment on the North Slope is projected to increase from 7.6 thousand in 2000 to 9.2 thousand in 2015, proportionately greater than that for oil and gas employment overall, but not large. Thus, the potential population influx in the future will be limited.

The NSB has chronic unemployment and underemployment (NSB, 1999) and has a stated policy objective of "seeking ways to diversify the economies of the North Slope communities to enable them to become less dependent upon the resources of the North Slope Borough government."

Commercialization of ANS natural gas could result in an influx of new workers. For example, if the LNG project is implemented, there will be a temporary influx of construction workers, chiefly to the Central TAPS and Valdez/PWS study areas (but also on the North Slope), for the construction of the pipeline, compressor stations, and the LNG plant, storage facility, and other marine terminal infrastructure. These effects are described in the EIS for the pipeline (BLM and USACE, 1988) and the LNG facility (FERC 1993, 1995). As noted in the TAGS EIS, "The major socioeconomic impact of the TAGS project during preconstruction and construction phases would be increased population and employment." In the TAGS EIS it is stated that "during the five-year detailed design and construction phase, average annual TAGS employment would peak at more than 7,200 people. By comparison, employment on the TAPS pipeline peaked at an annual average of

nearly 22,000 people." Employment and timing reported in the LNG EIS differ from those noted above (possibly because the scope was restricted to the LNG facility), but are substantial. Nonetheless, the Federal Energy Regulatory Commission (FERC) concluded that only limited adverse environmental effects would occur with appropriate mitigating measures. Implementation of a GTL alternative or ANGTS would also result in the influx of new workers. The number of workers required and the length of the construction period depend upon the option selected and, for ANGTS, the pipeline route selected.

Soc6. Job opportunities for Alaska Natives.

Alaska Natives have expressed concern over a lack of employment opportunities in the oil and gas industry. Section 29 of the Federal Grant states, "Permittees shall enter into an Agreement with the Secretary regarding recruitment, testing, training, placement, employment, and job counseling of Alaska Natives."

In furtherance of Alaska Native employment objectives, Alyeska entered into the Alaska Native Utilization Agreement (APSC, 1998d) with the U.S. Department of the Interior, which reaffirmed the "Section 29" obligation and set specific targets for training and hiring of Alaska Natives. The overall goal of this program is to increase the overall level of Alaska Natives in the Alyeska work force to 20 percent by 2004. Specific subgoals were established by employment category (e.g., managers/supervisors, professionals, technicians, and clerical and administrative workers) and by year to achieve this goal (Table 4.5-14). Upon reaching the 20 percent employment level,[9] it is expected that Alyeska will maintain these percentages for the life of the Federal Grant. It is assumed that this agreement would continue with the proposed action.

The employment goals apply to Alyeska and to "designated contractors." The agreement is wide-ranging, addressing recruitment, placement, training, and mentoring programs. It also establishes an advisory board to provide advice and counsel regarding the operation of the Section 29 program, assess the program's success in achieving the agreed-upon goals, make recommendations for improvement, and to report annually to Alyeska management on the overall effectiveness of the program. When successfully completed, this program should resolve Alaska Native concerns regarding TAPS employment.

Natural gas commercialization options would generate additional opportunities for employment of Alaska Natives.

Employment opportunities for Alaska Natives associated with the proposed action alternative are evaluated as having moderate intensity (measurable, but not substantial, change) with a high probability of occurrence.

Soc7. Income potentially affecting social problems.

Another social issue raised in several EISs relating to North Slope petroleum development is that income from oil and gas production may bring about increases in social problems, such as rising rates of alcoholism and drug abuse, domestic violence, wife and child abuse, rape, homicide, and suicide (BLM and MMS, 1998). Other EISs (e.g., Beaufort Sea Sale 97, MMS 1987a) restate this hypothesis but are less definite about the linkage between these effects and cash income derived from oil and gas activities. It is very difficult to identify and quantify the significance of possible causes of various social ills. The incidence of all of the above social ills may be increasing, but the practical question is whether this incidence would decrease if oil and gas income were eliminated—and all other factors were held constant.

Increased cash income (in the form of revenues of Native corporations or individual wages) provides financial resources to North Slope residents. Additional income provides a wide variety of options for the recipients, which include many socially beneficial uses (e.g., improved housing, schools and health care) as well as socially disruptive choices. North Slope communities can and have developed additional social programs to mitigate these effects and/or attempt to control access to liquor and drugs, if warranted.

Another issue of concern to those in North Slope communities is the desire to maintain fluency in the Iñupiaq language. Loss of language skills is perceived by many as an important element in the loss of cultural identity. Historically, federal and state governments were not sensitive to this issue and actively suppressed use of Alaska Native languages (Mead, 1978; Chance, 1970; Roberts, 1992). In more recent times, this situation has changed radically. The NSB believes that the use and preservation of the Iñupiaq language are fundamental to cultural survival and has developed school language instruction programs that have proven successful (NSB, 1999). Thus, it appears that local programs can mitigate this potential effect.

The Northstar EIS (USACE, 1999) states that NSB institutions "work vigorously and quite successfully at preventing any weakening of traditional cultural institutions and practices." The NPR-A EIS (BLM and MMS, 1998) concludes that sociocultural effects can be mitigated and does not include these among the unavoidable adverse effects of

[9]This level of utilization was established in the original 1974 Native Utilization Agreement and was derived from the estimated percentage of Alaska Natives in the total Alaskan civilian population at that time.

Table 4.5-14. *Alyeska Native employment goals.*

Year	1998	1999	2000	2001	2002	2003	2004
Managers/supervisors	4%	6%	7%	9%	10%	12%	14%
Professionals	10%	11%	13%	14%	16%	18%	19%
Technicians	11%	13%	15%	16%	18%	19%	21%
Clerical and administrative	21%	22%	24%	26%	27%	29%	30%
Totals	10%	12%	14%	16%	17%	19%	20%

Source: APSC, 1998d

the cumulative case.

Although the above discussion focuses on the North Slope, similar social concerns have been expressed with respect to the other study areas included in this analysis. As discussed in Section 3, many villages in the Central TAPS and Valdez/PWS study areas have a high percentage of Alaska Natives who have generally similar concerns.

Although it has been argued that increased income can have negative as well as positive effects, it appears that, on balance, the overall effect is positive. Because projected changes in personal income are modest, this effect is ranked as moderate intensity. These effects are judged to have a high probability.

Summary: Social Change

Overall, it is concluded that the effects identified in the social change cluster are high intensity and that the probability of these changes continuing is high. However, although linked in part to oil and gas development, these changes result from many causal events and trends. Moreover, selection of either the proposed action or the no-action alternative is unlikely to change the situation appreciably (the no-action alternative would lessen the degree of contact between Alaska Natives and others on the North Slope, however). It should be noted that not all social changes are adverse. Many of the economic effects discussed in a separate section have clearly beneficial social consequences.

The proposed action provides revenues for government programs designed to facilitate change and minimize adverse effects, but a return to pre-development conditions cannot be achieved because oil and gas development is only one of the factors involved in social change. Selection of the no-action alternative (see below) would be unlikely to reverse or arrest these changes and would almost certainly result in greater social disruption for all population groups as well as in fewer resources to deal with these disruptions.

Proposed Action: Subsistence

As noted at length in Section 3.3.3.2, subsistence is an essential component of Alaska Native life. Effects that threaten subsistence are potentially very important. The proposed action — together with the effects of other projects included in the cumulative analysis — could result in adverse effects on subsistence. Although common subsistence-related concerns exist for each of the study areas, there are differences among these that are sufficient to justify separate discussions for each of these areas.

The proposed action would raise three principal concerns relating to subsistence. The first concern is the possible effects of an oil spill on subsistence resources. The second issue relates to possible access restrictions and/or competitive pressures from others who wish to use subsistence resources. The third issue concerns other possible effects (e.g., noise) of ANS petroleum development that could adversely affect subsistence harvests.

Soc8. Large oil spills affecting quality of subsistence resources: ANS and Central TAPS.

Relevant statistics on spills associated with ANS activities are presented in Section 4.1.2 and Appendix B. ANS oil field spills (both crude and product) have accounted for about half (50.87 percent) of the total number of spills among all Operations elements (including oil fields, pipeline, VMT, and the marine transportation link) over the period from 1977 to 1999. However, the average ANS spill volume has been relatively small, with the result that ANS spills accounted for only 3.36 percent of the total volume spilled. Fifty percent of ANS crude spills were less than or equal to 10 gallons and 50 percent of product spills were less than or equal to 5 gallons. The mean sizes of ANS crude and product spills were 3.9 bbl and 1.34 bbl, respectively. From 1977 to 1999, no ANS oil spills >1,000 bbl occurred.[10] Most small spills are confined to pads, roads, or facilities; therefore, it is unlikely that a small spill would

have a significant effect on subsistence resources.

Based on the observed volumetric spill rate (bbl spilled per billion bbl produced), the expected total volume spilled in the ROW renewal period would be 6,050 bbl, an average of 202 bbl/year. During the period when the data used for the spill projections were gathered, nearly all production was onshore (Table 4.5-4). In the future, more production is likely to come from offshore wells (Table 4.5-4). However, the majority (76 to 81 percent) of future production is expected to come from onshore wells, which supports the spill projections given in Appendix B.

These projections notwithstanding, the possibility of one or more large oil spills in the future cannot be excluded, although this event is not likely on the basis of the historical record. Other EISs (e.g., MMS, 1998; BLM and MMS, 1998; USACE, 1999) have used alternative statistical approaches to estimate future spill volumes in the cumulative case and concluded that the probability of one or more large (>1,000 bbl) spills is relatively high (>90 percent). In the NPR-A EIS, for example, it is concluded that "cumulative effects from oil spills into the Colville River and the Beaufort Sea may significantly restrict subsistence use of fish and marine mammals." The Northstar EIS uses the same statistical methodology as that used in NPR-A and reaches a similar conclusion regarding the probability of a large oil spill. The Beaufort Sea Planning Area Oil and Gas Lease Sale 170 EIS (MMS, 1998) projected that the overall cumulative effects of a large oil spill would "cause one or more important subsistence resources to become unavailable, undesirable for use, or available only in greatly reduced numbers" for periods ranging from one to five years in Nuiqsut to one to two years in Barrow and Kaktovik.

All North Slope EISs conclude that the subsistence effects of a large spill could be significant should it occur. (The effect on subsistence resources depends upon the spill size, location, season, and other factors.) What is uncertain is the probability of occurrence of one or more large spills on the North Slope. The analysis presented in this report (based on analysis of actual ANS spills) indicates that this is at most a moderate probability,[11] while that based on outer-continental-shelf experience (chiefly in the Gulf of Mexico) indicates that the probability of one or more large (>1,000 bbl) spills is high.

Various methods for minimizing the effects of oil spills on subsistence resources include spill recovery capabilities, access to alternative harvest areas, and possible employment in cleanup activities and other remedial economic benefits, as occurred following EVOS.

Refer to Section 4.3.3.3 for additional detail regarding the likelihood and potential effects of an oil spill in the Central TAPS study Area. The probability and consequence of oil spills are discussed there.

Based on the criteria for ranking potential social effects presented in Table 4.5-12, the intensity of the potential effect of a large spill on subsistence is evaluated as moderate. This judgment is reached because the effects are likely to be localized and temporary. The probability of a large spill occurring and affecting subsistence is low, based on historical spill rates.

Soc9. Effects of noise on subsistence whaling.

The second major subsistence concern of North Slope residents is that industrial activity and associated noise will have adverse effects on subsistence whaling. Such effects could result from the bowhead whale's response to noise (particularly that associated with seismic surveys) and activity. This issue was discussed at length in the cumulative effects section of the Northstar EIS (USACE, 1999). This report concluded that such an effect could significantly affect whaling communities including Barrow, Nuiqsut, and Kaktovik. The EIS concludes that the operational noise associated with the Northstar production island should not cause significant disturbance of bowhead whales or the harvest. However, it also states that case-by-case evaluation will be needed for proposed future projects to see if cumulative noise effects will result.

Based upon the ranking criteria presented in Table 4.5-12, this potential effect is evaluated as having moderate intensity and moderate probability. Subsistence whaling is very important to Alaska Natives, but the potential effects of seismic surveys are temporary and can probably be mitigated by appropriate timing of these surveys and other measures.

[10]Several EISs have made projections of possible future large oil spills on the North Slope. No large ANS spills have occurred, and these projections were based on outer-continental-shelf experience in the Gulf of Mexico. However, the factors and operating procedures involved in Gulf of Mexico oil spills differ significantly from what might be expected on the North Slope, and the utility of Gulf of Mexico data is questionable.

[11]Over the period from 1977 to 1999 there were no large (> 1,000 bbl) ANS spills. The largest individual ANS crude spill during this period was 925 bbl. Based upon the historically observed volumetric spill rate and projected future throughput, the average annual ANS spill is approximately 200 bbl. Even if it is assumed that the 925 bbl spill qualifies as a large spill, the estimated number of these spills per billion bbl is 1/12.758 = 7.84 x 10-2 and the projected number of such spills over the ROW renewal duration is this quantity times approximately 7 billion bbl to be produced, or 0.55 (less than one). Using the Poisson approximation discussed in Appendix B, the probability of 1 or more "large" ANS spills over the renewal period is 1-exp(-0.55) = 0.42.

Soc10. Large oil spills affecting quality of subsistence resources: Valdez/PWS.

Potential oil spills from TAPS or associated activities into the Copper or Lowe rivers or into the marine waters of PWS could affect subsistence harvests in the short term by lowering potential harvest resources and/or diverting harvesters away from traditional subsistence activities and into response operations. Longer-term effects would depend on the timing and size of the spill, but might include a decline in availability of certain resources, or food safety issues regarding affected subsistence resources.

In the cumulative case, there is a possible interaction between the operations of the TAPS marine transportation link and LNG tankers if TAGS is commercialized. This is also examined.

Relevant statistics on oil spills associated with VMT and the marine transportation link are presented in Section 4.1.2 and in Appendix B. Based on historical experience from 1977 to 1999, the volumetric spill rate for VMT is 0.32 bbl crude and product spilled in bbl/million bbl throughput. The projected TAPS throughput over the ROW renewal period is approximately 7.02 billion bbl. Thus, the total spill volume from VMT over the ROW renewal period is estimated to be approximately 2,270 bbl, or 76 bbl/year. As with other operations segments, most VMT spills have been relatively small.

Based on historical experience from 1977 to 1999 and estimated improvements in the post-EVOS period, including SERVS and the introduction of double-hull tankers, the analysis presented in Section 4.1.2 concludes that the annual average spill volume for large (>1,000 bbl) spills would range from 690 bbl to 2,750 bbl, depending on the effectiveness of double-hull tankers and other mitigating measures. Small spills are estimated to account for approximately 33 bbl annually. Put another way, this analysis concludes that over the 30 years of the ROW renewal period:

- The probability of one or more spills greater than 1,000 bbl ranges from 50 to 90 percent. The lower probability (50 percent) represents a conservative estimate of the effectiveness of double-hull tankers and other mitigating measures. The upper probability (90 percent) assumes that these measures do not result in any improvement.
- The expected number of large spills over the ROW renewal period ranges from 0.69 (conservative estimate of possible improvement) to 2.75 (no improvement).[12]
- The expected size of a large spill, given that one occurs, is 30,000 bbl.

These probabilities do not reflect any contribution to the possible effects of additional LNG tanker traffic if TAGS is authorized. Figure 4.5-9 shows the historical and projected number of oil tankers loading at Valdez from 1977 to 2020. If the TAGS project were authorized immediately, the earliest that it could be operational would be 2010. The maximum predicted annual number of LNG tankers loaded is 275. These are also shown in Figure 4.5-9. As can be seen, the total (oil and LNG) number of tankers, assuming immediate TAGS go-ahead in the future is well below the traffic in earlier years. This is a conservative depiction, because TAGS is not now economically feasible. Therefore, even if TAGS were implemented at a later date, LNG tankers visits would be postponed and the total traffic would be even smaller, compared to past activity, because of continuing declines in projected oil tanker traffic.

The draft EIS for the LNG facility (FERC, 1993) considered the possibility of a collision between an LNG tanker and an oil tanker and concluded (based on 900 oil tankers loaded per year) that the increase in tanker traffic would be well within the limitations of the Vessel Traffic Safety system and that the probability of a collision would be low.

The draft EIS for the LNG facility included a qualitative analysis of the effects of an LNG tanker accident and concluded that groundings could result in the release of LNG. An LNG spill would not present the same environmental effects as a crude oil spill; much of the LNG would vaporize and form a vapor cloud. This cloud would be flammable, however, until sufficiently dispersed and could present a significant fire and explosion hazard. In the event of a collision of sufficient magnitude to cause the rupture of an LNG cargo tank, it is likely that sparks would ignite the vapors at the spill site which would result in intense thermal radiation levels within several thousand feet of the fire. Groundings are believed to have less potential for ignition of the vapor cloud.

Implementation of a GTL option would increase TAPS throughput by the liquids production rate of the GTL unit(s). Use of the spill methodology discussed in Appendix B will result in a projected increase in oil spill amounts and/or the probability of large spills if TAPS throughput increases.

A large oil spill in the Valdez/PWS area could result in a material impairment of subsistence resources (e.g., reduc-

[12]The upper end of this range falls within the range of from 2 to 4 large spills estimated for the cumulative case by the Minerals Management Service (MMS, 1998). The MMS analysis does not include any allowance for the benefits of double-hull tankers and other measures.

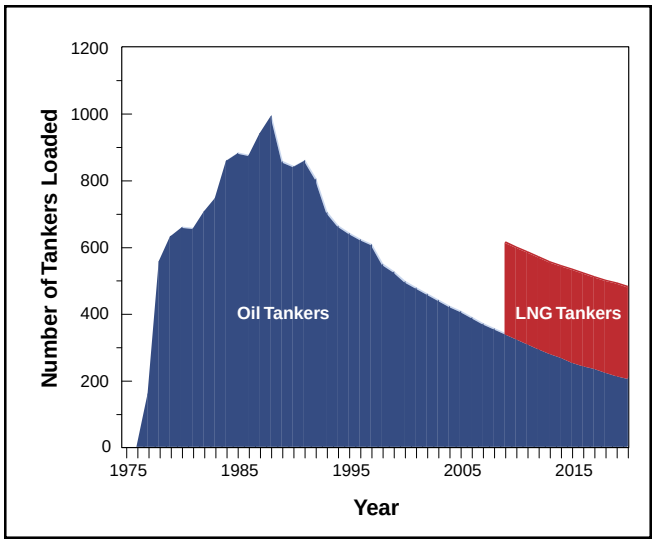


Figure 4.5-9. *Historical and projected tanker loadings at Valdez, 1977-2020*

tion in numbers of marine mammals, fish, and waterfowl) that could take several years to return to pre-spill values (Rice et al, 1996). As noted in the Northstar EIS, fears of consuming contaminated fish and sea birds could cause less tangible effects on subsistence and could continue to affect subsistence harvesting for years after the spill (USACE, 1999).

In accordance with the evaluation criteria shown in Table 4.5-12, the intensity of the effect is ranked as high. The probability is judged as low, based on the conservative estimate (50 percent probability of one or more spills) summarized above. The probability of a large spill affecting subsistence resources is low and would depend on the size, location, and time of year of the spill. The response capability of SERVS should significantly reduce the potential impacts of a large oil spill.

Soc11. Access to subsistence resources.

One of the recurring issues related to subsistence relates to access. Concerns vary to some extent with the study area, so this discussion is organized on this basis.

North Slope. The total land area occupied/disturbed by oil fields on the ANS, shown in Table 4.5-15, is not large — particularly in proportion to the area of the region (Gilders and Cronin, 2000). However, "traditionally, all access for subsistence hunting has been restricted in the oil fields for security and safety reasons" (USACE, 1999). Subsistence access concerns exist in the cumulative case since the amount of restricted land could increase with the development of new fields. The environmental evaluation document for the Alpine Development, for example, notes that the most commonly expressed Nuiqsut concerns about effects of oil and gas development on subsistence involve potential damage to biological resources and habitats, and freedom of access to harvest areas (USACE, 1997).

ARCO agreed to permit access at its Alpine and Tarn developments for subsistence hunting and fishing purposes, with the exception of reasonable security and safety procedures. The following points are relevant to North Slope hunting activities:

- Operators have prohibited firearms, firearm parts, or deadly weapons (including large knives, crossbows, martial arts weapons, etc.) ammunition or explosive material of any kind on the North Slope (BPXA, 1999). A very specific and limited exception may be made to this policy in regards to employees working in remote areas. Such authorization may be granted for bear protection where people are working in such remote areas that bears are of concern. Prudhoe Bay Unit Archery Club members may bring archery equipment to the Prudhoe Bay Unit.
- The Alaska Department of Fish and Game (ADF&G, undated) has established a Prudhoe Bay Closed Area (Game Management Unit [GMU] 26 B) which is closed to the hunting of big game. Small game may be hunted as outlined in the current edition of the Alaska State Hunting Regulations.
- ANILCA requires that subsistence users have a priority over other users to take fish and wildlife on federal public lands where a recognized consistent and traditional pattern of use exists. When necessary to restrict the taking of fish and wildlife on these lands, subsistence uses are given preference over the other consumptive uses.
- Special provisions are in force regarding GMUs 26(A), 26(B), and 26(C). These pertain, among other things, to restrictions on use of aircraft, seasonal restrictions, bag limits, and use of various types of weapons and ammunition.

Beyond restricting hunting by its employees, the oil industry cannot control possible competition from non-residents.

Implementation of one or more gas commercialization options could raise additional access issues. During the construction phase, there might be access restrictions and/or construction activities that would disrupt harvests. Unless constraints were imposed, construction workers could compete with Alaska Natives for subsistence resources.

Central TAPS. The opening of the Dalton Highway to general use is a cumulative effect that has raised concerns among residents of several communities in the Central TAPS study area. This development provides greater access

Table 4.5-15. *North Slope oil fields.*

Oil field (Note a)	First production	Unit area (ha) (Note b)	Number of production facility gravel pads	Area disturbed by mine sites and gravel placement (ha)	Percent of unit disturbed by mine sites and gravel placement	Current (1999) oil production level (bbl/day) (Note c)
Prudhoe Bay	1977	99,103.6	50	2,592.5	2.62%	639,000
Kuparuk	1981	104,514.2	49	1,033.8	0.99%	266,000
Milne Point	1985	22,002.8	11	182.0	0.83%	55,000
Lisburne	1986	32,359.5	8	100.7	0.31%	7,000
Endicott	1987	7,099.1	2	207.1	2.92%	44,000
Pt. McIntyre	1993	4,384.1	2	12.7	0.29%	119,000
Niakuk	1994	2,623.7	1	9.8	0.37%	29,000
Badami	1998	15,139.6	1	74.4	0.49%	4,000
Pt. Thomson/ Sourdough	Planned	33,896.8	4 ±	112.0	0.33%	0
Alpine	Planned	32,576.5	2	56.5	0.17%	0
Liberty	Planned	2,152.9	1	2.2	0.10%	0
Northstar	Planned	12,491.8	1	1.8	0.01%	0
TAPS and Dalton Highway (North Slope)	1977 (pipeline completed)	NA	NA	4,412.9 (Note d)	NA	NA

(a) "Oil field" refers to both units and participating production areas. There are six additional production areas on the North Slope whose oil is processed by existing facilities (i.e., no additional surface impact).
(b) Unit areas cannot be totaled because overlap exists among the unit and participating areas.
(c) Alaska Department of Revenue, Oil and Gas Audit Division, January 25, 2000.
(d) Senner, 1989.
Note: 1 hectare (ha) is equal to approximately 2.47 acres.
Source: Gilders and Cronin (2000).

for tourists, recreation seekers, and hunters/anglers. This increase in access provides benefits to these groups and to tour agencies. However, some residents of communities near this road are concerned that this will adversely affect subsistence harvests as a result of competition for subsistence resources. ADF&G regulations are likely to mitigate this possible effect. The Dalton Highway Corridor Management Area consists of those portions of GMUs 20, 24, 25, and 26 extending 5 miles from each side of the Dalton Highway from the Yukon River to Prudhoe Bay. This area is closed to the use of motorized vehicles except aircraft and boats, and to licensed highway vehicles, snowmachines, and firearms with few exceptions. These exceptions include:

- The use of snowmachines is authorized only for the subsistence taking of wildlife by residents living within the Dalton Highway Corridor Management Area.
- The use of licensed highway vehicles is limited only to designated roads within the Dalton Highway Corridor Management Area.
- The use of firearms within the Corridor is authorized only for the residents of Alatna, Allakaket, Anaktuvuk Pass, Bettles, Evansville, Stevens Village, and residents living within the corridor.

These regulations limit the degree of competition to subsistence users.

Construction activities associated with gas commercialization efforts (e.g., the LNG project) or the NMDS could also effect subsistence.

Valdez/PWS. Subsistence uses in the Valdez/PWS area are presently managed jointly by the ADF&G, U.S. Forest Service, and the U.S. Fish & Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS). The proposed action would not affect access of harvesters in the Prince William Sound communities.

Access issues in the Valdez/PWS study area are less significant than those on the North Slope, although some residents of PWS perceive an increased competition from Valdez-based charter boats for fish and game resources. The draft EIS for the TAGS LNG facility noted that there could be some increase in hunting by construction crews, but the effects were not judged significant. GTL or ANGTS would not result in any effects on access.

Access effects are judged to have moderate significance, as is the probability that these effects will occur.

Subsistence: Conclusions

Probable cumulative effects on subsistence vary with the study area. However, for both the North Slope and Valdez/PWS areas, possible effects of one or more oil spills on subsistence harvests are fairly characterized as having high magnitude, moderate geographic scope, and moderate duration. Not all large spills would adversely affect subsistence resources, the effects of the spill would be temporary, and it is likely that subsistence users would receive some compensation. For these reasons the environmental consequences are judged to be moderate. The probability of one or more large (>1,000 bbl) oil spills in the North Slope study area during the ROW renewal period is estimated to be low in this analysis. The probability of one or more large spills in the Valdez/PWS area also is estimated to be low.

On the North Slope, access to subsistence resources is a concern. Stipulations have been devised (e.g., for NPR-A) that will mitigate these effects.

Proposed Action: Visual/Recreational Effects

Soc12. Effects on visual/recreational resources.

The fourth issue group relates to cumulative visual and recreational effects. In broad terms, the issues related to visual effects concern possible adverse changes in the overall appearance of the landscape as a result of the proliferation of industrial structures (e.g., wells, tanks, pipelines, and terminals) which alter the visible characteristics of an area and the possibility of oil spills (and visible cleanup activities) that would temporarily mar the appearance of land and water bodies. Recreational issues relate to the effects of these facilities on the quality of the recreational experience and also to increased access to lands for recreational use and, therefore, increased levels of recreational use. The nature, severity, and probability of potential adverse effects vary with the study area, so this discussion is organized by study area.

North Slope. ANS developments have a visible footprint, which changes the appearance of the landscape. As noted in the Northstar EIS (USACE, 1999), existing development in the Prudhoe Bay-Kuparuk area has substantially altered the visual character of this area. The presence of industrial structures in an otherwise undeveloped area and introduction of artificial lighting over broad areas where none previously existed are generally perceived as adverse effects of existing North Slope development. Reasonably foreseeable future projects will result in the geographic expansion of these visual effects.

Some of these visual effects are short-term, while others will last until DR&R activities are complete. Among the causes of short-term effects are exploration activities, including seismic surveying work in winter. The moving camps associated with this work would cause a short-term negative effect on scenic quality (BLM and MMS, 1998).

Longer-lasting effects (two to five years) are “green trails” resulting from overland personnel and equipment moves (BLM and MMS, 1998). Vehicles compacting snow and vegetative matter create green trails with greater moisture and the availability of greater nutrients for underlying vegetation in the following growing season; in short, the vegetation becomes greener in a pattern following the tracks of the ground vehicles. This effect is not always apparent from a ground view (although readily detectable from the air) and does not always occur. Vegetative greening also occurs under vacated ice pads, airstrips, and roads.

Exploration and production wells, gravel pads, gathering facilities, pump stations, pipelines, roads, and other industrial structures produce yet longer-lasting (30 years) visual effects. From a statistical perspective, the actual land area occupied by these facilities is relatively small (Table 4.5-15) in both absolute and relative terms, typically occupying less than 1 percent of the unit area and a very much smaller percentage of the total area of the North Slope. Moreover, there has been progress in reducing the operational footprint of these facilities. Following are some of the measures taken to reduce this footprint (Gilders and Cronin, 2000).

- Consolidation of facilities;
- Use of ice road technology to eliminate unnecessary gravel roads adjacent to pipelines, and elevating those pipelines to 1.5 m above the tundra surface to allow free movement of wildlife;
- Directional drilling to reduce the number of gravel pads and wellhead spacing; and
- Improved waste handling and the elimination of reserve pits for surface storage of drilling muds and cuttings (these drilling by-products are now reinjected into confining geological formations).

According to Gilders and Cronin (2000), drill pads can now be built 70 percent smaller than those built in the past.

In addition, aggregate land disturbances are reduced by consolidation/sharing of facilities. The principal impetus for facilities sharing may be economic (minimizing initial capital investments, pooling overhead on otherwise underutilized facilities, see CERA, 1999d), but the effects on land disturbance are beneficial nonetheless. Development of new fields under the proposed action will expand the visible disturbed area. When fields become uneconomic and are finally shut down, DR&R will remove most visible traces of this development.

Selection of any of the gas commercialization options will result in the construction of additional facilities on the North Slope (e.g., a GTL plant or gas conditioning facilities). Selection of either the LNG or the ANGTS pipeline entails the construction of a buried pipeline and other facilities (e.g., compressor stations). The incremental land area required is small.

Statistics on oil spills are discussed above. An oil spill on land would probably affect only a relatively small area (see Section 4.3.3.2) and would cause temporary adverse visual effects. A large spill that entered a river or the Beaufort Sea would have larger adverse effects.

The NPR-A EIS offered the following summary of potential cumulative effects of ANS oil and gas developments on visual/recreational resources on the North Slope (BLM and MMS, 1998):

> There is potential for significant cumulative effects on recreation/visual resources in certain locations on the North Slope. Within the planning area, the area around Nuiqsut has a high potential for significant cumulative effects. However, the region being considered is so large these 'high risk' areas make up only a small percentage of the North Slope. Also although there may be certain areas and times of concentrated activity and development, generally, expected activity and development will be quite dispersed both in time and space greatly reducing the probability of a significant cumulative effect.

Central TAPS. The situation differs in the Central TAPS study area. The pipeline has been constructed, and no additional industrial development is expected in connection with TAPS. As noted in Section 4.3, minor ground-impacting activities — including corrosion digs, slope/workpad maintenance, washouts/river training structure repairs, and below ground valve inspections — will occur in the future. A pipeline reroute is also possible, although reroutes have not been frequent in the past. Collectively these effects are likely to be minor.

As noted in Section 3.3.6.3, TAPS occupies a relatively small land area (16.3 square miles) in absolute terms and a minuscule fraction of the state. TAPS is readily visible from the air and several scenic overlooks have been created (along the Dalton Highway), together with visitor areas at Fairbanks, Pump Station 9, and the VMT.

Section 4.3.3.3 addresses the probability and possible consequences of an oil spill from continued operation of the TAPS pipeline under the proposed action. Oil spills, particularly if these were large and entered water bodies, together with associated cleanup activities could result in substantial but temporary visual/recreational effects in the Central TAPS study area. From 1977 to 1999, there were five large (>1,000 bbl) oil spills along the pipeline. All resulted in minor, localized, and temporary effects. Had any of these spills entered rivers, however, the effects would have been greater.

If TAGS or ANGTS southern route project were built, a new buried pipeline would be constructed near portions of the present TAPS pipeline. Construction of the TAGS gas pipeline and associated compressor stations would result in a disturbed area of 23,216 acres during construction and 8,425 acres during operation. Much of the disturbed land would be located in the Central TAPS study area. If the ANGTS pipeline were built, the aggregate disturbance would vary with the route, but is not likely to be large in any event. This said, a buried gas pipeline would have less affect than TAPS.

If gas commercialization were achieved by use of the GTL technology, no new pipeline or terminal would be required and consequently there would be no increase in the disturbed area. Compared to TAGS, this would minimize the disturbed area and avoid large-scale construction efforts.

The NMDS site at Fort Greely is expected to have little or no effect on visual/recreational resources.

The state's takeover and subsequent opening of the Dalton Highway to general use is a cumulative effect noted in the above discussion of subsistence. In principle, increased tourism could also affect recreational uses, but there is no evidence that this is occurring. With the exception of maintenance of visitor centers, any increase in tourism or related activities is not caused by or under the control of the applicants for the TAPS ROW. Moreover, it is unknown whether selection of the proposed or the no-action alternative would materially affect recreational use of these areas. The proposed action is expected to result in a larger state population and also a larger Fairbanks population. However, if the no-action alternative were selected, there would be greater economic pressures for many in the area to increase subsistence harvests. The severe economic contraction resulting from the no-action alternative might spur development of tourism in an attempt to replace lost earnings. Given the present state of knowledge, this effect is indeterminate.

Valdez/PWS. Because the proposed action would not result in the construction of any new facilities for TAPS, no new adverse visual effects would result from this source. Scenic overlooks would be expected to remain in place, as would the visitor center at the VMT.

If the TAGS project is implemented, a new LNG terminal and vessel berthing facility, occupying approximately

390 acres, would be constructed at Anderson Bay, approximately three miles east of the Valdez Narrows on the south shore of Port Valdez (FERC, 1993, 1995; BLM and USACE, 1988). Anderson Bay and the proposed LNG project site are visible from the city of Valdez, from Shoup Bay State Marine Park, and to boat and plane traffic passing the proposed site (FERC, 1993). Visibility of the site depends on several factors including weather (e.g., clouds and fog), sun angle, and light (FERC, 1993). The FERC EIS (FERC, 1993) concluded that the visual effect of this facility was not significant, but noted that two miles of pristine shoreline would be permanently changed by the development. A GTL option would result in less visual effect with relatively minor new facilities at VMT.

A large oil spill and associated cleanup efforts could create significant, but temporary, adverse visual effects. Appendix B provides information on the probability of an oil spill at either the VMT or the marine transportation link and the mitigation measures (e.g., double-hull tankers, SERVS) that are now or will be in place during the ROW renewal period. Tourism would be adversely affected; however, this adverse economic effect would be compensated for by cleanup activities.

If TAGS were implemented, LNG spills could occur. Various design features to minimize and contain LNG spills are discussed in the TAGS EIS (FERC, 1993, 1995). An LNG spill would volatilize and would not result in similar visual effects to those that would occur with an oil spill. However, LNG is flammable, and a fire or explosion could result in adverse visual effects. Safety issues would be a greater concern in this event, however.

Use of GTL technology would lead to an increase in TAPS (and thus, VMT) throughput to accommodate GTL products. With a constant volumetric spill rate for the TAPS system, the projected annual spill volume would increase proportionately with the amount of GTL product shipped.

Visual/Recreational: Overall Assessment

Cumulative visual/recreational effects associated with implementation of the proposed action include those resulting from construction of additional industrial facilities on the North Slope and at Valdez if one or more gas commercialization alternative is selected. Incorporation of new methods for oil field exploration, development, and production have significantly reduced the visible footprint associated with individual facilities, however. The Central TAPS study area would experience few, if any, effects associated with facility construction, unless TAGS or a southern ANGTS project is implemented. Additional facilities would be built at Valdez for TAGS or a GTL project.

A large oil spill would have significant, but temporary, adverse effects on visual/recreational resources. The probability and consequences of such a spill are mitigated by spill prevention measures. The probability of a large oil spill sometime during the ROW renewal period is estimated to be moderate to high in PWS and low on the North Slope. Overall, it is judged that the intensity of adverse effects on visual resources is moderate (based on the threat of an oil spill) and that the probability of such adverse effects is likewise moderate (based on the estimated probability of an oil spill in PWS).

Proposed Action: Environmental Justice

Executive Order 12898 signed by President Clinton on February 11, 1994, requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects of their actions on minority populations and low-income populations in the United States and its possessions (Executive Order 12898, 1994). The purpose of this Executive Order is to promote fair treatment of all races and the poor so that no one demographic group suffers adverse environmental effects disproportionately. Section 4–4 of Executive Order 12898 directs federal agencies, whenever practicable and appropriate to collect, maintain, and analyze information on populations who principally rely on fish and/or wildlife for subsistence. Section 6–606 of this order specifically notes that federal-agency responsibilities shall apply equally to Native American programs. This topic has been addressed in recent EISs (e.g., BLM and MMS 1998; USACE, 1999).

Some of the potential effects resulting from selection of either the proposed or the no-action alternative raise environmental justice issues. Selection of the proposed action would have certain effects that are beneficial in this context. As noted above, the Alaska PFD, which is funded by oil and gas revenues, is distributed to all Alaskans who satisfy residency and other minimal requirements. The affect of the PFD on household income is proportionately greater for larger families and for low-income families. Other possible effects of the proposed action are less benign. For example, subsistence users, including Alaska Native and rural residents who principally rely on subsistence could be disproportionately affected as a result of adverse effects on subsistence that might occur from oil spills if the proposed action is selected. As noted in the section on subsistence, such adverse effects would be temporary and could be partially offset by wage income from spill cleanup activities. Moreover, the Trans Alaska Pipeline Authorization Act (TAPAA) established strict liability (except in cases where damages are caused by an act of war or negligence of the

United States, other government entity, or the damaged party) for all damages [Section 1653 (a) (1)] in connection with or resulting from activities along or in the vicinity of the ROW. Other laws (e.g., OPA 90) also address liability and/or the establishment of funds to pay claims for spills associated with the production and/or transportation of oil. For example, under OPA 90, responsible parties are liable for removal costs and damages (including damage for loss of subsistence use of natural resources) [OPA 90, Section 2702 (a),(b)].[13] In the past (e.g., in the case of EVOS), subsistence users have been compensated for the monetary value of lost subsistence harvest. Lack of access to subsistence resources because of constraints imposed by oil and gas development may also raise environmental justice issues, because subsistence users would be disproportionately affected.

Environmental justice is not shown separately on the intensity-probability charts, because the individual effects are addressed as part of other categories (e.g., economics, subsistence).

Proposed Action: Land Use and Related Issues

This issue cluster includes land use, coastal management, cultural resources, and wilderness and related cumulative effects.

Soc13. Land use and related issues.

Because potential effects and their severity vary with the study area, separate discussions are included for each of the study areas.

North Slope. Potential cumulative effects on land use, coastal management, and cultural resources are reviewed in several recent EISs, including Northstar (USACE, 1999), NPR-A (BLM and MMS, 1998), and Beaufort Sea Planning Area Oil and Gas Lease Sales 144 (MMS, 1996a) and 170 (MMS, 1998). All of these are incorporated by reference. The Arctic National Wildlife Refuge (ANWR) is east of oil and gas development areas on the North Slope. Present regulations restrict oil development activity in ANWR and these regulations are assumed to remain in force in the event the proposed action is selected. As noted in Appendix A, no production is assumed to come from ANWR in the baseline throughput forecast.

Onshore areas associated with reasonably foreseeable future projects (e.g., Alpine and Tarn) have been rezoned (USACE, 1999). NSB land management regulations address various aspects of project design and include seasonal restrictions as well as provisions for protection of other land uses (e.g., subsistence) that are intended to mitigate/minimize adverse environmental effects. There is a potential for conflict with other regulations (e.g., 6 AAC 80.070 [Energy Facilities], 6 AAC 80.080 [Transportation and Utilities]; 6 AAC 80.120 [Subsistence], and 6 AAC 80.130 [Habitats]) that would need to be addressed on a case-by-case basis to select appropriate development plans.

A cumulative land use effect that would not be avoided is the geographic expansion of industrial uses beyond the existing developed Kuparuk River Unit/Prudhoe Bay Unit area. This represents a cumulative, large-scale change in the designated land use of the North Slope area (USACE, 1999), although recent technological improvements (discussed above) will reduce the land area occupied by individual oil and gas facilities.

Reasonably foreseeable offshore developments would result in the construction of subsea pipelines built through state waters, requiring rezoning from Conservation Districts to Resource Development Districts and a compliance review with the NSB Coastal Management Plan. This could result in cumulative effects on the existing Resource Development Areas extending land uses to Conservation Districts not presently utilized in this manner. Because the areal extent of seafloor utilized by industry would not be large, this cumulative effect would be minor.

Expansion of the land area used for oil and gas production could effect cultural resources in the area. Cultural resources may be affected by seismic activities and overland moves and similar activities that might disturb the surface (BLM and MMS, 1998). Material borrow pits, gravel roads, and airstrips could also effect cultural resources. Cultural resources (sites, shipwrecks) may underlie offshore areas (MMS, 1998) that would be developed. This said, mitigation methods (and regulatory procedures) have been developed that minimize these effects.

Oil spills could adversely effect cultural resources by

[13]For example, Section 2702 of OPA 90 (33 CFR 40) notes that "each responsible party for a vessel or a facility from which oil is discharged. . . into or upon the navigable waters or adjoining shorelines or the exclusive economic zone is liable for the removal costs and damages specified in subsection (b)." Damage to subsistence resources is covered in subsection b (paragraph (C)) and specifically includes "damages for loss of subsistence use of natural resources, which shall be recoverable by any claimant who so uses natural resources which have been injured, destroyed, or lost, without regard to the ownership or management of the resources." Section 2701 defines "facility" as follows: "facility" means any structure, group of structures, equipment or device (other than a vessel) which is used for one or more of the following purposes: exploring for, drilling for, producing, storing, handling, transferring, processing, or transporting oil. This term includes any motor vehicle, rolling stock, or pipeline used for one or more of these purposes." Thus, ANS spills, VMT spills, or marine transportation spills discharged into or upon the navigable waters or adjoining shorelines clearly fall within the scope of OPA 90. Responsible parties for such spills are subject to damage claims for loss of subsistence resources.

direct damage and by cleanup activities (including the possibility of vandalism). The severity of these effects depends on the volume spilled, location, season, and other factors.

Central TAPS. TAPS-related effects are expected to be at most moderate (see Section 4.3.3.4). No land use changes are anticipated, and no additional effects on wilderness areas are foreseen. Oil spills and cleanup activities could result in adverse effects. The severity of these effects depends on the volume spilled, location, season, and other factors.

Construction of either the TAGS or ANGTS gas pipelines would disturb land, although these effects would be mitigated. Selection of a northern route for the ANGTS pipeline would eliminate effects in this study area. An additional pipeline would not be needed for a GTL option.

Valdez/PWS. No additional TAPS-associated construction activities would create any significant adverse effects in the Valdez/PWS study area. As in the other areas, an oil spill could produce adverse effects on cultural resources. To mitigate the potential effect of spills on cultural resource sites in PWS, SERVS added cultural resource data to the graphical resource database (GRD) for PWS and adjoining areas (Wooley et al., 1997). The GRD is part of the *Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan* and consists of digital "layers" of sensitive environmental areas. The known cultural resource site data for PWS and the Copper River area are digitized and included in a confidential layer of the GRD to assist the Federal On-Scene Coordinator with cultural resource site protection during a spill response.

Development of GTL would increase TAPS throughput, but not result in any significant additional land disturbance.

Implementation of TAGS would entail construction of an LNG facility and result in incremental land disturbance.

Land Use and Related Issues: Overall Assessment

The intensity of cumulative effects to land use and related issues are judged moderate, as is the probability of these effects. Potential effects are greatest in the North Slope (arising from incremental industrial development) and Valdez/PWS (resulting from a possible large oil spill) study areas. The probability of a large oil spill sometime during the duration of the ROW extension period is moderate, but the probability of significant damage to cultural resources is low as a result of mitigating measures.

Proposed Action: Social Resources, Cumulative Effects Summary

Effect groups with high consequences and high probability include economics and social change. The economic effects are largely (if not exclusively) beneficial. Continued operation of the ANS fields is important in a national, state, and local context. Although the benefits of the proposed action are likely to be smaller in the future compared to the past, these effects are very significant. Selection of any of the gas commercialization options would result in additional economic benefits, but it is premature to develop specific estimates.

The effects related to social change are mixed, some are beneficial, and others are adverse. However, as noted in the discussion of these social effects, the choice of development alternative is unlikely to halt or reverse social change. Moreover, selection of the no-action alternative would almost certainly result in much more significant and adverse social changes.

Effects on subsistence are judged moderate to high, and the probability of these effects is moderate. Subsistence effects are expected to be adverse (although generally temporary), resulting principally from the possibility of a large oil spill on the North Slope and the moderate probability of a large spill in the Valdez/PWS study area. Use of double-hull tankers, creation of SERVS, and other mitigation measures reduce the probability and expected size of a large spill. Additionally, liability provisions of various applicable statutes and possible wage and salary employment will cushion the adverse monetary effects on subsistence users. Concerns have been expressed regarding the possibility of increased access resulting from the opening of the former haul road to public use.

4.5.4 Results: No-Action Alternative

4.5.4.1 No-Action Alternative: Physical Resources

By R.G.B. Senner, J.M. Colonell, J.D. Norton, and B. Trimm

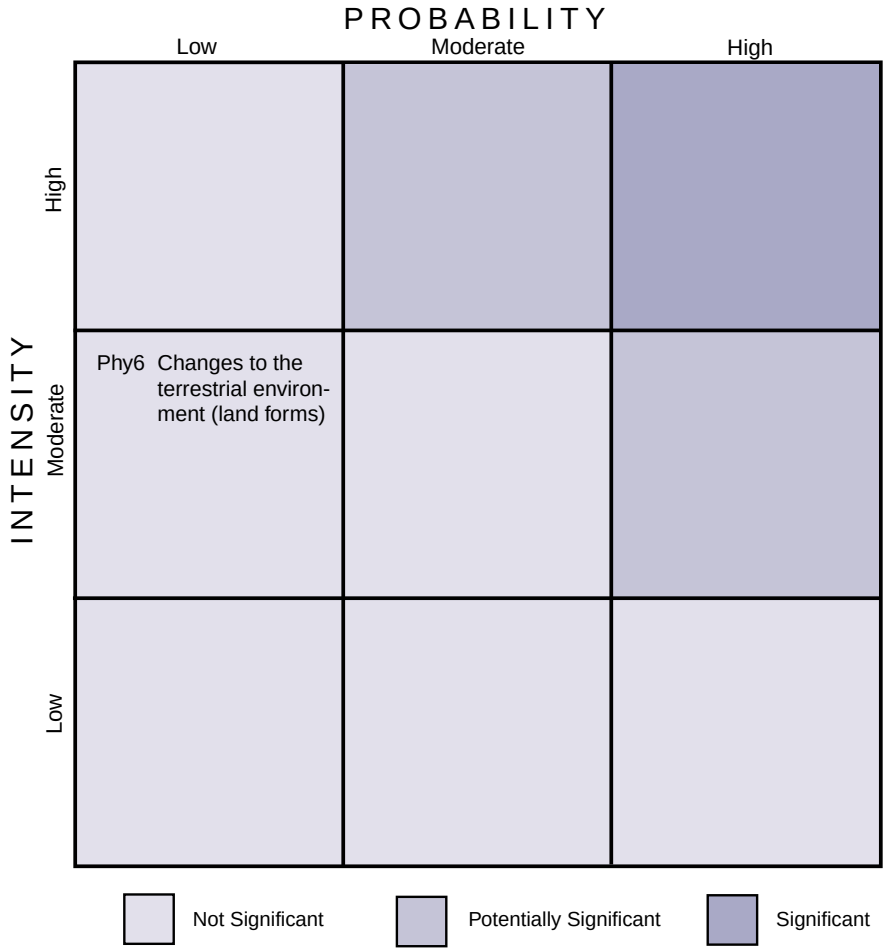
In the no-action alternative, it is assumed that aboveground facilities related to TAPS will be removed during a 3-year period of DR&R. During that time, major activities will occur involving the physical removal of equipment and subsequent transportation to disposal sites. For a relatively short time, these activities will result in disruption to the terrestrial environment along the TAPS ROW, the potential for spills, increased use of heavy vehicles and traffic with attendant increase in emissions and dust, and increased water discharges from the work camps and in cleaning pipe and equipment. After DR&R, it is likely that some of the work pad, access roads, and the Dalton Highway will remain in place. The following discussion and Figure 4.5-10

summarize the one physical impact issue that will endure for the no-action alternative after DR&R is complete. Potential cumulative effects during the three year DR&R are not addressed.

Phy6. Changes to the terrestrial environment (land forms).

Under the no-action alternative, significant restoration of the TAPS ROW will occur after the ROW expires in 2004. Similar DR&R activities would occur to the North Slope production facilities. The effects to the integrity of the terrestrial environment will likely be of relative short duration once the construction activities cease. However, there is the potential for the lasting presence of the work pads, rehabilitated material sites, access roads, pump station sites, and other visible signs of the former pipeline and production systems following DR&R to add to the visible presence of future construction that might occur. The visual or aesthetic effects are discussed in the Section 4.5.4.3.

Potential cumulative effects could be caused by use of the remaining work pads and access roads for recreational or industrial purposes. Such use and future maintenance of access roads would not be under control of the applicants after DR&R is completed to the satisfaction of the authorities. The magnitude of this potential cumulative effect on the terrestrial environment is ranked as low, because resource values and human health would not be impaired after DR&R is complete. Geographic scope is ranked as high, because the effect occurs along the entire length of the pipeline and on the North Slope. It should be noted that the impact is confined to a narrow zone in the TAPS ROW. Frequency/duration is ranked low, because the physical



NOTE: The intensity and probability rankings in this matrix are based on the qualitative criteria in Table 4.5-8.

Figure 4.5-10. *Ranking matrix of cumulative impacts on physical environment (no-action alternative).*

disturbance will be a one time activity (over several years) and the remaining work pads and access roads will stabilize relatively quickly after restoration activities. Intensity is ranked as moderate. The probability that the integrity of the terrestrial environment will be affected is low. The aesthetic impact is discussed in Section 4.5.4.3.

4.5.4.2 No-Action Alternative: Biological Resources

By M.A. Cronin, R.G.B. Senner, S.R. Johnson, L.L. Moulton, H. Whitlaw, W. Ballard, D.W. Fun,. staff of LGL Alaska Research Associates, Inc., and staff of Alaska Biological Research, Inc.

Table 4.5-16 and Figure 4.5-11 summarize the cumulative biological impact associated with the no-action alternative. The analysis in this section follows the procedure described in Section 4.5.1 to analyze potential cumulative effects. Past, present and reasonably foreseeable future actions, in addition to the non-renewal of the TAPS ROW, were identified. Under the no-action alternative, it is assumed that all operations of TAPS, VMT, the ANS oil fields, and oil tanker traffic will stop. DR&R will occur along TAPS and in the ANS oil fields. It is also assumed that no natural gas development will occur on the ANS. The Dalton Highway and other existing roads will remain open to the public, and an NMDS installation will be implemented at Fort Greely. Other industry, such as mining, will continue to develop. The following analysis considered the same impacts and used the same ranking procedure and criteria (Table 4.5-10) as in the analysis of potential cumulative impacts of the proposed action (Section 4.5.3.2).

No-Action: Vegetation and Wetlands

By R.G.B. Senner and D.W. Funk

This section describes the cumulative effects of the no-action alternative on vegetation and wetlands in the Central TAPS and ANS study areas.

Bio36. Wetland and vegetation loss from gravel mining and placement, and dust fallout at roads, pads, and facilities.

DR&R activities would be coordinated from TAPS pump stations, and the labor force would be housed in temporary facilities on pump station sites. These measures would help to ensure that most workers are concentrated at existing facilities on gravel pads and use existing gravel access roads. There may be a requirement for permitted temporary camps and permitted sites for equipment storage and temporarily stockpiled materials at additional locations. If these were needed, vegetation would be removed and/or disturbed at these locations. This is a potential cumulative effect because it might be additive with other construction along the TAPS ROW for installation of an NMDS facility at Ft. Greely, other industry developments, or for construction of campgrounds and facilities for public recreation. In the final stages of TAPS DR&R, disturbed sites would be scarified and fertilized to encourage re-invasion by native plants. Reseeding would occur where erosion is a concern.

Increased dust loads would occur along the Dalton Highway and on TAPS access roads and pads for the three-year period of DR&R. However, dust loads would be high only in a particular location during activity in that sector of the pipeline, and dust loads would decrease substantially following DR&R. Development of the NMDS facility and other industry, as well as increased public access, would have some impact on dust loads as well, primarily concentrated near the facilities and along the Dalton Highway.

The magnitude and geographic scope of this effect are ranked low and frequency/duration is low, for an overall intensity rank of low. The magnitude would be low, because the disturbances would not measurably alter the distribution of a plant community, and other DR&R activity would be conducted on existing workpads and pump station pads. The geographic scope would also be low, because activities on previously undisturbed ground — i.e., off the workpad and off pump stations — would be prohibited except for site-specific permitted facilities as noted above. The frequency and duration would be low, because DR&R will be concluded within about three years. The probability is ranked moderate, because the need for establishing temporary camps or other facilities on previously undisturbed sites during DR&R has not been determined.

Bio37. Changes to natural drainage patterns causing changes to wetlands and vegetation.

Drainage impacts associated with DR&R activities would generally be similar to those occurring for the proposed renewal of the TAPS ROW. Workpads would remain in place, and adjacent impoundments would persist. Conversion of culverts to low water crossings would reduce erosion and scouring associated with cross-drainage and greatly reduce icings at these locations. River training structures would also remain in place and continue to provide habitat for willows and other early successional species where sedimentation occurs in slack-water areas behind the dikes. Some erosion of the unmaintained structures would occur but would be a minor impact. Installation of an NMDS site at Ft. Greely and the development of other industry along the TAPS route would contribute to changes in

BIOLOGICAL CUMULATIVE EFFECTS SUMMARY: NO-ACTION ALTERNATIVE

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
VEGETATION AND WETLANDS											
Bio36 **Wetland and vegetation loss from gravel mining and placement, and dust fallout at roads, pads, and facilities.**	DR&R will disturb vegetation along the TAPS ROW. After DR&R, pioneering plant species will colonize the ROW, and plant succession will proceed over the long term. Dust deposition will increase for 3 years during DR&R, then diminish to below existing levels.	No impact.	Well-documented dust shadow effect along heavily traveled roads. Placement of gravel fill for new roads, pads and facilities, has occurred, but newer fields have a substantially reduced footprint and are often roadless. Dust shadow effect along heavily traveled roads would continue if roads are left in place.	Will contribute to dust shadow along the Dalton Highway. Increased ORV use of the TAPS ROW may occur following DR&R resulting in disturbance to plant communities along the ROW.	Gravel placement at facility sites and road dust from construction and facility use.	Gravel placement at facility sites and road dust from construction and facility use.	L	L	L	L	M
Bio37 **Changes to natural drainage patterns causing changes to wetlands and vegetation.**	Because the TAPS workpad will remain in place, impoundments associated with the workpad will continue to affect vegetation productivity and species composition. Conversion of culverts to low-water crossings will eliminate or reduce icing problems at stream crossings.	No impact.	Numerous site-specific changes in natural drainage patterns resulting in localized habitat change and loss of wetlands. Since new facilities with a smaller footprint are sited along natural drainage lines fewer impacts now occur. No impact from future development.	No impact.	Potential localized drainage issues depending on facility siting.	Potential localized drainage issues depending on facility siting.	L	L	H	M	H
Bio38 **Changes in plant community structure resulting from thermokarst.**	Since the TAPS workpad and access roads will be left, revegetated, and not maintained, thermokarst causing localized changes in plant species composition will continue with small amounts of new subsidence.	No impact.	In heavily developed areas about 3% of the total area may be affected resulting in habitat loss and alteration. Thermokarst is probably increasing in those areas. New developments generally cause localized thermokarst. No impact from future development.	No impact.	Minor localized thermokarst.	Minor localized thermokarst depending on the size and location of the development.	L	M	H	M	H
Bio39 **Detrimental impacts on plants from air pollution.**	DR&R will increase exhaust emissions in the ROW over a three-year period. Following DR&R there will be no TAPS associated emissions.	No impact.	No detectable impacts on plants from air pollution have occurred or will occur.	No impact.	Project will probably have little or no impact on plants from air pollution.	Potential for some impacts on local plant communities depending on the type of industry.	L	L	H	L	L
Bio40 **Alteration of the natural fire regime.**	DR&R activities will increase personnel and potential for fire suppression and human caused fires for a period of three-years. After DR&R no impacts will occur.	No impact.	Development has had and will have little or no impact on the natural fire regime.	May increase number of human caused wildfires but is unlikely to have any effect on the natural fire regime.	Potential increase in fire suppression during construction and operation but is unlikely to affect the natural fire regime.	Potential increase in fire suppression during construction and operation.	L	L	L	L	L
Bio41 **Vegetation destruction and alterations from oil, fuel, and chemical spills.**	Minor fuel and oil spills likely but most contained on workpads, some potential for a major spill during pipeline DR&R.	No impact.	Most spills have been contained on workpads, Localized areas of tundra have been killed requiring remediation. No major spills on tundra have occurred. Major spill possible but unlikely. No impact from future development.	Minor fuel and oil spills mostly confined to roadways.	Localized fuel, oil and chemical spills mostly confined to work areas.	Localized fuel, oil and chemical spills mostly confined to work areas.	L	M	L	L	L
Bio42 **Introduction of exotic vegetation from revegetation of disturbed areas.**	Revegetation of the TAPS workpad and access roads will likely introduce some exotic species that are unlikely to displace indigenous species but may slow regrowth of natural communities.	No impact.	Some revegetation of construction and spill impacted sites has occurred and is occurring. Revegetation likely with DR&R of oil fields.	Low level introduction of weedy species.	Revegetation of portions of missile defense site likely.	Revegetation of mined sites and construction impacts are likely to occur.	L	M	M	M	H
FISH											
Bio43 **Obstruction of fish movements in freshwater rivers and streams.**	Removal of culverts at TAPS stream crossings will facilitate fish passage. However, during culvert removal fish may be temporarily stranded.	No impact.	Some impacts have occurred, but populations have not been affected. Some impacts from maintenance activities. Newer developments have a smaller footprint and fewer roads decreasing impacts. No impact from future development.	Little or no impact.	Some impacts possible depending on siting of facility and the road corridors required for the development.	Some impacts possible depending on siting of facility and the road corridors required for the development.	M	M	H	M	H
Bio44 **Obstruction of fish movements in the marine environment due to causeways and docks.**	DR&R of the TAPS ROW will not impact marine fish.	No impact.	Some impacts have occurred at West Dock, but populations have not been affected. Some impacts have occurred, but populations have not been affected. Mitigation efforts have alleviated impacts. No impact from future development. DR&R may remove causeways.	No impact.	No impact.	No impact.	L	L	L	L	L
Bio45 **Alteration of marine habitats.**	DR&R of the TAPS ROW will have no impacts on marine habitats.	No impact.	Impacts have been within discharge and regulatory standards. Minor impacts currently at Northstar development, but DR&R may disturb fish habitat during causeway removal.	No impact.	No impact.	No impact.	L	L	L	L	L
Bio46 **Alteration of freshwater fish habitats.**	DR&R may disturb, dewater, or degrade fish overwintering sites, and may cause stranding during culvert removal. Sedimentation of freshwater habitat in localized areas associated with removal of culverts and erosion of workpads.	No impact.	Some impacts have occurred, but populations have not been affected. Mitigation efforts have alleviated impacts. No impact from future development, but DR&R may disturb fish habitat over the short term.	Following DR&R, public use of ORVs in the ROW may cause erosion and sedimentation at stream crossings, reducing levels of invertebrate prey, fish spawning success, and egg survival.	Potential for some impacts depending on size and location of facilities.	Potential for some impacts depending on size and location of facilities.	M	M	M	M	H

Table 4.5-16.
Biological cumulative effects summary: No-action alternative.

BIOLOGICAL CUMULATIVE EFFECTS SUMMARY: NO-ACTION ALTERNATIVE

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
VEGETATION AND WETLANDS (CONT'D)											
Bio47 **Effects of oil, fuel, and chemical spills on fish.**	DR&R of TAPS will not cause spills into marine environments. Small potential for a spill contacting marine waters when the VMT is decommissioned. Off-pad fuel spills during DR&R that reach streams could have lethal or sublethal effects on fish and their food resources in the immediate spill area, but, spills will usually be contained on the gravel pads.	No impact.	Impacts from major tanker spill in past. Potential for spills from marine terminal, tankers and subsea pipelines. Completion of DR&R will eliminate the potential for spills.	No impact.	No impact.	No impact.	M	M	L	M	L
Bio48 **Effects on fish populations from increased fishing.**	Increased sport fishing pressure from public use of decommissioned pads and access roads may lead to overharvest of fish in some areas depending on the level of regulation and enforcement of catch limits.	No impact.	No past or current impact due to access restrictions. Overharvest of fish may occur in some areas depending on the level of regulation and enforcement of catch limits following DR&R of the oil fields.	Increased public access may cause overharvest of fish may occur in some areas depending on the level of regulation and enforcement of catch limits following DR&R of the oil fields.	May increase access somewhat but tight restrictions on access would prevent large impacts from occurring.	May increase access to previously inaccessible areas -- may lead to increased fishing pressure depending on level of regulation/enforcement.	M	H	H	H	H
BIRDS											
Bio49 **Obstruction of bird movements by roads, causeways, pipelines, and other structures.**	There may be minor impacts during DR&R with increased traffic. After DR&R no impact.	No impact.	No permanent obstructions to bird movements have occurred; birds habituate to structures and traffic. After DR&R, most structures and traffic will be gone and there will be no impact.	Increased public access may increase traffic along the TAPS ROW and ANS with a minor impact.	No impact.	There are potentially local impacts	L	L	L	L	L
Bio50 **Disturbance and displacement of birds by traffic, aircraft, and other activities.**	Disturbance of birds may occur during the 3-year DR&R period along TAPS. Following DR&R there will be no impact.	No impact.	Localized disturbances infrequently impact small numbers of birds. Disturbance to birds may occur during the 3-yr DR&R period along TAPS and on the ANS, but there will be no impact after DR&R.	Increased public access may disturb birds, but impacts will be minor.	Local disturbance may occur at the NMDS during construction.	Local impacts may occur at specific sites.	L	L	L	L	M
Bio51 **Bird use of man-made habitats including gravel pads, causeways, artificial islands, and pipelines.**	Removal of TAPS structures will eliminate artificial nesting, perching, and resting sites.	No impact.	Birds use oil-field structures for nesting, perching, and foraging. After DR&R bird use of structures will diminish. Remaining gravel structures will continue to provide habitat. No impact from future development.	No impact.	Birds may use new developments at the NMDS for nesting, perching, and foraging.	Birds may use new developments for nesting, perching, and foraging.	L	M	M	M	M
Bio52 **Loss of bird habitat from roads, pipelines, and other facilities.**	Following DR&R, habitats will be restored to pre-TAPS conditions or some other viable habitat over most of the ROW.	No impact.	Habitats have been altered by gravel and facilities, but there have been no population-level impacts. After DR&R, habitats will be restored or created and there will be limited impact depending on extent of gravel roads and pads left. No impact from future development.	No impact.	Small amounts of habitat will be altered, but impacts to bird populations will be minor.	Small amounts of habitat will be altered, but impacts to bird populations will be minor.	L	L	L	L	L
Bio53 **Early vegetation green-up and habitat use by birds due to deposition of dust from roads.**	Following DR&R, effects from dust fallout will diminish along with traffic levels on the Dalton Highway. Formerly altered habitats will gradually approach pre-oil field and pre-TAPS conditions or some other viable habitat.	No impact.	Positive impacts have occurred where birds aggregate in areas of early spring green-up to feed. After DR&R in ANS oil fields the impact will diminish.	After DR&R, there may be increases in public access along the TAPS corridor that will maintain dust to some extent.	No impact.	Positive impacts may occur near roads.	L	M	M	M	M
Bio54 **Bird habitat changes caused by water impoundments.**	After DR&R some impoundments may remain and will continue to provide bird feeding and nesting habitats.	No impact.	Some impoundments have affected bird habitats and resulted in changes in species using habitats. DR&R may remove some impoundments.	No impact.	Some impacts may occur depending on facility location and design.	Some impacts may occur depending on facility location and design.	L	M	L	L	L
Bio55 **Mortality of birds from highway vehicle roadkills.**	Following DR&R traffic and road kills along the Dalton Highway will decline in frequency.	No impact.	No impact.	Road kills may increase with increased public access.	No impact.	Some mortality possible with increased road traffic; depends on extent and ion of developments.	L	M	L	L	L
Bio56 **Incidental bird mortality at facilities.**	No impact after DR&R.	No impact.	Small numbers of bird mortalities have occurred at oil-field structures. No impact after DR&R.	No impact.	Bird mortality could result at facilities.	Bird mortality could result at facilities.	L	L	L	L	L
Bio57 **Increased predation on birds.**	During the 3-year DR&R period proper garbage management will result in little or no impact. After DR&R no impact.	No impact.	Impacts have occurred in the past, particularly predation on waterfowl and shorebird eggs. During the 3-year DR&R period, proper garbage management will result in little or no impact. No impact after DR&R.	Potential impacts could occur, depending on garbage management by the public.	Potential impacts could occur, depending on garbage management.	Potential impacts could occur, depending on garbage management.	L	L	L	L	L
Bio58 **Injury or death of birds from oil, fuel, or chemical spills.**	No impacts from TAPS and tanker traffic. During DR&R, small fuel spills could have a small impact.	No impact.	No impact in past. Fuel spills during DR&R could impact birds. No impact from future developments.	Small fuel spills could impact small numbers of birds.	Small fuel spills could impact small numbers of birds.	Small fuel spills could impact small numbers of birds.	L	H	L	L	L
Bio59 **Increase in bird hunting from increased access.**	There is a potential impact from increased numbers of workers during DR&R. After DR&R no impact.	No impact.	Access via the Deadhorse airport may have increased hunting pressure on the ANS where hunting is allowed. No impact after DR&R.	Impacts may increase with increases in public access.	Possibly increased hunting will result from new military personnel.	Impacts may increase with increased access, depending on location and extent of development.	L	H	M	M	M

Table 4.5-16 (Cont'd).
Biological cumulative effects summary: No-action alternative.

BIOLOGICAL CUMULATIVE EFFECTS SUMMARY: NO-ACTION ALTERNATIVE

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
TERRESTRIAL MAMMALS											
Bio60 **Obstruction of mammal movements by roads, pipelines, and facilities.**	Removal of the above-ground pipeline in the TAPS ROW will completely stop this impact. During the 3-year DR&R period, traffic and other activity may cause localized obstruction to movement of terrestrial mammals.	No impact.	Some wildlife movements may have been obstructed, but no population level impacts have occurred. Some obstruction of movement may occur during DR&R, but no impact after that.	Increased traffic may cause some obstruction of terrestrial mammal movement.	No impacts are expected except possibly during the construction phase.	Depending on extent and location of activity, vehicle traffic or new roads may deflect wildlife movements.	L	L	L	L	L
Bio61 **Disturbance and displacement of large mammals by human activities.**	Noise and activity associated with DR&R will disturb and displace some mammals. No impact after DR&R.	No impact.	Some disturbance and displacement of calving caribou on the ANS have occurred, but with no population-level impacts. Some disturbance displacement of calving caribou may occur during DR&R. No impact after DR&R.	Increased public access in PWS, the TAPS ROW, and the ANS may result in increased disturbance of terrestrial mammals.	No impacts are expected except possibly during the construction phase.	Depending on extent and location of activity, vehicles, aircraft, or other human activity may disturb and displace terrestrial mammals.	L	M	L	L	L
Bio62 **Reduced habitat quality for terrestrial mammals caused by fragmentation and alteration of habitat.**	During DR&R, habitat alteration will result from ground disturbance, and dust fallout. Following DR&R, later successional stages will gradually replacing currently disturbed areas.	No impact.	Mammalian habitats have been altered in the ANS oil fields, but no population-level effects have occurred. Insect relief habitat will be lost as gravel, and buildings and pipelines providing shade are removed in DR&R. Revegetation of gravel fill may provide more foraging areas. No impact from future development.	No impact.	Minor impacts may occur at the development site.	Impacts may occur at development sites, depending on the location and extent of projects.	L	L	L	L	L
Bio63 **Mortality of terrestrial mammals from highway vehicle roadkills.**	During DR&R, the incidence of roadkills could increase as a result of higher traffic levels on the Dalton Highway. No impact after DR&R.	No impact.	Occasional roadkills have occurred in the ANS oil fields. Occasional roadkills may occur during DR&R. No impact after DR&R.	Increased public access could result in increased numbers of roadkills on public highways.	Traffic associated with new military developments could result in increased road kills.	This impact depends on the amounts of traffic associated with new industry activity.	L	M	L	L	L
Bio64 **Effects on predators from anthropogenic food sources and habitat enhancement.**	DR&R activity may attract predators and scavengers, potentially increasing the mortality. No impact after DR&R.	No impact.	Predator populations have probably been enhanced by anthropogenic food in the ANS oil fields. However, mortality in adjacent areas has also occurred. Recent mitigation and management actions may have reduced this impact. DR&R should have minimum impacts if strict control of anthropogenic food sources is implemented. No impact after DR&R.	Increased public access could provide anthropogenic food for predators depending on the extent of garbage and other foods made available to wildlife.	This impact depends on the quality of control of anthropogenic food sources at the military installation.	This impact depends on the quality of control of anthropogenic food by other industries and regulators.	L	M	L	L	L
Bio65 **Mortality, injury, or disturbance of terrestrial mammals from oil, fuel, or chemical spills.**	Fuel spills could increase in frequency during DR&R, but they are not likely to affect terrestrial mammals. No impact after DR&R.	No impact.	No impact in past. Fuel spills could increase in frequency during DR&R, but they are not likely to affect terrestrial mammals. No impact after DR&R.	No impact.	No impact.	No impact.	L	L	L	L	L
Bio66 **Increased hunting of terrestrial wildlife from increased access**.	There is a potential impact from increased numbers of workers during DR&R. After DR&R no impact.	No impact.	Access provided from Deadhorse airport has increased hunting pressure on ANS outside the oil fields. There is a potential impact from increased numbers of workers during DR&R. No impact after DR&R.	Increased access from TAPS roads, Dalton Highway, and facilities has increased hunting pressure. Regulatory changes maintain populations to meet objectives.	Increased military personnel could add to hunting pressure.	New human presence in rural areas could increase hunting pressure.	M	H	H	H	H
MARINE MAMMALS											
Bio67 **Disturbance and displacement of marine mammals by petroleum-related operations.**	DR&R of the TAPS ROW will not disturb marine mammals.	No impact.	Offshore exploration and development at Endicott and West Dock may have disturbed some marine mammals. Potential disturbance could occur during DR&R of offshore facilities. No impact after DR&R.	Increased public access in PWS may disturb marine mammals.	No impact.	No impact.	L	L	L	L	L
Bio68 **Mortality, injury, disturbance, or alteration of habitats for marine mammals from oil, fuel, or chemical spills.**	Spills from TAPS DR&R activities will not impact marine mammals. No impact after DR&R.	No impact.	Past spill of ANS oil into PWS from the *Exxon Valdez* resulted in mortality of sea otters and seals and potential impacts on whales. Small potential for fuel spills during DR&R of offshore facilities. No impact after DR&R.	No impact.	No impact.	Spills near the coast could impact marine mammals.	L	L	L	L	L
THREATENED / ENDANGERED SPECIES											
Bio69 **Collisions of eiders with onshore or offshore structures.**	DR&R will remove aboveground structures eliminating collisions. No impact after DR&R.	No impact.	There are possibly a few instances where this impact occurred. DR&R will remove the threat of this impact. No impact after DR&R.	No impact.	No impact.	No impact.	L	L	L	L	L
Bio70 **Disturbance of Spectacled and Steller's eiders on the North Slope from noise and activities from oil-field operations.**	DR&R of TAPS on the North Slope may disturb a few eiders. No impact after DR&R.	No impact.	Some disturbances of eiders probably have occurred but with no effect on the population. Some disturbances of eiders currently may occur but will be minimized by regulation. Noise and activities from oil-field DR&R may result in disturbance of Spectacled and Steller's eiders on the North Slope. No impact after DR&R.	No impact.	No impact.	No impact.	L	L	L	L	L

Table 4.5-16 (Cont'd).
Biological cumulative effects summary: No-action alternative.

INTENSITY \ PROBABILITY	Low	Moderate	High
High			Bio48 Impact on fish populations from increased fishing Bio66 Impacts on terrestrial mammal populations from increased hunting
Moderate	Bio47 Impact on fish from spills	Bio51 Bird use of man-made habitat Bio53 Bird use of dust shadow vegetation Bio59 Increased bird hunting because of increased access	Bio37 Wetland change/loss from water flow changes Bio38 Plant community changes from thermokarst Bio42 Exotic plants introduced by revegetation Bio43 Fish movement obstructions in freshwater streams Bio46 Alteration of freshwater habitats
Low	Bio39 Plant damage from air pollution Bio40 Alteration of natural fire regime Bio41 Habitat change from toxic spills Bio44 Fish movement obstructions in marine water from causeways Bio45 Alteration of marine habitats Bio49 Bird movement obstructions from facilities Bio52 Loss of bird habitat from facilities Bio54 Bird habitat changes from impoundments Bio55 Bird mortality on roads Bio56 Increased predation on birds Bio57 Incidental bird mortality at facilities Bio58 Bird mortality or injury from spills Bio60 Obstruction of mammal movements by facilities Bio61 Disturbance/displacement of mammals by human activities Bio62 Decrease in habitat quality for terrestrial mammals because of habitat fragmentation/alteration Bio63 Roadkills of mammals Bio64 Impacts on predators from anthropogenic food sources Bio65 Impacts of oil spills on terrestrial mammals Bio67 Disturbance/displacement of marine mammals by activities Bio68 Impacts of oil spills on marine mammals Bio69 Eider mortality from collision with facilities Bio70 Disturbance of Spectacled and Steller's eiders from noise	Bio36 Wetland change from gravel mining/placement and dust Bio50 Disturbance/displacement of birdsfrom traffic and activities	

Not Significant | Potentially Significant | Significant

NOTE: The intensity and probability rankings in this matrix are based on the qualitative criteria in Table 4.5-10.

***Figure 4.5-11**. Ranking matrix of cumulative impacts on biological environment (no- action alternative).*

drainage patterns in localized areas. Increased public access along the ROW would have little impact on drainage patterns.

Magnitude and geographic scope are ranked low and frequency/duration is ranked high, giving an overall intensity rank of moderate. The probability is ranked high. Magnitude and geographic scope are ranked low because impacts would occur at specific locations and would not measurably alter the distribution of a plant community. The frequency/duration of the impacts would be high since the altered drainage patterns are likely to remain after DR&R. The probability of these impacts is high because the effects of changes in drainage patterns will remain since roads and workpads will remain in place after DR&R.

Bio38. Changes in plant community structure resulting from thermokarst.

Thermokarst associated with TAPS workpads left in place would have little additional effect on adjacent areas, but may enhance revegetation by increasing soil moisture and creating a diversity of habitats around the workpads. Thermokarst associated with TAPS impoundments would persist and continue developing in place. Minor localized thermokarst would be likely from development of an NMDS site at Ft. Greely and from other industry developments along the ROW. The amount of thermokarst occurring from these developments would depend on the size and locations of the facilities.

Cumulative thermokarst impacts from DR&R activities and future developments would have low magnitude and moderate geographic scope but would be of high frequency/duration, giving an intensity rank of moderate. The probability of impacts occurring is high. Magnitude is ranked low because effects are site-specific and would not alter the distribution of a plant community. However, the geographic scope is moderate reflecting the continued effects of current thermokarst that would remain and develop in place in the ANS oil fields and along the TAPS route. Frequency/duration is ranked high because these effects will continue following DR&R. Because effects will continue, the probability is high.

Bio39. Detrimental impacts on plants from air pollution.

DR&R activities along the TAPS ROW will cause little or no impact on plants from air pollution. Vehicle emissions will increase during the three-year period of DR&R but will end when DR&R is completed. Development of other industry along the TAPS route may have localized impacts on plants from pollution depending on the type of industry and location of the facility. An NMDS site at Ft. Greely is unlikely to impact concentrations of air pollutants reaching plants. No cumulative impacts on plants from air pollutants are anticipated from DR&R activities.

Magnitude and geographic scope are ranked low and frequency/duration is ranked high, for an overall intensity of low. Probability is ranked low. Magnitude and geographic scope are ranked low because potential impacts would occur in only a few locations and would not alter the distribution of plant communities. Frequency/duration is ranked high because emissions from potential development facilities would occur on a regular basis. Intensity is ranked low despite the high ranking for frequency/duration because removal of TAPS would greatly limit impacts. The probability of impacts occurring is low since current facilities have not produced detectable impacts on vegetation.

Bio40. Alteration of the natural fire regime.

DR&R activities will increase the number of people and the amount of equipment along the ROW for a three-year period. During that time, potential fire suppression would increase for work areas. Conversely, there would also be an increased potential for human-caused fire. Neither of these effects of DR&R are likely to impact the natural fire regime. Development of other industry and an NMDS site at Ft. Greely will also increase the number of people and facilities in the vicinity of the ROW and would increase the potential for fire suppression and for human-caused fires. These activities could alter the natural fire regimes in areas of human development.

Magnitude, geographic scope, and frequency/duration are all ranked low, giving an intensity ranking of low. Probability is also ranked low. The magnitude and geographic scope of these impacts are low because they would be site-specific. Frequency/duration of the impacts is also ranked low because they would be infrequent. The probability of influencing the natural fire regime is low.

Bio41. Vegetation destruction and alteration from oil, fuel, and chemical spills.

Fuel, oil, and chemical spills may occur during the three years of DR&R, because of the large number of vehicles involved and the potential for spills as pipe is decommissioned. Most of these spills would be confined to gravel pads and roads, but some could contact vegetation. After DR&R, spills from TAPS would not occur. Some fuel spills could still occur along the road system from public access. Most of these spills would be confined to the roadways and would be unlikely to contact vegetation. Development of an

NMDS site at Ft. Greely and the development of other industry would also likely contribute to spills of toxic material. These spills would probably occur in defined work areas and would not in most cases contact vegetation.

Magnitude is ranked low, geographic scope moderate, and frequency/duration low, giving an intensity rank of low. Probability is low. The magnitude of these impacts would be low because spills would be confined to small areas and would not alter plant community distributions. The geographic scope is moderate because spills could occur along TAPS and on the ANS but primarily during DR&R. Spills would likely be infrequent, and frequency/duration is thus ranked low. The probability of a spill reaching vegetation is low. Following DR&R, the probability of a spill would decrease to that associated with other industry developments and the NMDS facility.

Bio42. Introduction of exotic vegetation from revegetation of disturbed areas.

As for the proposed action, this unintentional effect of revegetation would very likely follow any reseeding conducted during DR&R. The removal of above-ground pipeline and facilities along the TAPS ROW would require extensive site rehabilitation. Much of this effort could be accomplished with scarification and fertilization alone, without reseeding, to encourage the invasion of pioneer species from surrounding native plant populations. However, in erosion-prone areas, reseeding is an effective mitigation measure, and the introduction of exotic weedy species would be a probable side-effect. The result of introducing exotic plants on the North Slope and along the TAPS ROW in this fashion has usually been benign and has not led to large-scale replacement of indigenous plant species. However, in some cases these species may slow the reformation of natural plant communities and successional patterns on disturbed sites. This impact could occur in localized areas along the TAPS ROW near other construction, for example, with the Ft. Greely NMDS installation or with the development of recreational facilities.

The magnitude of this impact is ranked low, the geographic scope moderate, and frequency/duration moderate, giving an overall intensity of moderate. The probability for at least occasional unintended introductions of exotics would be high. The magnitude is ranked low because revegetation would be site-specific and not alter the distribution of plant communities. Geographic scope is moderate because revegetation would occur along the TAPS ROW and throughout the ANS oil fields during DR&R. The frequency/duration is ranked moderate because revegetation would occur intermittently during and after DR&R.

No-Action: Fish

By L.L. Moulton

Bio43. Obstruction of fish movements in freshwater rivers and streams.

Although culverts will be removed during DR&R and TAPS traffic at low water crossings will cease, the public will probably use the workpad for subsistence and recreational access for the foreseeable future. Vehicles — including trucks, ATVs, and snowmachines — will continue to cross streams at or near the points where the workpad intersects them. This may occur whether or not measures are taken to prevent this and whether or not the workpad drive-lane is publicly regulated and maintained after the TAPS ROW is terminated. Development of other industry sites and an NMDS site at Ft. Greely would potentially cause some additional site-specific impacts depending on the size and location of the facilities and access roads.

Magnitude is ranked moderate, geographic scope is moderate, and frequency/duration is high, for an overall intensity rank of moderate. Probability is ranked high. The magnitude is moderate because impeding fish migration at problem crossings can lead to loss of upstream spawning groups. Because these types of impacts can occur all along the TAPS route, geographic scope is rated moderate. The frequency/duration of impediments to migration can be high since the crossings are dynamic and subject to alteration at least annually during the spring flood and more frequently if there are high flows during summer. High traffic levels at low water crossings, particularly during high-use periods such as the moose-hunting season, will also influence the frequency and duration of the effect. The probability is also high because this problem may occur after DR&R.

Bio44. Obstruction of fish movements in the marine environment due to causeways and docks.

DR&R of TAPS will not affect marine fish movements, and DR&R of the North Slope oil fields will probably remove causeways. Past and current developments have had some impacts on fish movements at West Dock, but no population-level impacts have occurred. Current mitigation techniques have reduced or eliminated most impacts to marine fish. Increased public access to the ROW, development of an NMDS site at Ft. Greely, and development of other industry along the TAPS route will have no impact on marine fish movements.

Magnitude and geographic scope of this effect are ranked low, and frequency duration is ranked low, giving an intensity rank of low. Probability of this impact is low. The

magnitude is low because it will not affect fish populations. Geographic scope is also ranked low because only marine fish nearshore to the North Slope oil fields have been affected. Frequency/duration and probability are low since structures will be removed during DR&R.

Bio45. Alteration of marine habitats.

DR&R of TAPS would have no impacts on marine fish habitats. DR&R of the North Slope oil fields would have impacts on marine fish habitats during removal of offshore man-made structures. Some disturbance of habitats near causeways and islands may occur but would impact a limited area. Recreation/tourism, new industry, or development of an NMDS site would not impact marine fish habitat.

Magnitude, geographic scope, and frequency/duration are ranked low, for an overall intensity of low. Probability is low. Magnitude and geographic scope are ranked low because potential effects are site-specific and will not affect fish populations. Frequency/duration and probability are low because the impact will be stop after DR&R.

Bio46. Alteration of freshwater fish habitats.

DR&R activities may contribute to erosion and increased sedimentation in some streams. DR&R may also disturb, dewater, or degrade fish overwintering sites, and may cause stranding during culvert removal. Following DR&R, public use of off-road vehicles in the ROW may cause erosion and sedimentation at stream crossings. New industry developments and construction of an NMDS will also contribute to sedimentation in freshwater streams. The amount of impact from these new developments will depend on their location and size, and the number of stream crossings required.

Magnitude, geographic scope, and frequency/duration are ranked moderate, giving an intensity rank of moderate. Probability of the impact occurring is high. The magnitude is moderate because increased sedimentation and other forms of habitat loss can lead to loss of overwintering or spawning habitats downstream from problem areas. These types of impacts can occur along the TAPS route, which leads to a moderate geographic rating. The frequency/duration is moderate because the impact occurs intermittently, at least through the DR&R phase. The probability of this impact is high, because it will occur during DR&R and when public access restrictions in the TAPS ROW end.

Bio47. Effects of oil, fuel, and chemical spills on fish.

During DR&R, off-pad fuel spills that reach streams could have lethal or sublethal effects on fish and their food resources in the immediate spill area. However, spills have usually been contained on the gravel pads, and it is probable that this would also occur during DR&R. Following DR&R, spills would be limited to those caused by public access, which would most likely be small and would occur along the road system. New industry development and an NMDS site would also probably contribute to oil, fuel, and chemical spills. In most cases these would be confined to workpads and would be small, but there is potential for spills contacting fresh water and impacting fish in the local area.

Magnitude is ranked moderate, geographic scope is moderate, and frequency/duration is low, giving an intensity rank of moderate. The probability is ranked low. The magnitude of this impact is moderate because spills could result in measurable lethal or sublethal effects on fish. The geographic scope is moderate because spills could occur along the TAPS ROW and on ANS during DR&R, but would be unlikely to contact water and fish in most instances. The frequency/duration is ranked low since spills that contact water and fish would be infrequent and generally are short-term events. The probability of the impacts is low. It is likely that spills will occur, but unlikely those spills will contact fresh water and impact fish.

Bio48. Effects on fish populations from increased fishing.

Increased access and increased human presence — i.e., elimination of the “refuge” effect — may intensify fishing after DR&R along TAPS and on the ANS. As discussed under the proposed action, overharvest can occur when access is provided to desirable resources and fishing regulations and enforcement do not adequately control harvest. Developments in remote areas, such as along the TAPS ROW and the Dalton Highway, can allow access to previously unavailable harvest opportunities (BLM, 1972). The problem is magnified in northern areas because productivity is low and populations are more susceptible to excessive harvest. While DR&R activities will decrease access to some areas as facilities are decommissioned, other areas may become more accessible to the public as current restrictions for use are eliminated. The end of oil industry operations will be accompanied by significant reductions in statewide employment. This may increase the subsistence or commercial harvest of fish to compensate for the loss of income (see Sections 4.4 and 4.5). If decreased state revenue results in less enforcement of fish and game regulations, this impact could be intensified. However, it is also possible that the human population (and fish and wildlife harvests) will decrease in response to the economic decline

Development of other industry may also increase access

to areas not previously used for fishing. Development of an NMDS site at Ft. Greely is unlikely to contribute to this impact since the site would have high security.

Magnitude is ranked moderate, geographic scope is high, and frequency/duration is ranked high, for an overall intensity rank of high. Probability of this impact is high. The intensity of this impact is rated high, but the impact can be controlled through regulation and enforcement. The magnitude is moderate because overharvest at former TAPS access points could lead to substantial reductions in local stocks. Harvest impacts could occur all along the TAPS route or on the ANS, leading to a high geographic scope rating. The frequency/duration is high because overharvest could occur annually during the open-water season when fish are migrating between feeding, rearing, and spawning areas. The probability of this impact is high because it is a current and continuing issue, and because the policy for mitigating it in the event of TAPS ROW termination and North Slope oil field decommissioning has not been established.

No-Action: Birds

By S.R. Johnson

Bio49. Obstruction of bird movements by roads, causeways, pipelines, and other structures.

This impact may occur from traffic associated with DR&R activity. After DR&R, the TAPS and ANS pipelines will be gone, and traffic on oil field roads reduced or stopped entirely. Impacts from public access and other industry could occur, depending on levels and locations of traffic. The magnitude, geographic scope, and frequency/duration of the impact are low, for an overall intensity of low. The probability of the impact is low.

Bio50. Disturbance and displacement of birds by traffic, aircraft, and other activities.

Birds could be disturbed or displaced by DR&R activity. After DR&R, there will be no disturbance from activity along TAPS, in the ANS oil fields, or at the VMT. Other industry developments and increased public access along the Dalton Highway and remnants of the TAPS workpad and side roads could disturb and displace breeding, postbreeding, molting or brood-rearing birds. The NMDS may have local impacts during construction. The magnitude, geographic scope, and frequency/duration of the impact are low, for an overall intensity of low. The probability is moderate that human activities will disturb and displace some birds on a site-specific and intermittent basis.

Bio51. Bird use of man-made habitats including gravel pads, causeways, artificial islands, and pipelines.

The nature and extent of this impact depend on the nature of the DR&R efforts. Since above-ground pipelines will all be removed, these structures will no longer be available for nesting and perching. The use of gravel habitats for nesting and perching along TAPS and on the ANS will continue if pads, roads, artificial islands in the Beaufort Sea, and the Endicott Causeway are left in place. Many gravel structures will be revegetated, naturally or as part of the DR&R plan. The impact will be negative for species that currently use TAPS and oil field structures and potentially positive for those that do not.

The magnitude of this impact will be low, the geographic scope moderate, and the frequency/duration moderate, for an overall intensity of moderate. The probability of the impact is moderate.

Bio52. Loss of bird habitat from roads, pipelines, and other facilities.

In general, bird habitats lost to TAPS, ANS oil fields, and VMT facilities will be reclaimed during DR&R, although the habitat type may be different from the original. Some roads, pads, and facilities may remain, but most infrastructure will be removed or revegetated. The magnitude, geographic scope, and frequency/duration of the impact are low, for an overall intensity of low. The probability of the impact is low.

Bio53. Early vegetation green-up and habitat use by birds due to deposition of dust from roads.

Traffic associated with non-petroleum industry and tourism and recreation will probably maintain dust shadows along the Dalton Highway and adjacent side roads as long as roads and gravel pads remain unpaved. The extent of the dust shadows may decrease with decreasing traffic in the ANS oil fields and along the Dalton Highway. The duration of impacts is annual, primarily in early spring. The effects on the energy balance of bird populations have not been studied, but they are likely highly beneficial. The magnitude of this impact will be low, the geographic scope moderate, and the frequency/duration moderate, for an overall intensity of moderate. The probability of the impact is moderate.

Bio54. Bird habitat changes caused by water impoundments.

In some areas along the TAPS ROW and in the ANS oil fields, road and gravel pad construction has resulted in

impounded water bodies that affect bird habitats. DR&R may remove most structures that cause impoundments, but some may remain. The amount of habitat and numbers of birds affected will be small relative to other habitat available. The magnitude of this impact will be low, the geographic scope moderate, and the frequency/duration low, for an overall intensity of low. The probability is low.

Bio55. Mortality of birds from highway vehicle roadkills.

Highway traffic will continue to kill some birds during and after DR&R of TAPS and the ANS oil fields. The attraction of birds to the unpaved roads, including the Dalton Highway, by the early green-up effect will continue. However, roadkills will decline since commercial traffic to the ANS will stop. The magnitude of this impact will be low, the geographic scope moderate, and the frequency/duration low, for an overall intensity of low. The probability of the impact is low.

Bio56. Incidental bird mortality at facilities.

Facilities at the VMT, TAPS pump stations, and in the ANS oil fields will be removed during DR&R. Incidental mortalities will not occur any longer. The magnitude of this impact will be low, the geographic scope low, and the frequency/duration low, for an overall intensity of low. The probability of the impact is low.

Bio57. Increased predation on birds.

Operations at the VMT, TAPS pump stations, and in the ANS oil fields will stop after DR&R. It is possible that anthropogenic foods will be available to predators during the DR&R phase, as during construction. However, recognition of this problem should result in better management of garbage and feeding of wildlife during DR&R. Predator populations will not be enhanced by anthropogenic food from oil and gas operations after DR&R. Increased predation on birds will therefore stop. Increased public access or other industry activity could maintain this impact to some extent. The magnitude of this impact will be low, the geographic scope low, and the frequency/duration low, for an overall intensity of low. The probability is low.

Bio58. Injury or death of birds from oil, fuel, or chemical spills.

This impact will decline dramatically after oil and gas operations stop. There will no longer be the potential for large spills from TAPS or ANS pipelines or tankers in Prince William Sound. Small fuel spills during DR&R and from public access and other industry may occur from PWS to the ANS. The magnitude of this impact will be low, the geographic scope high, and the frequency/duration low, for an overall intensity of low. The probability is low.

Bio59. Increase in bird hunting from increased access.

Bird hunting will probably stay at the same levels after oil and gas operations stop along TAPS and on the ANS. If public access is allowed in the abandoned and restored ANS oil fields, bird hunting may increase there. The end of oil industry operations will be accompanied by significant reductions in statewide employment. This may increase the subsistence harvest of birds to compensate for the loss of income (see Sections 4.4 and 4.5). If decreased state revenue results in less enforcement of fish and game regulations, this impact could be intensified. However, it is also possible that the human population (and fish and wildlife harvests) will decrease in response to the economic decline.

The magnitude of this impact will remain low, the geographic scope will be high if the ANS is opened to hunting, and the frequency/duration moderate, for an overall intensity of moderate. The probability of the impact is moderate.

No-Action: Terrestrial Mammals

By W. Ballard, M.A. Cronin, H. Whitlaw

Bio60. Obstruction of mammal movements by roads, pipelines, and facilities.

After DR&R, above-ground pipelines will be removed, and traffic will decrease substantially along TAPS and in the ANS oil fields. The obstruction of wildlife movements will be restricted to impacts from public and other-industry traffic on roads. Most traffic would probably occur in summer. During the three years of DR&R, traffic along TAPS could increase from associated activity, with some effect on animal movements. However, traffic during construction and operation of TAPS have not affected wildlife at the population level, and this will also be the case during the DR&R phase as well.

The magnitude of this impact will remain low, the geographic scope low, and the frequency/duration low, for an overall intensity of low. The probability is low.

Bio61. Disturbance and displacement of large mammals by human activities.

After DR&R, activity along TAPS, at the VMT, and in the ANS oil fields will stop, and this impact will be greatly diminished. Public access and other industry activity will include year-round human presence (mainly recreational vehicles, ATVs, snowmachines) along the Dalton Highway

and TAPS ROW and will cause some noise and disturbance of wildlife. The level of recreational use of the highways and TAPS remnants following DR&R is unknown but can be assumed to be similar to current levels.

The DR&R phase will involve some disturbance along the TAPS ROW and on the ANS from noise, and vehicle and equipment operations. This can be minimized by restricting or prohibiting activity during sensitive times such as when caribou are calving.

The magnitude of this impact will remain low, the geographic scope moderate, and the frequency/duration low, for an overall intensity of low. The probability is low.

Bio62. Reduced habitat quality for terrestrial mammals caused by fragmentation and alteration of habitat.

In general, DR&R will restore habitats to the pre-TAPS condition or to other viable habitat. In the ANS oil fields, removal or revegetation of roads and pads may provide additional foraging habitats but will remove insect-relief habitat. The removal of oil field buildings and pipelines will decrease the amount of shade available to caribou, thus reducing the relief available from oestrid flies.

The magnitude of this impact is low, the geographic scope low, and the frequency/duration low, for an overall intensity of low. The probability of the impact is low.

Bio63. Mortality of terrestrial mammals from highway vehicle roadkills.

Highway traffic will continue to kill some wildlife during and after DR&R of TAPS and the ANS oil fields. A small proportion of the roadkills in Alaska are on the Richardson or Dalton Highways (ADOT, 1996). Wildlife mortality due to collisions with vehicles has not been identified as a significant limiting factor for populations in the vicinity of the TAPS ROW. There is no evidence of adverse population-level effects. Increased traffic during DR&R of TAPS may increase the numbers of roadkills for three years, but the subsequent reduction in TAPS and ANS traffic will then reduce the numbers. Local and recreational traffic will continue after DR&R and cause some roadkills.

The magnitude of this impact is low, the geographic scope moderate, and the frequency/duration low, for an overall intensity of low. The probability is low.

Bio64. Effects on predators from anthropogenic food sources and habitat enhancement.

Garbage and other anthropogenic food sources from oil and gas industry sources will no longer be available after DR&R, and this impact will stop in the ANS oil fields. The impact could occur along TAPS, at the VMT, and in the ANS oil fields during DR&R. The intentional feeding of wildlife and the use of garbage occurred during TAPS construction (McCarthy and Seavoy, 1994; Follmann and Hechtel, 1990; Miller and Chihuly, 1987; Milke, 1977; also see Section 4.3.2.5). However, this impact is no longer a problem in the TAPS ROW because of Alyeska's improved garbage management and prohibition on feeding animals. These same management practices can be implemented during DR&R to limit this impact. The recreational-use areas along TAPS may result in this impact after DR&R. However, mortality of nuisance wildlife has not been identified as a significant limiting factor for populations in the vicinity of the TAPS ROW, and there is no evidence of adverse population-level effects.

The magnitude of this impact is low, the geographic scope moderate, and the frequency/duration low, for an overall intensity of low. The probability is low.

Bio65. Mortality, injury, or disturbance of terrestrial mammals from oil, fuel, or chemical spills.

The potential for oil spills from TAPS and ANS pipelines or tankers will cease after operations are stopped. A potential for fuel spills during DR&R and from other industry operations and public vehicles will remain, but such spills are unlikely to impact terrestrial mammals.

The magnitude of this impact is low, the geographic scope low, and the frequency/duration low, for an overall intensity of low. The probability of the impact is low.

Bio66. Increased hunting of terrestrial wildlife from increased access.

Hunting of terrestrial mammals will probably stay at the same levels after oil and gas operations stop along TAPS and on the ANS. Hunting is currently prohibited in he Prudhoe Bay Closed Area. If this changes with DR&R, wildlife populations could be impacted more than they are with the oil fields in operation. Hunting of caribou, grizzly bear, polar bear, and muskoxen, and trapping of furbearers from the oil field roads after DR&R could change distributions and numbers. Since oil-field development, the caribou and grizzly bear populations have been able to grow and use traditional habitats in the oil fields, but this could change if hunting and trapping were allowed in this area. Depending on the regulation of hunting and trapping after DR&R, access provided by oil field roads would make this issue potentially important to maintain current numbers and distribution of terrestrial wildlife. It is likely that hunting regulations would be imposed, as in other areas, to achieve herd objectives.

The end of oil industry operations will be accompanied

by significant reductions in statewide employment. This may increase the subsistence harvest of mammals to compensate for the loss of income (see Sections 4.4 and 4.5). If decreased state revenue results in less enforcement of fish and game regulations, this impact could be intensified. However, it is also possible that the human population (and fish and wildlife harvests) will decrease in response to the economic decline.

Hunting could increase during the three years of DR&R with the influx of workers. Hunting will probably not be allowed while workers are on-shift, but access to remote areas may allow them to hunt while off-duty.

The magnitude of this impact is moderate, the geographic scope high, and the frequency/duration high, for an overall intensity of high. The probability is high.

No-Action: Marine Mammals

By R. Senner and M.A. Cronin

Bio67. Disturbance and displacement of marine mammals by petroleum-related operations.

After DR&R, there would be no impacts on marine mammals from the oil and gas industry in either the Beaufort Sea or Prince William Sound. The DR&R phase would include some noise at offshore facilities (Northstar and Endicott), but restricting activity outside the bowhead whale migration would minimize impacts. Increased public access, primarily in Prince William Sound, could disturb some marine mammals.

The magnitude of this impact is low, the geographic scope is low, and the frequency/duration low for an overall intensity of low. The probability of the impact is low.

Bio68. Mortality, injury, disturbance, or alteration of habitats for marine mammals from oil, fuel, or chemical spills.

After DR&R, there would be no potential for oil and gas industry spills that impact marine mammals in either the Beaufort Sea or Prince William Sound. The DR&R phase would include the potential for fuel spills at offshore facilities (Northstar and Endicott), but most spills would be confined to the gravel islands.

Increased public access and other industry activity, primarily in Prince William Sound, may include fuel spills that could impact marine mammals. The volumes spilled and numbers of animals impacted would be relatively small.

The magnitude of this impact is low, the geographic scope is low, and the frequency/duration low for an overall intensity of low. The probability of the impact is low.

No Action: Threatened and Endangered Species

By R. Senner and M.A. Cronin

Bio69. Collisions of eiders with onshore or offshore structures.

Onshore and offshore facilities in the ANS oil fields will be removed during DR&R. Collisions of eiders with structures will not occur. The magnitude of this impact is low, the geographic scope low, and the frequency/duration low, for an overall intensity of low. The probability of the impact is low.

Bio70. Disturbance of Spectacled and Steller's eiders on the North Slope from noise and activities from oil-field operations.

After DR&R, oil field activity on the ANS and along the northern portion of TAPS will stop, and this impact will not occur. Other industry activity or public access in the range of eiders could result in disturbance. During the three years of DR&R, noise and human activity could disturb some eiders. The magnitude of this impact is low, the geographic scope low, and the frequency/duration low, for an overall intensity of low. The probability of the impact is low.

No-Action: Biological, Cumulative Effects Summary

In summary, under the no-action alternative, two potential biological cumulative impacts met the significance criteria of high intensity and high probability:

- **Bio48**. Impacts on fish populations from recreational fishing.
- **Bio66**. Impacts on terrestrial mammal populations from increased hunting.

Both of these impacts can be mitigated by regulation and enforcement by the appropriate agencies. Other impacts could potentially be biologically important, depending on chance events (e.g., oil spills) or mitigation during and after DR&R. In general after DR&R, TAPS, ANS oil fields, and oil tanker traffic will have ceased operations and direct impacts will no longer occur. The primary cumulative impacts that will continue relate to the increased access to remote areas provided by roads built during operation of TAPS, such as increased hunting or fishing pressure.

4.5.4.3 No-Action Alternative: Social Issues

By L.D. Maxim, O.S. Goldsmith, M. Galginaitis, C. Gerlach, P. Bowers, C. Wooley, R. Niebo

This section examines the cumulative effects that would

result from selection of the no-action alternative. In brief, the no-action alternative would halt all ANS production at the end of 2003 and initiate DR&R activities for ANS facilities, the pipeline, VMT, and tanker transport of crude oil from Valdez. Refineries dependent on ANS output would also close. Alaska would become a net importer of crude oil and/or refined products, and tanker shipments into Alaska would be increased to satisfy in-state demand.

The no-action alternative would also foreclose gas commercialization, including GTL, TAGS, and the ANGTS pipeline for the foreseeable future. It is assumed that the NMDS site at Fort Greely is implemented in any event, although the incremental effects of this action are minor and very localized.

Table 4.5-17 shows a list of issues potentially relevant to the no-action alternative, while Figure 4.5-12 presents the summary effect-ranking matrix. As for the proposed action, these are grouped into "issue clusters" for analysis: economics, social change, subsistence, visual/recreational, environmental justice, and land issues. Effects are characterized in terms of intensity and probability.

The economic and social consequences of selecting the no-action alternative would be adverse and prolonged. Because many of these changes would begin within a relatively short period (i.e., by 2004), the effects would be particularly disruptive.

No-Action: Economics

Economic issues resulting from the no-action alternative are addressed in Section 4.4.3.1. Aside from the incremental economic effects from loss of revenues and employment associated with gas commercialization, Section 4.4.3.1 addresses cumulative economic effects at some length, and only a summary of these effects is presented here.

The economic consequences of the no-action alternative are relevant in national, state, and local contexts.

- **National:** Elimination of ANS production would reduce domestic oil production by nearly 20 percent, increase the balance-of-payments deficit in crude oil, reduce federal revenues, and eliminate the demand for double-hull tankers to serve the ANS trade (and therefore reduce output of domestic shipyards and the demand for U.S. seafarers)
- **State:** Elimination of ANS production would bring about some short-term gains in employment (though not necessarily Alaskan-resident employment) and income resulting from DR&R activities. In the intermediate and long-term, however, these small gains would be overshadowed by substantial and continuing losses. Direct employment in the North Slope oil fields, pipeline, and VMT would be eliminated, starting ripple effects through the economy. Employment in firms that provide goods and services for the oil and gas industry would fall off, as would indirect employment supported by purchases made by these workers. State revenues would decline, and the state would have to implement measures (e.g., the imposition of an income tax and elimination of PFDs) to conserve resources so as to continue to provide essential services. State economic activity would decline, resulting in additional revenue losses, and a prolonged economic contraction would be precipitated. Disposable personal incomes would decline, and unemployment and out-migration would rise.
- **Local:** These same effects would also be felt locally. Property tax revenues paid by the oil and gas industry would fall, straining municipal budgets. Employment losses and out-migration would lead to a fall in property values, increased bankruptcies, and other adverse trends, which would further reduce local revenues. Not all communities would be equally affected. The most severe effects would occur on the North Slope, and in Fairbanks and Valdez/Cordova.

Soc14. National economic effects.

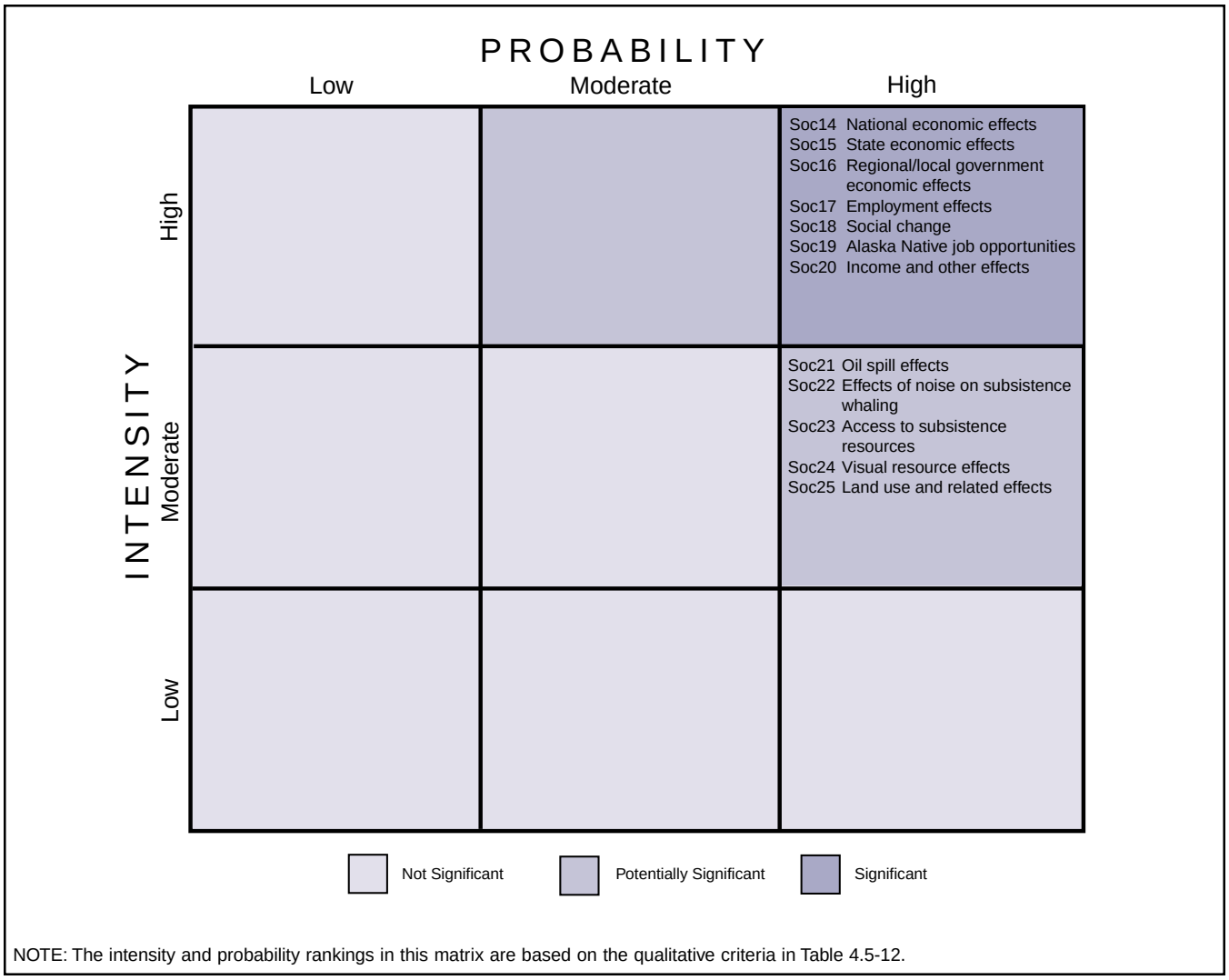
As noted in the discussion of the proposed action, ANS production accounts for about 20 percent of domestic oil production. This will decrease over time, but an appreciable amount of production will continue throughout the ROW renewal period. Closure of the ANS fields would increase the balance-of-trade deficit by approximately $150 billion in 1998 dollars (based on USDOE energy price forecasts) and reduce federal revenues by approximately $10.8 billion from 2004 to 2033.

The no-action alternative not only leaves ANS oil reserves stranded, but also prevents commercialization of natural gas in the foreseeable future, which entails revenue losses, increases the balance-of-trade deficit, and likewise increases U.S. dependence on imports.

Application of the criteria shown in Table 4.5-12 indicates that the intensity of this effect is high, as is the probability that this will occur.

Soc15. State economic effects.

At the state level, selection of the no-action alternative would result in the loss of revenues from royalties and severance taxes associated with ANS production and the pipeline. Figure 4.5-13 shows these losses cumulatively from 2004 to 2034; cumulative losses at the end of this period total $14.2 billion ($ 1998) in comparison to the proposed



NOTE: The intensity and probability rankings in this matrix are based on the qualitative criteria in Table 4.5-12.

Figure 4.5-12. *Ranking matrix of potential cumulative impacts on social environment (no-action alternative)*

action. This revenue loss is particularly significant because of the relatively large share of state revenues contributed by oil combined with the large share of total economic activity supported by public spending.

Gross state product (GSP) is a measure of the importance of different activities to the economy and the overall level of economic activity. GSP includes wages paid to workers, taxes paid to government, and investment in new equipment and profits. Loss of oil production would cause GSP to fall about 30 percent and the ripple effect would cause non-oil GSP to fall about 17 percent in the no-action alternative compared to the proposed action.

Considering both direct and indirect (multiplier) effects, the no-action alternative would reduce state employment substantially (Soc17, ranked below). Figure 4.5-14 (left y-axis) shows statewide employment under both the proposed action and no-action alternatives. Following a small in-

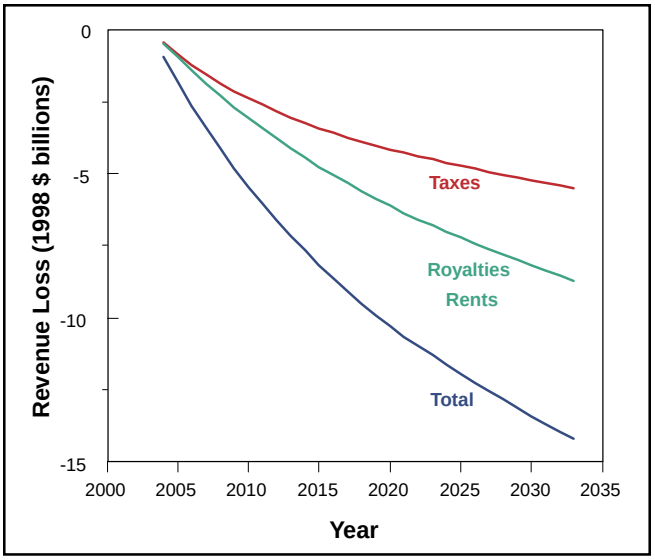


Figure 4.5-13. *Revenue losses to state.*

SOCIAL RESOURCES CUMULATIVE EFFECTS SUMMARY: NO-ACTION ALTERNATIVE

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
ECONOMIC											
Soc14 **National economic effects.**	The no-action alternative will result in closure of TAPS and commencement of DR&R activities.	All ANS gas commercialization opportunities would be foregone, because the production infrastructure on the North Slope would be terminated. Potential federal revenues from these future developments would not materialize.	All ANS production would cease because of closure of TAPS. Remaining oil reserves would be stranded, U.S. oil production would decrease, the balance of trade would be adversely affected, and federal revenues (from taxes, royalties, and lease bonuses) attributable to ANS activities would cease.	No impact.	Closure of ANS fields and the pipeline would not affect the NMDS program. National security benefits of this program would not be affected.	No impact.	H	H	H	H	H
Soc15 **State economic effects.**	Shutdown of the pipeline would reduce APSC purchases, resulting in decreased economic activity. In the short term, DR&R activities would generate some economic benefits.	All potential revenues associated with gas commercialization would be foregone.	Remaining oil reserves would be stranded, Alaska oil production would decrease dramatically, gross state product would decrease, and state revenues (from taxes, royalties, and lease bonuses) attributable to ANS activities would cease. The state would suffer a substantial and long-lasting economic contraction. The PFD would be eliminated.	No impact.	The state would receive some benefits resulting from the economic activity associated with the NMDS.	No impact.	H	H	H	H	H
Soc16 **Effects on local governments and communities.**	Local government would lose property taxes associated with TAPS facilities. Other revenues also would decline as the economy and population contract by both direct and indirect (multiplier) effects.	Local governments would lose property tax revenues associated with potential gas-related facilities (e.g., pipeline, LNG facility) and direct and indirect benefits associated with the economic activity associated with these facilities.	Local government would lose property tax revenues associated with ANS and VMT facilities and the direct and indirect economic benefits associated with these operations. Lost revenues would precipitate budget crises for many communities.	No impact.	No impact.	No impact.	H	H	H	H	H
Soc17 **Employment effects.**	Pipeline closure will result in loss of jobs for operations and oversight workers.	Failure to commercialize ANS gas reserves forecloses future employment opportunities associated with these operations.	ANS oil-and-gas-industry jobs would be lost. Jobs would also be lost in those industries that directly or indirectly support the oil and gas industry. Losses in state and local government revenues would precipitate further employment declines.	No impact.	Construction of the NMDS facility will necessitate a small, temporary influx of workers during the 5-year construction period.	No impact.	H	H	H	H	H
SOCIAL CHANGE											
Soc18 **Social change effects.**	Many factors will combine to alter traditional lifestyles. DR&R activities will create an influx of workers, but this will be temporary. In the longer term, there will be a net out-migration. Employment losses associated with shutdown of TAPS will create individual hardships and create pressures on social systems.	The potentially adverse social effects associated with the influx of workers associated with gas commercialization would not occur.	Closure of ANS oil and gas operations would lead to net out-migration, easing certain social pressures. Revenue losses to the state, North Slope Borough, and other entities would create budget pressures that would result in a loss of social services and an increase in other social pressures.	No impact.	Construction of the NMDS facility will necessitate a small, temporary influx of workers.	No impact.	H	M	H	H	H
Soc19 **Job opportunities for Alaska Natives.**	Alaska Natives employed by Alyeska, subcontractors, and vendors would lose jobs.	Failure to commercialize ANS gas reserves forecloses employment opportunities.	Alaska Natives employed in ANS operations, subcontractors, and vendors would lose jobs. Moreover, pressure on state and North Slope Borough budgets could lead to additional employment losses.	No impact.	No impact.	No impact.	H	M	H	H	H
Soc20 **Income potentially affecting social problems.**	Reduction of real incomes and budget pressures on state and local government will force reductions in various social programs at a time when the need for these programs might increase. Closure of TAPS will create budget problems for several communities in the vicinity of TAPS.	No impact..	Closure of ANS operations will create budget problems for ANS communities and those effected by state budget cutbacks.	No impact.	No impact.	No impact.	H	H	H	H	H

Table 4.5-17.
Social resource cumulative effects summary: No-action alternative

SOCIAL RESOURCES CUMULATIVE EFFECTS SUMMARY: NO-ACTION ALTERNATIVE

Potential Effect	PROPOSED ACTION	GAS COMMERCIALIZATION (GTL, LNG, Gas Pipeline)	NORTH SLOPE OIL FIELDS AND ANS TANKER TRADE (Past, Present, Future Development)	PUBLIC ACCESS	MILITARY (NMDS)	OTHER INDUSTRY	Intensity Factors			Ranking	
							Mag	Geo	Freq/ Dur	Int	Prob
SUBSISTENCE											
Soc21 **Oil spills affecting quality of subsistence resources.**	TAPS pipeline-related oil spills would be eliminated, and effects on subsistence resources would be reduced because the potential for oil spills would be reduced.	There would be no spills, fires, or explosions associated with ANS gas activities.	Oil spills associated with ANS and Valdez tanker operations would be eliminated. Oils spills in Alaska would not be eliminated, however, because crude oil and/or refined products would have to be imported for in-state consumption.	No impact.	No impact.	No impact.	M	H	L	M	L
Soc22 **Effects of noise on subsistence whaling.**	Closure of TAPS would have no effect on whaling.	No impact.	DR&R of ANS production facilities and cessation of exploration activities would prevent adverse effects on whaling.	No impact.	No impact.	No impact.	M	L	L	M	L
Soc23 **Access to subsistence resources.**	Little to no effect on access to subsistence resources as a result of TAPS closure.	Failure to commercialize gas reserves avoids additional constraints on access to subsistence resources.	Removal of ANS oil and gas infrastructure would eliminate access constraints on the North Slope.	No-action alternative would not eliminate public access to former haul road.	No impact.	No impact.	M	M	L	M	L
VISUAL/RECREATIONAL											
Soc24 **Effects on visual/ recreational resources.**	Closure of TAPS eliminates visual effect of pipeline and related facilities. Closure also diminishes some recreational activities because highway observation points and visitor centers would be eliminated.	Elimination of potential gas development options prevents adverse effects on visual/recreational resources.	Closure and DR&R of ANS facilities eliminate potentially adverse effects of these facilities on visual/recreational resources.	No impact.	Construction of this facility would result in an added visual effect.	No impact.	M	M	L	M	L
LAND USE AND RELATED ISSUES											
Soc25 **Land use and related issues.**	Closure and DR&R of TAPS make additional areas available for other land uses.	No impact.	Closure and DR&R of ANS facilities make additional areas available for other land uses.	No impact.	Localized effects possible.	No impact.	M	M	L	M	H

Table 4.5-17 (Cont'd).
Social resource cumulative effects summary: No-action alternative

crease in 2002 and 2003 resulting from DR&R activities, employment would drop sharply below that associated with the proposed action in succeeding years. By 2010, employment would be 18 percent lower. An improved measure of adverse employment effects is the total worker-years lost, which is the area between the two curves (the cumulative sum of worker losses in each year). Cumulative wage and salary worker-years lost are plotted on the right y-axis of Figure 4.5-14. Cumulative wage and salary worker-years lost are 561,000 through 2015. Statewide employment in the no-action alternative would ultimately recover after many years and equal the level before the pipeline was shut down. However, the total loss in worker-years will not recover unless employment ultimately becomes much greater than it would have under the proposed action — and for many years — a very unlikely outcome. In this sense, worker-years are irretrievably lost. (The same point is valid for most of the other economic measures discussed in Section 4.4.3.1, including personal income and GSP.) The loss of jobs translates into unemployment and out-migration.

Section 4.4.3.1 identifies and quantifies many other adverse effects statewide, including decreases in total personal income, personal income per capita, population, non-oil GSP, and increases in unemployment. Collectively these developments would result in a recession/depression that is projected to be considerably more severe and longer lasting than the recessions of 1976 or 1985. Figure 4.5-15 shows actual employment dips for these two recessions compared to that projected if the no-action alternative were selected. Measured by the size of the trough generated by the drop in employment, the projected no-action alternative recession would be more than 6 times as severe as the one Alaska experienced during the 1980s.

Selection of the no-action alternative would foreclose gas commercialization options for the foreseeable future, resulting in the potential loss of additional state revenues.

The combination of substantial revenue declines, reductions in economic activity, employment declines, and a severe and prolonged economic contraction fully justify an intensity ranking of high. These effects have been estimated from the best available data and econometric models and the predictions are believed to have high reliability. The probability of occurrence is high.

Soc16. Effects on local governments and communities.

There are substantial adverse regional effects in many of these same measures. Moreover, these effects are not evenly distributed; some communities are likely to experience relatively small effects, others proportionately larger.

Several local governments depend on property taxes on North Slope oil production and pipeline facilities to support public services. The aggregate loss of revenues to local governments from 2004 to 2033 from affected oil facilities is projected to be $2.098 billion in 1998 dollars. As shown in Figure 4.5-16, these losses are greatest for the North Slope Borough ($1.896 billion), and smaller, but still significant, for Valdez/Cordova ($126 million), Fairbanks ($51 million), and Anchorage ($25 million). These estimates make no allowance for the opportunity lost because natural gas will not be commercialized.

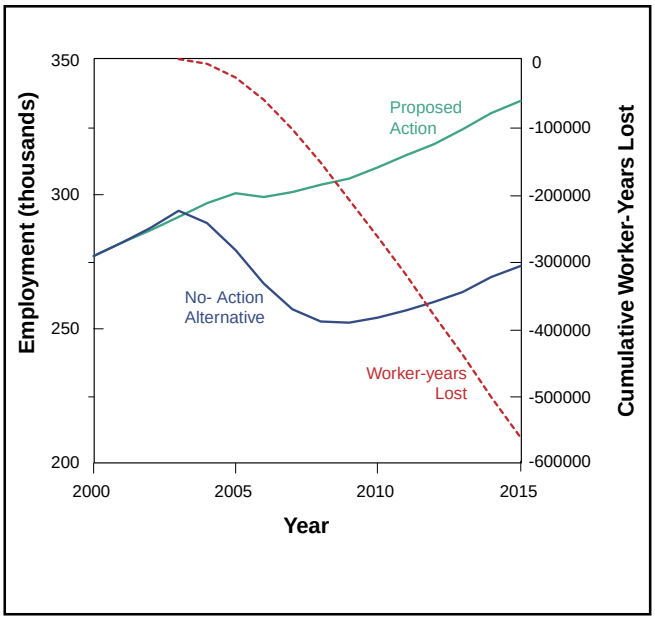


Figure 4.5-14. *State employment.*

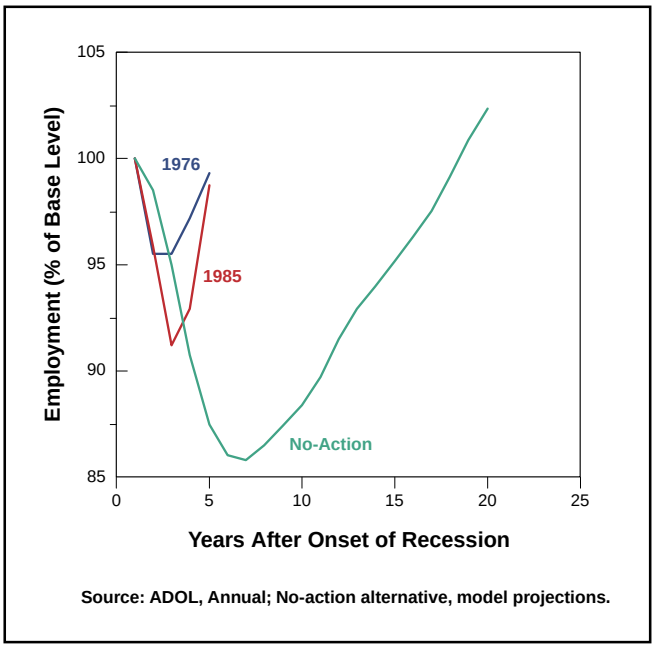


Figure 4.5-15. *Employment as percent of base level.*

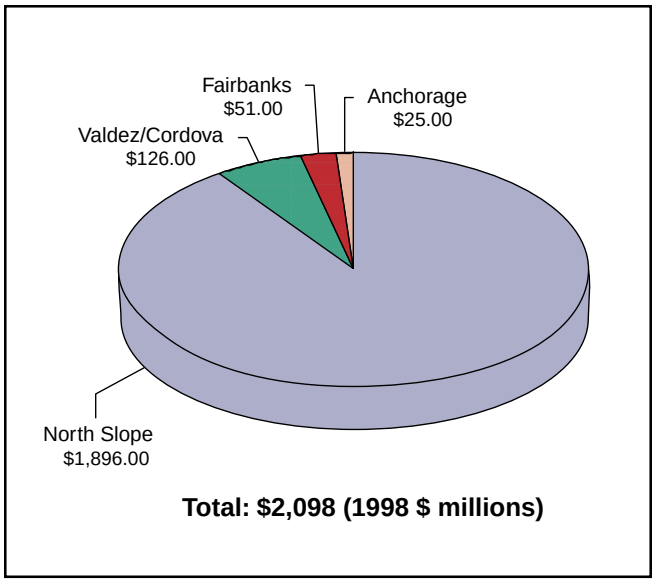


Figure 4.5-16. *Regional revenue losses.*

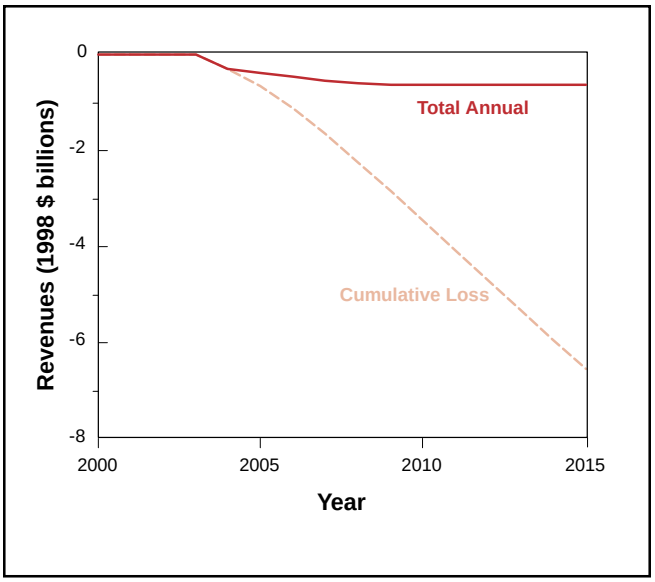


Figure 4.5-17*. Revenue.*

As with state government, the "ability to pay" of local government is reduced in the no-action alternative by the loss of property taxes associated with oil production and transportation. Other revenues also decline as the economy and population contract by both direct and indirect (multiplier) effects, and as state transfer payments fall. Figure 4.5-17 shows this decline in both annual and cumulative terms from 2000 to 2015. Total annual revenues in 2010 fall 24 percent below the proposed action and exceed the projected drop in population, so that the ability of local government to pay for public services is also reduced.[14] Even though annual losses seem to have stabilized by 2015 (Figure 4.5-17), cumulative losses continue to mount. From 2000 to 2015, local revenues are lower in the no-action alternative by a total of more than $6.5 billion (1998 dollars) — a very substantial adverse effect.

The no-action alternative brings about reduced employment, increased unemployment and out-migration, reduced personal income, loss of property values, and other losses. Figure 4.5-18, for example, shows the effect on resident employment in 2015 by community. All communities suffer, but the North Slope and Valdez/Cordova would experience particularly large employment losses compared to the proposed action. The large losses are due both to the loss of employment opportunities in the petroleum industry and to the loss of employment in industries dependent on petroleum revenues.

Employment losses on the North Slope would include direct losses of all oil and gas industry jobs. Although these jobs do not account for a large fraction of North Slope resident employment, they are relatively high paying. Figure 4.5-19, for example, shows the average monthly earnings for North Slope residents by job category (NSB, 1999). Oil industry jobs are the highest paying among all job categories reported in the North Slope Borough 1998/99 Economic Profile and Census Report, but under the no-action alternative, job losses would not be limited to those in the

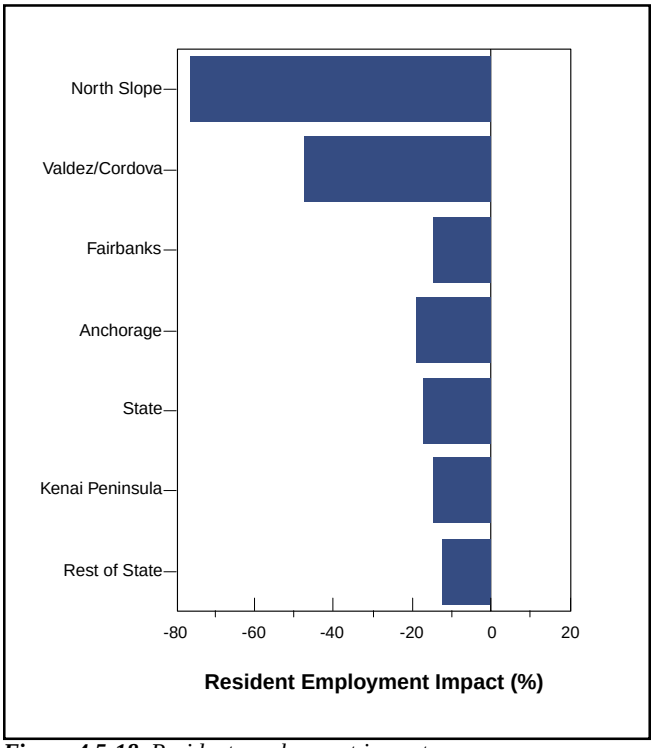


Figure 4.5-18. *Resident employment impact.*

[14]Unit costs (i.e., costs per capita) of providing services would also increase, because fixed costs would be spread over fewer people.

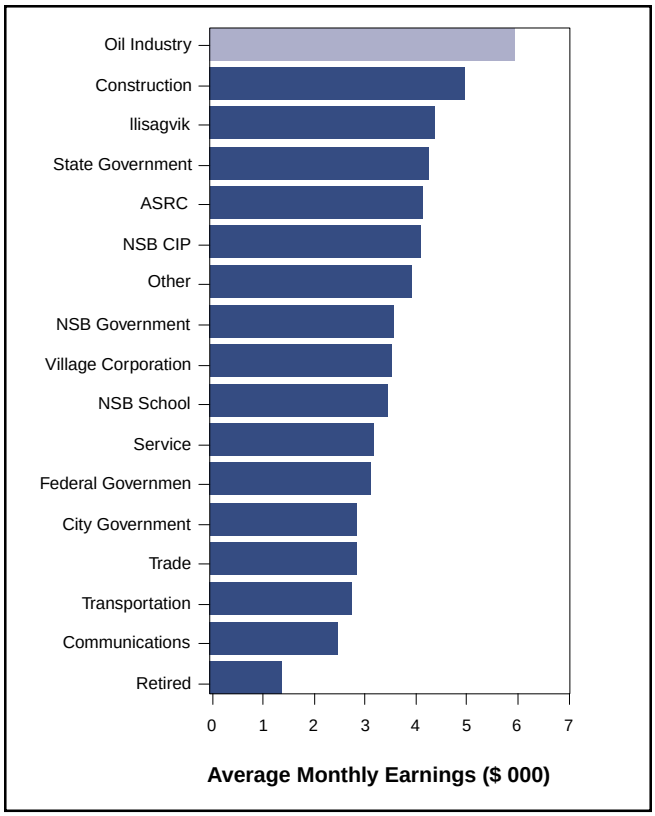


Figure 4.5-19. *Average monthly earnings.*

oil and gas industry. Many other jobs would be lost as a result of indirect and multiplier effects and because of revenues losses to the state and local governments. Jobs in several of the categories shown in Figure 4.5-19 (e.g., construction, state government, Arctic Slope Regional Corporation, NSB government) are linked directly to state and local government revenues.

How state and local governments would cut budgets to accommodate revenue shortfalls cannot be predicted with any certainty. It is noteworthy that education is a large line-item in both state and local government budgets and it is financed in most communities through a combination of local property taxes and state assistance. The state's "foundation program" (kindergarten through 12th-grade education) accounts for about one-third of the state general fund budget. For example, the NSB spent slightly more than $45 million on local education in 1998, 35 percent of total spending on public services (ADCED, 2000). However, the NSB received only about $25 million in state/federal education funds in this same year (ADCED, 2000). It is reasonable to believe that continued funding of education would be a priority in any budget cutting, but it is unlikely that any program would survive unscathed, given the magnitude of the necessary budget cuts.

Application of the criteria shown in Table 4.5-12 indicates that the intensity of this effect is high, as is the probability that this will occur.

Soc17. Employment effects.

These effects are summarized above. Application of the criteria shown in Table 4.5-12 indicates that the intensity of this effect is high, as is the probability that this will occur.

Economic Effects Summary

Collectively, these economic effects are adverse and very substantial. Smaller economic changes have brought about social and political upheavals in other countries. For all study areas included in this analysis, these economic effects are rated as high in intensity and virtually certain to occur.

No-Action: Social Change

Social change issues related to the proposed action include possible cumulative effects associated with population changes (influx of new workers), potential for social strains as a result of increased contact between Natives and non-Natives, demand for increased housing, the effect of wage and salary employment on Alaska Natives, concern over possible loss of cultural identity in an industrial society, the need to maintain proficiency in Native languages.

Some of these issues and concerns would be eliminated or become less important if the no-action alternative were implemented. For example, the influx of new workers would certainly be halted except for a short-term increase during DR&R. However, social concerns associated with the proposed action would be replaced by others that are nearly intractable and ultimately of greater consequence. It is almost impossible to imagine that most Alaskan Natives, let alone most Alaskans, would be better off under the no-action alternative.

Soc18. Social change effects.

Selection of the no-action alternative will not enable a direct resumption of pre-oil culture or return to the status quo before oil. The abrupt exit of the oil industry from Alaska (with the exception of the Kenai Peninsula fields and refinery) would certainly reduce the influx of workers to the North Slope and other communities. Indeed, the no-action alternative would result in substantial out-migration. Contact between Alaska Natives and non-Natives on the North Slope would be reduced. This would eliminate some incidental opportunities for friction.

Concerns over the consequences of social change are legitimate. It is likely that there will be continuing pressures on Alaska Natives and others for cultural assimilation. But,

largely because the causes of these pressures are many and complex, it is difficult to imagine that selection of the no-action alternative would materially alter these pressures.

Accordingly, this effect is judged to have high intensity and high probability — just as it is in the case of the proposed action.

Soc19. Job opportunities for Alaska Natives.

Concern over employment of Alaska Natives in the oil and gas industry would also cease to be an issue, but because overall employment would be lower under the no-action alternative, unemployment and underemployment would increase. As noted in the economic sections, the adverse effects of the no-action alternative on employment would be substantial. Compared to the proposed action, resident employment on the North Slope would decrease by more than 76 percent by 2015. Employment decreases in other areas would be less severe, but substantial nonetheless. Projected employment decreases by 2015 resulting from selection of the no-action alternative include Fairbanks (15 percent), Anchorage (19 percent), Kenai Peninsula (15 percent), and Valdez/Cordova (47 percent).

Reductions in real per-capita income are also likely to have adverse social, as well as economic, consequences. By 2015, for example, the real per-capita income changes (1998 dollars) would be more than $3,700 in the NSB, $3,200 in Valdez/Cordova, and nearly $1,600 in Fairbanks.

How should these effects be evaluated? In the case of selection of the proposed action, the magnitude of the jobs effect is evaluated as moderate (measurable and noteworthy, but not substantial), the geographic scope moderate (because the effect would be limited), and the duration high (because the effect would be nearly continuous). Weighed together, these are ranked as having moderate intensity, but high probability. Considering now the effects of the no-action alternative, the magnitude is ranked high (more jobs are lost than would have been gained under the proposed action), the geographic scope moderate (because jobs in more than one study area, possibly the entire state, would be affected), and the duration high. Taken together the intensity is rated as high and the probability high.

Soc20. Income potentially affecting social problems.

If the no-action alternative were selected, there might be fewer and/or less intense cultural pressures on Alaska Natives for assimilation, including those that might lead to a loss of familiarity with Native languages. But there would also be severe budget pressures to reduce education expenditures, because both the state and local governments would have sharply reduced revenues.

Rather than eliminating or easing social changes, the no-action alternative would only substitute a different set of problems and challenges. Employment opportunities would be sharply reduced, not only because of direct losses resulting from the closure of the ANS fields and other TAPS elements, but also because of the substantial decrease in oil revenues provided to state and local governments. State and local governments, schools, and Native corporations are major sources of employment. Sharply reduced budgets translate into fewer employment opportunities and fewer government services.

Setting budget priorities when revenues are plentiful and expanding is a difficult enough task. Reducing budgets requires making painful and often unpopular choices. It can also be divisive: “shared hardships” are generally more difficult to manage than “shared wealth.”

Whether or not sharply reduced income would reduce domestic violence and/or substance or alcohol abuse is unknown. Some of the views contained in other EISs imply that it might. Implementing the no-action alternative amounts to initiating a large, uncontrolled, and irreversible social experiment without any certainty of a successful outcome. What is certain is that funds for social programs to combat existing ills would be reduced.

Much of the above material is particularly relevant to the North Slope. Many other communities/areas would suffer social effects if the no-action alternative were selected. Valdez residents would experience increasing unemployment, reduced government revenues, and diminished per capita incomes. Historically, Valdez residents held positive attitudes about the construction of the pipeline terminus and port development. The town had a poor economic base prior to TAPS construction, and adverse effects of the construction activities were made tolerable by the prospects for long-term economic benefits from the pipeline. However, residents would probably not maintain the same positive attitudes toward the effects of DR&R because there would be no compensating long-term benefits. Loss of VMT and SERVS employment among Chenega Bay and Tatitlek villagers (Tatitlek Chenega Chugach contracts) would negatively affect these communities.

Application of the criteria shown in Table 4.5-12 indicates that the intensity of this effect is high, as is the probability of its occurrence.

No-Action: Subsistence

Soc21. Oil spills affecting quality of subsistence resources.

The no-action alternative would eliminate the possibil-

ity of crude oil spills on the North Slope, Central TAPS, and Valdez/PWS study areas. Not all oil spills would be eliminated, however. Relatively large volumes of crude oil and/or refined products would be imported into Alaska to satisfy in-state demand. Incoming tankers would not have the protection provided by SERVS as it would no longer exist. Elimination of crude oil spills in the three study areas would also eliminate any adverse effects of these spills on subsistence resources and harvests — a potentially significant benefit.

DR&R activities might have adverse spill-related effects on subsistence, but these would be temporary. These effects would also result if the proposed action were selected, though not in the time frame of this analysis of cumulative effects, because DR&R will ultimately be required at the end of TAPS' economic life.

Based on the ranking criteria presented in Table 4.5-12, this potential effect is evaluated as having moderate intensity, but a low probability of occurrence.

Soc22. Effects of noise on subsistence whaling.

The no-action alternative would eliminate this concern because exploration activities (including seismic surveys) would cease on the North Slope. The probability is, therefore, low. The intensity of this effect is ranked as moderate.

Soc23. Access to subsistence resources.

Although access would be increased by the elimination of constraints in certain areas (e.g., the North Slope), the no-action alternative might actually have mixed effects on subsistence harvests. As noted above, adverse economic developments would provide an economic incentive for residents to increase subsistence efforts in order to compensate for income reductions. Balanced against this, subsistence users would also have less cash income to pay for various types of equipment (e.g., snowmachines, all-terrain vehicles, small boats, outboard motors, fuel, guns, and ammunition) that increase the efficiency of hunting/fishing efforts. Population on the North Slope and Valdez-Cordova would decrease with the no-action alternative, and pressure on subsistence resources in these areas could ease as a result. The net effect of these factors cannot be predicted.

Overall, this effect has moderate intensity and low probability.

No-Action: Visual/Recreation Aspects

Soc24. Effects on visual/recreational resources.

The no-action alternative would eliminate ANS oil and gas activities. DR&R activities would ultimately eliminate most visible evidence of industrial development on the North Slope, along the pipeline, and in Valdez. Potential damage from oil spills would also be eliminated. Some recreational opportunities would also be eliminated/reduced, because pipeline observation points would be removed, as would visitor centers. Overall, the negative effects of the no-action alternative are moderate and the probability low.

No-Action: Environmental Justice

The no-action alternative would raise some environmental justice issues. These are linked to the economic effects of the no-action alternative and, in particular, the effects of revenue reductions on the various social programs of state and local government including the PFD. Employment losses might also have an environmental justice component because, although Alaska Natives are not employed in large numbers by the oil industry, the effective shutdown of this industry in Alaska would eliminate the future benefits of Section 29 initiatives and also because government is a large employer of Alaska Natives in certain geographic areas (e.g., the NSB).

As noted in the discussion of economics, it is assumed that no-action alternative would result, among other things, in elimination of the PFD. Because this dividend is a flat sum given to all eligible residents, the proportional significance of the dividend is greatest for large and for low-income families. Alaska Natives, among others, would be disproportionately affected. Figure 4.5-20 shows the average household income for villages on the North Slope in 1998 (NSB, 1999). According to these data, Iñupiat households have lower average incomes than do non-Iñupiat households for most villages and for the NSB as a whole. Figure 4.5-21 shows the distribution of the number of people per household for the NSB in 1998 for both Iñupiat and non-Iñupiat households (NSB, 1999). As can be seen, Iñupiat households have a larger number of people (3.87) on average than non-Iñupiat households (2.08). Thus, elimination of the PFD would have a disproportionate effect on Iñupiats on the North Slope.

Other environmental justice issues associated with the no-action alternative include adverse effects on Native corporations. For example, the Arctic Slope Regional Corporation (ASRC), one of the largest private businesses in Alaska, derives revenues from outright ownership or joint venture arrangements with oil industry and oil field service companies, engineering, and construction firms. ASRC owns the subsurface resources underlying Kuukpik surface lands (USACE, 1997). If commercial quantities of oil and gas are discovered and produced from those lands, the principal economic beneficiary would be ASRC. Many resi-

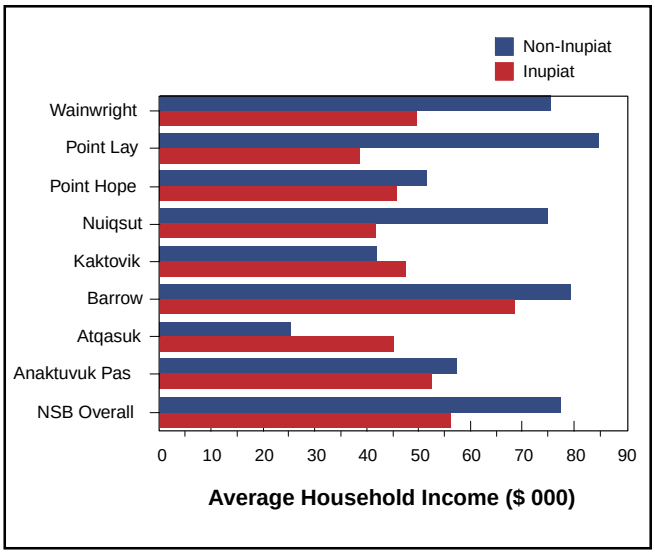


Figure 4.5-20. *Average household income.*

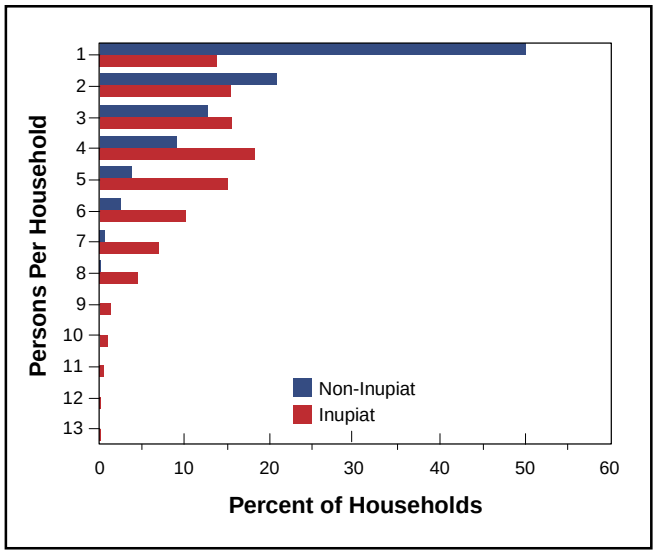


Figure 4.5-21. *Persons per household.*

dents of the North Slope are also shareholders in ASRC and would be adversely affected if its revenues were to decline.

No-Action: Land Use and Related Issues

Soc25. Land use and related issues.

The no-action alternative would eliminate the potential land-use issues identified for the proposed action, but would result in land-use changes. The same applies to closure and DR&R of ANS facilities. The consequences relative to land use are judged to be moderate, and the probability of such effects is high.

No-Action: Social Resources, Cumulative Effects Summary

Effects with high consequences and high probability include economics, social change, and subsistence. Although all of these fall into the same classification, the effects are quite different. The economic and social change effects are principally (if not exclusively) adverse, whereas the effects on subsistence are likely to be beneficial. Visual/recreational effects are judged moderate and largely beneficial, with a high probability of occurring. Effects on land use and related issues are moderate, but with a high probability of occurrence.

4.5.5 Summary and Conclusion

By R.G.B. Senner

Renewal of the TAPS ROW would extend current oil production and transportation operations for 30 years, until 2034. Although specific features and procedures would change if new facilities and processes were added, the same basic attributes that have been documented on the Alaska North Slope, along the Central TAPS study area, and in the Valdez/PWS study area would continue with little change. This means that the baseline established since 1974 can serve as an accurate basis for predicting the potential cumulative effects of the North Slope oil fields, the TAPS pipeline, and the VMT and tanker link in combination with other reasonably foreseeable future actions.

The most important cumulative effects of ROW renewal would be economic and social. ANS oil production, which is viable only if the TAPS ROW is renewed, currently total about 20 percent of U.S. production. The estimated 7 billion barrels of future production during the renewal period will result in a reduction of the U.S. foreign trade deficit by approximately $150 billion in 1998 dollars (based on USDOE energy price forecasts). Revenues to the State of Alaska from continued operation and development of the ANS oil fields, in combination with employment income to a broad sector of Alaskans and continuation of the PFD, would produce statewide multiplier effects. Royalties and severance taxes would continue to contribute to the state capital and operating budgets, funding a wide range of public facilities and services and supporting the long-term maintenance of highways and public facilities that have already been built with federal and state funds. The commercialization of ANS natural gas, whether by a GTL technology using the existing TAPS pipeline, or transport of natural gas by one or more new pipelines, would enhance these economic benefits over the long term.

Continuation of ANS production and TAPS will provide

a large employment base for residents of Alaska and Alaska Natives. Social changes will continue to occur, with positive benefits related to employment opportunities and social services funded in large part by oil revenues and potentially negative benefits related to increased competition for subsistence resources via hunter access along the Dalton Highway. There is also a risk that subsistence resources could be affected if there is a major oil spill.

Potential cumulative effects to fish, wildlife, and their habitats would not be significant, because they would not reduce the population size or geographic range of any species. On the North Slope, caribou and other large mammal populations would continue much as now, with evidence of sporadic local perturbations similar to those currently observed. In the Central TAPS study area, the most notable potential for an adverse cumulative effect would result from the construction of a buried, chilled, large-diameter natural gas pipeline parallel to the existing TAPS pipeline. If built by winter construction using a workpad made of ice, the new pipeline would produce little lasting impact to terrestrial and wetland habitats, other than localized gravel extraction and placement required for compressor stations. Any new pipeline built within the existing BLM utility corridor would likely use the existing TAPS workpad, material sites, access roads, and other infrastructure to the maximum extent compatible with continued safe operation of TAPS.

The greatest potential for an adverse biological cumulative effect along the TAPS ROW could result from increased recreational hunting and fishing via access from the Dalton Highway. The Dalton is a state highway on its own right-of-way, and the applicants have no control over its use. Hunting and fishing effects can be mitigated by game management regulation and enforcement. Additional impacts on fish could occur at stream crossings, where short-term, construction-related streambed disturbance and siltation would result from burial of a natural gas pipeline. Downstream siltation is of concern because of the potential for silt to cover fish eggs and to degrade water quality. Mitigation would be achieved through the Title 16 permitting process by scheduling in-stream construction to avoid sensitive periods, and by employing construction practices designed to minimize erosion and siltation. Longer-term effects associated with equipment and vehicle traffic would be mitigated by using existing TAPS stream crossings. However, the addition of a new pipeline approximately parallel to the TAPS pipeline would necessitate heavier traffic loads on the drivelane of the existing TAPS workpad and at low-water crossings. This effect can be mitigated by continuing monitoring and maintenance of the stream crossings. Clearing of vegetation along both the TAPS and new pipeline ROWs would be minimal and limited by strict dimensional guidelines.

Some change in habitat could occur as a result of future ANS development or a gas disposition project which would add cumulatively to effects of the continued operation of TAPS. The potential altered habitats would be relatively small compared to the total land area along TAPS and on the ANS. Effects will be mixed. Additional wetlands will result from thermokarsting, and manmade structures will provide positive benefits, while additional gravel pads and above-ground facilities could cause loss of habitat and obstruct movement.

If a natural gas pipeline terminated at Prince William Sound, a new marine terminal incorporating an LNG plant would be constructed at Anderson Bay near the existing VMT. The new terminal would produce habitat loss roughly equivalent to that associated with the VMT, and tanker traffic in Port Valdez and PWS would increase. Although LNG tankers would not introduce the potential for crude oil spills, there would still be an increased cumulative risk of fuel spillage that would require careful preventive measures similar to those currently employed by Alyeska Pipeline Service Company.

Cumulative effects on physical resources would relate primarily to oil spills, water discharges, and air quality, and none are expected to be significant with respect to the integrity of the terrestrial environment or long-term air or water quality. As the ANS oil-field infrastructure expanded with the addition of new fields, the aggregate length of oil pipelines would increase, raising the potential for spills. However, the existing pattern and character of oil and fuel spills documented for the North Slope would not change with the expected small increments of new pipelines and facilities necessary to develop marginal fields. If gas commercialization were to proceed through GTL technology, new breakout tanks and other modifications could be required at TAPS pump stations to allow the pipeline to be operated as a batch line. There could be transient flaring, with brief releases of black smoke, associated with diversion of liquids to the breakout tanks. This effect would be minimized through the careful scheduling and precise timing that would be required for switching the pipeline load between crude oil and GTL products.

If the TAPS ROW were not renewed, the North Slope oil fields would be decommissioned, and all above-ground facilities and structures associated with the TAPS pipeline would be removed. This would reduce the potential for cumulative effects related to TAPS. Without the North Slope oil fields, commercialization of natural gas would be unlikely because the infrastructure developed on the ANS

at a cost of many billions of dollars would not be available for use in a gas disposition project. Along the TAPS ROW, the greatest potential for biological cumulative effects would come from the increased public access and use of the TAPS workpad for recreational and subsistence pursuits. With existing access restrictions removed, the public could make greater use of the TAPS workpad drivelane, and it is possible that an expanding zone of habitat disturbance would gradually develop along the ROW unless regulatory controls were imposed.

Most significantly, severe economic dislocations from decreased state revenues and increased unemployment could not be replaced by other sectors, necessitating greater dependence on Permanent Fund earnings to fund the annual budget, the reinstatement of a state income tax, and increases in local property and sales taxes. The Alaskan economy would go into a deep recession and would require a period of years to reconfigure and stabilize following these dislocations.

In conclusion, there will be longer-term cumulative effects on physical, biological, and social resources associated with TAPS ROW renewal than with ROW termination. The combined intensity of these effects, however, would be less than the direct and indirect economic dislocations that would result from termination of the ROW. While ROW renewal would perpetuate the status quo, with some additional local impacts due to additive or synergistic effects with new actions, TAPS DR&R would result in statewide adverse economic impacts that would outweigh the less intense, smaller-scale effects of renewal.

4.6 Unavoidable Adverse Effects of Proposed Action

By L.D. Maxim and R. Niebo

This section contains information on the unavoidable adverse impacts that would occur if the proposed action were selected. *Unavoidable adverse effects* are considered impacts that are directly related to the proposed action and deleterious to the environment, the health of biological resources, and social systems. Specifically, the effects listed below refer only to impacts associated with the continued operation of TAPS. These effects have been distilled from direct and indirect impacts listed among the Physical Characteristics (Section 4.3.1), Biological Resources (Section 4.3.2), and Social Systems (Section 4.3.3) sections in this Environmental Report. Adverse cumulative effects are addressed in Section 4.5.

TAPS has existed for over 20 years and is now part of the affected environment. Thus, major construction-related impacts to landforms, soil, vegetation, waterbodies, habitat, and cultural resources have already occurred and in most cases have been mitigated.

Disturbance related to TAPS operations and maintenance will occur with material sites, corrosion digs, and potential pipe repairs and reroutes, but the disturbance will be much smaller compared construction impacts. Operation of TAPS pump stations and the VMT will cause continuing discharges to water and emissions to air, but these will take place under regulatory permits and should not create significant effects on air or water quality. No population-level effect on any animals have occurred from TAPS operation and none are expected. Finally, the many positive economic and social effects of ANS oil production and TAPS operation will continue throughout the ROW renewal period, but will diminish in proportion to declines in production.

Thus, nearly all unavoidable adverse effects associated with TAPS renewal are minor and can be mitigated, and some effects have been positive. The one exception is a major oil spill to water such as could occur at the VMT or to a major river along TAPS. Serious impacts to the local environment and to biological and subsistence resources could occur but would likely be of relatively short duration (years). However, TAPS will operate under spill prevention and contingency plans approved by state and federal agencies. Major supplies of spill response equipment are available to combat any spill.

Table 4.6-1 identifies the unavoidable adverse effects.

Table 4.6.1. *Unavoidable adverse effects of proposed action.*

RESOURCE	UNAVOIDABLE ADVERSE EFFECT	REPORT SECTION
PHYSICAL CHARACTERISTICS		4.3.1
Paleontological Resources	• Effects would result directly from excavations, pipeline relocation activities or oil spills. Since the location of buried vertebrate remains is unknown until an excavation begins, it is difficult to assess the severity of the potential. However, since TAPS is already in operations, most ground disturbance will be on land already disturbed by construction.	4.3.1.1
Soils and Permafrost	• Development changes soils and permafrost. However, since the pipeline and associated facilities have already been built, the current condition of soils and permafrost should remain largely unchanged. Future excavations, oil spills, and oil spill cleanups could adversely impact some soils and permafrost, resulting in the potential for minor thermokarsting.	4.3.1.1
Sand, Gravel, and Rock	• Though TAPS construction is complete, Alyeska will use approximately 100,000 cubic yards of sand, gravel and rock material per year for maintenance. Mining and gathering this material could result in minor adverse impacts on local topography, cause a loss of vegetation and soils, and alter drainage patterns. In most cases, materials will be mined from existing public and private mining areas or from existing stockpiles.	4.3.1.1
Hazardous Materials	• Hazardous materials may be spilled. To mitigate effects, hazardous materials are contained, used, and disposed of in accordance with regulatory requirements. • There are 58 contaminated sites on the TAPS ROW. Half of these sites are either closed, requiring no further action, or are pending closure.	4.3.1.1
Rivers and Floodplains	• Effects could be caused by maintenance or construction of structures used to bolster and protect TAPS installations. For example, river and stream channels may need to be diverted to ensure the safety of a site. In general, these effects are minor when the behavior of the entire stream or river is considered and in most cases result only in a localized short-term change in stream morphology.	4.3.1.1
Water Resources	• Water will be needed to support operations and maintenance. • Wastewaters, such as groundwater removed during excavations or construction, will continue to be treated, discharged, and assimilated by upland and freshwater receiving environments along TAPS. Marine waters of Port Valdez will continue to assimilate treated discharges from the VMT, including sanitary wastewater and ballast water. Discharges will be in accordance with permits under the Clean Water Act and may change but not adversely affect water quality.	4.3.1.2
Atmospheric Environment	• The atmosphere will continue to assimilate air emissions from TAPS pump stations. However, these emissions are in accordance with permits under the Clean Air Act. • No known existing air quality impacts associated with TAPS have any serious effects on the health or welfare of humans or any serious detrimental effects on the environment.	4.3.1.3
Global Climate Change	• TAPS ROW renewal will not result in a net effect.	4.3.1.4
BIOLOGICAL RESOURCES		4.3.2
Special Area, Special Management Zones and Zones of Restricted Activity	• Due to the rigorous restrictions and permits required to perform TAPS activities in these areas, few, if any, unavoidable adverse effects are predicted to impact resources in SASMZs and ZRAs.	4.3.2.1
Vegetation and Wetlands	• Disturbance and displacement of vegetation takes place when pipeline sections are replaced or rerouted. This activity is expected to be infrequent since only three reroutes have occurred. Future disturbance to vegetation and wetlands is expected to be minimal.	4.3.2.2

Table 4.6.1 (Cont'd). *Unavoidable adverse effects of proposed action.*

RESOURCE	UNAVOIDABLE ADVERSE EFFECT	REPORT SECTION
Vegetation and Wetlands (Cont'd)	• Vegetation and wetlands are impacted by dust from TAPS activities, by water impoundments, by settling due to thermokarst, and by oil spills. The effect of dust on vegetation and wetlands is likely to remain the same as over the last 20 years. • Water impoundments created by TAPS activities may continue to impact vegetation adjacent to the workpad on the Arctic Coastal Plain, but will be of only minor concern along the rest of the ROW, where natural drainages are more effective. • Thermokarst impacts from impoundments, icings, and dust are likely to occur, with small amounts of additional settlement, but impacts to new areas should be negligible. Future maintenance work involving clearings could lead to minor thermokarst changes in surface thermal regimes. • Vegetation and wetlands impacted by a large oil spill could be adversely impacted by the oil and the cleanup process.	
Fish	• Obstructions to fish movement are expected when construction activities impact streams. However, ADF&G regulations are followed to minimize the effect of obstructions to fish movement along TAPS. • Minor fish mortality has been related to gravel mining and thermal irregularities caused by TAPS activities. Large oil spills to water could have sub-lethal or lethal effects on fish and their food resources in the immediate spill area. The effects would be greatest when spills coincide in time and location with migrating fish and overwintering areas. • Pressure on fish populations could increase with harvesting due to continued access to remote areas. The effect can be mitigated by regulation and enforcement.	4.3.2.3
Birds	• Disturbance could be caused by equipment noise, vehicles, pedestrians, aircraft operations, boats associated with spill response dills, and other maintenance and operation activities of TAPS. Activities such as road traffic, brush clearing, and helicopter surveillance flights would have the most impact. Many of these activities are infrequent and disturb only a few birds. • Bird habitats may be changed by TAPS activities. Activities that change snowmelt patterns, water impoundments, and vegetation could have either positive or adverse effects on birds, depending on the species. • Mortality of birds from TAPS activities is minor compared to the entire bird population. Mortality can be caused by collisions with TAPS facilities and traffic, but these events have been infrequent. • Large oil spills to water at the VMT could have an effect on bird mortality depending on the spill location and time of year. Birds rarely survive moderate to severe contact with spilled oil. Spills to land generally affect a limited area and have little or no impact on birds. • Access would still be available for harvesting game birds, though firearm restrictions currently limit harvest by humans.	4.3.2.4
Terrestrial Mammals	• Terrestrial mammal populations are not significantly impacted by TAPS structures and activities. However, certain maintenance activities, such as helicopter surveillance flights, have caused short-term responses in individual animals. Though these effects are unavoidable and adverse, the reactions from individual animals are not realized within the entire herd. Consequently, no adverse effects regarding herd movement and distribution are predicted. • Furbearers and small mammals will probably continue to be disturbed by pipeline maintenance activities, oil-spill drill activities, and oil spills. However, population-level impacts are not predicted. • Oil spills from TAPS activities may cause disturbances in a variety of habitats. If future oil spills are similar to spills over the last 30 years, adverse effects are not predicted for terrestrial mammals. • Access would still be available for harvest of terrestrial mammals though hunting restrictions currently limit harvest by humans.	4.3.2.5
Threatened and Endangered Species	• None expected.	4.3.2.6

Table 4.6.1 (Cont'd). *Unavoidable adverse effects of proposed action.*

RESOURCE	UNAVOIDABLE ADVERSE EFFECT	REPORT SECTION
SOCIAL SYSTEMS		
Economy	• The overwhelming majority of economic effects associated with the continued operation of TAPS are positive. • Declining petroleum revenues for state government are predicted to lead to the reintroduction of a state personal income tax and reduction of the Permanent Fund Dividend. This will impact larger, lower-income families who rely on the PFD for income.	4.3.3.1
Sociocultural Systems	• None expected.	4.3.3.2
Subsistence	• Large oil spills to land and water could affect subsistence resources. Spills to water, depending on spill location and time of year, generally impact subsistence resources much more severely than spills to land. • If access to subsistence areas is improved, use by recreationists, tourists, and sports hunters and fishers could cause conflicts between those who use the resources for subsistence and those who used them for recreation. Game management regulations, enforced by ADF&G and federal land management agencies, are expected to continue to mitigate access-related issues.	4.3.3.3
Cultural Resources	• Access to areas with potentially valuable cultural resources will continue during the renewal period. As material sites used for TAPS construction are developed, cultural sites may be affected by erosion. • Ground-impacting activities such as corrosion investigations, slope/workpad maintenance, potential reroutes, mainline valve inspections, river crossing repairs, and repair and development of new material sites/rock quarries have the potential to damage cultural sites. However, most such activities will be on lands already disturbed by TAPS construction and with archaeological clearances. Furthermore, damage to cultural resources is mitigated by following Section 106 procedures. • Cultural resource sites may initially be impacted by large oil spills and then be further disrupted by cleanup efforts.	4.3.3.4
Land Ownership	• None expected.	4.3.3.5
Land Use	• The continued use and improvement of the Dalton Highway allow non-residents to access lands near the TAPS ROW. This will result in use conflicts between visitors and private landowners, though federal and state land managers make every effort to alert visitors to private landowners' rights.	4.3.3.6
Coastal Management	• None expected.	4.3.3.7
Recreation	• None expected.	4.3.3.8
Visual Resources	• None expected.	4.3.3.9
Wilderness	• None expected.	4.3.3.10
Transportation	• None expected.	4.3.3.11

4.7 Relationship Between Local Short-Term Uses and Maintenance and Enhancement of Long-Term Productivity

By L.D. Maxim

As used in this section, "short-term" refers to the 30-year duration of the right-of-way (ROW) renewal for the Trans-Alaska Pipeline System (TAPS), whereas "long-term" refers to an indefinite period beyond the termination of the ROW and oil and gas production on the North Slope. As noted in the discussion of direct, indirect, and cumulative impacts of the proposed action, effects vary in kind, intensity, and duration.

In most environmental impact statements, the no-action alternative is literally a "do-nothing" alternative, and the environmental impacts associated with this alternative are presumed to be nonexistent. This is not the case for the analysis of TAPS ROW renewal. Historically, short-term environmental and social impacts have occurred, and whatever long-term effects follow from these prior short-term effects cannot be altered by selection of either the proposed or the no-action alternatives. In this sense, some of these long-term effects are foreordained. The pipeline and Valdez Marine Terminal (VMT) have been constructed, as have present Alaska North Slope (ANS) fields. Long-term consequences of these actions will be faced whether or not the ROW is renewed. So too are the effects of the Permanent Fund. Depending upon how this fund is invested and what dividends are authorized, financial benefits from this fund could persist in perpetuity.

In assessing the relationship between short-term and possible long-term effects what is relevant is the difference in the level of these effects comparing the cases where the pipeline and VMT are closed, as are presently operating ANS fields, versus continued operation of TAPS, development of additional ANS fields, and potential development of ANS's vast natural gas reserves.

4.7.1 Physical Resources

As noted in several EISs for ANS developments (e.g., National Petroleum Reserve-Alaska (NPR-A), various Beaufort Sea Lease Sales) oil and gas exploration and development activities will produce short-term, and may produce long-term, effects. For example, the EIS for NPR-A (BLM and MMS, 1998) states:

> "Construction activities associated with road and pad construction, culvert and bridge work in streams and lakes that disturb stream banks or shorelines, blockages of natural channels and floodways that disrupt drainage patterns, and removal of gravel would cause short-term increases in erosion and sedimentation. Water removal could cause short-term changes in aquatic habitat. Permanent gravel roads and pads, airstrips, pipelines, and facilities constructed adjacent to or crossing streams and lakes would have long-term effects on water resources. Magnitude and duration of effects would vary with the type and extent of the activities."

Likewise, the EIS for the Beaufort Sea Planning Area Oil and Gas Lease Sale 170 (MMS, 1998) states:

> "Water pollution from onshore activities is a long-term but local effect...although the pristine water quality of the study area may be impaired, spillage is judged an insignificant long-term, low, local effect for water quality. This level of effect may be considered an appropriate compromise for obtaining oil and gas resources."

Other ANS EISs contain much the same language. It should be noted that the long-term effects on water quality associated with construction activities and physical infrastructure could, in principle, be controlled by the actions taken for dismantling, removal, and restoration (DR&R).

4.7.2 Biological Resources

Exploration, development, and production activities will produce localized adverse short-term effects on vegetation. The recovery time for vegetation from construction activi-

ties and spills is such that damage is likely to extend only briefly beyond cessation of operations. Moreover, the area potentially impacted is only a small fraction of the total resource area.

Short-term adverse effects on biological populations and habitats could occur in the event of an oil spill. The areal extent of these impacts depends upon several factors, including the location of the spill (onshore versus offshore), quantity spilled, season, meteorological conditions during and after the spill, and the success of cleanup and mitigation measures. Potential effects include adverse impacts on population size, reductions in the number of species in the affected area, and changes in behavior and migration patterns. Long-term effects also might occur if recovery from the short-term effects extended beyond the duration of the ROW extension.

It is generally believed (see, e.g., BLM and MMS, 1998; MMS, 1996a, 1998) that after completion of oil production, oil spills and their effects would not occur and the marine environment would be expected to "remain at or return to its normal long-term productivity level." Experience with Outer Continental Shelf (OCS) areas where oil and gas have been produced for many years indicates that there has been no discernible decrease in long-term productivity. Experience differs somewhat in the North Sea, where some persistent effects may have taken place.

4.7.3 Cultural/Paleontological Resources

Archeological and historic sites discovered prior to and during development and continued production would enhance long-term knowledge of Alaska's history and prehistory. However, cultural and paleontological resources are inherently nonrenewable. To the extent that these occur, adverse impacts may be difficult to mitigate or reclaim.

4.7.4 Visual Resources

DR&R of pads, pipeline sections, pump stations, and other facilities can provide vistas which present similar visual appearance to the undisturbed land. Airstrips might be removed, which restores the original appearance of the land or at least reduces the visual impact. Alternatively, airstrips might be maintained, permitting continued access to the area, which might benefit residents and visitors alike. The Dalton Highway will be maintained under either alternative and visual impacts are not expected to change.

Increased visitor access could result in a degradation of the wilderness quality of certain areas.

4.7.5 Socioeconomic Effects

Socioeconomic effects of selection of the preferred action alternative are mixed, but largely beneficial:

- Among the adverse impacts are potential disruptions in subsistence activity that could result from oil spills. These are believed to be short-term effects, however. Under either alternative recreational hunting and fishing are likely to increase in areas important for subsistence users. These effects can only be influenced or mitigated by resource managers and regulators.
- Obvious beneficial impacts include jobs and revenues in the short term. However, these short-term effects can have long-term consequences. The Permanent Fund, for example, could provide financial resources for citizens of Alaska long after the cessation of oil and gas production. Selection of the preferred action alternative provides additional contributions to the Permanent Fund. Moreover, prospects for gas-to-liquids (GTL) or other gas commercialization schemes could develop within the planning horizon and continue to provide benefits after the close of the ROW renewal period.

4.8 Irreversible and Irretrievable Commitment of Resources

By O.S. Goldsmith, R. Senner, M. Galginaitis, C. Gerlach, P. Bowers, C. Wooley, L.D. Maxim, and R. Niebo

4.8.1 Crude Oil and Gas

Most environmental impact statements (EISs) associated with minerals development (see, e.g., BLM and MMS, 1998; MMS, 1987a, b, 1990, 1991, 1998; USACE, 1997) note that implementation of a preferred development alternative leads to the irretrievable consumption of resources (e.g., crude oil produced as a result of the development). In this case, the amount of crude oil that is ultimately consumed (and, therefore, irretrievably committed) in the event that the proposed action is selected is numerically equal to the cumulative TAPS throughput over the period from 2004 through 2034 discussed in other sections of this report (e.g., Section 4 and Appendix A). The total crude production in the baseline throughput assumption over the years from 2004 to 2034 is approximately 7 billion bbl. For comparison, cumulative throughput of the Trans Alaska Pipeline System (TAPS) over the period from 1977 to 1998 was approximately 12.5 billion bbl.

However, it is also important to note that selection of the no-action alternative is likely to lead to virtually the same outcome, albeit for different reasons. This is because if TAPS were dismantled, then the remaining oil and perhaps gas (see below) on the Alaska North Slope (ANS) would not be economically recoverable (given present or foreseeable costs and prices) because a new pipeline would have to be constructed to transport resources to markets. The proceeds from future ANS production would have to be sufficiently large to fund construction of another pipeline and field infrastructure as well as the operating costs of the production and transportation system. The decision to redevelop ANS reserves and recreate the production and transportation infrastructure would be conceptually identical to the original decision faced by the oil industry 30 years ago. However, the quantity of the reserves would be smaller (because more than 12.5 billion bbl has already been produced) and the cost of construction of a new pipeline would be substantially greater. It is unlikely that future economic conditions would justify a decision to redevelop ANS reserves if the no-action alternative were selected. Thus, the crude oil (and possibly gas as well) would be "stranded" (physically available, but not economically viable to produce) if the no-action alternative were selected.

The key difference between the outcomes associated with the proposed and the no-action alternatives is that if TAPS continues operations, these resources will be irretrievably committed because they are consumed directly (with attendant benefits), whereas if TAPS were dismantled these resources would be irretrievably committed because economic redevelopment would not be feasible and otherwise recoverable resources would be lost. Dismantling of TAPS virtually forecloses future oil and gas development on the ANS for the foreseeable future.

What is at stake here is not only the crude oil included in the baseline throughput projection over the life of the lease, but also possible additional resources (noted in the cumulative effects discussion) that might become available in the future. For example, as part of an analysis of five National Energy Strategy (NES) oil fields (Thomas et al., 1993) it was noted that "an important factor affecting the future of these fields and all future development on the North Slope is the continued operation of TAPS." As another example, there have been numerous proposals to develop the more than 30 trillion cubic feet (tcf) of ANS natural gas (CERA, 1999a), including the El Paso System (FPC, 1976), the Alaska Natural Gas Transportation System (ANGTS) (BLM, 1976), and Yukon Pacific Corporation's Trans Alaska Gas System (TAGS) (BLM and USACE, 1988). However, aside from minor amounts of natural gas liquids (NGLs) that are blended with crude oil for transport in TAPS, this gas is not marketed. Most proposals for development of ANS gas have included the construction of one or more pipelines (and possibly marine transportation links). To date, none of these proposals has proven eco-

nomically viable, in part because of the economic barrier arising from the capital costs required to create another transportation system.

However, more recent analyses (Thomas et al., 1996) indicate that use of gas-to-liquids (GTL) conversion technology may prove economically attractive. The essential idea (refer to the discussion on cumulative effects for additional detail) is to use this technology to convert natural gas to hydrocarbon liquids and to use the existing TAPS infrastructure for transportation. Whether or not this technology proves commercially attractive, it serves as another example of a possible option that would be foregone in the event that the right-of-way of TAPS is not renewed and the pipeline dismantled. In short, there is a clear "option value" for TAPS. Closure, decommissioning, and removal of TAPS results in an irretrievable commitment of resources.

4.8.2 Physical Environment

4.8.2.1 Water Resources

Short- and long-term effects of ANS development on water resources are discussed in several EISs, including that developed for NPR-A (BLM and MMS, 1998). As noted in the NPR-A EIS,

> "construction activities that disturb stream banks or lake shorelines, temporary blockages of natural channels, and removal of gravel would cause short-term increases in erosion and sedimentation. Water removal could cause short-term changes in aquatic habitat. Permanent gravel roads and pads, airstrips, pipelines, and facilities constructed adjacent to or crossing streams and lakes would have long-term effects on water resources. Removal of these structures from streams and lakes after production ceases would restore drainage patterns and natural sedimentation processes."

Some of these same effects could result from ongoing TAPS maintenance activities.

4.8.2.2 Water Quality

Considering direct, indirect, and cumulative effects, water quality would be affected by permitted discharges from exploration, development, production and terminal operations, turbidity from offshore construction activities, and oil spills on the ANS, pipeline corridor, or Valdez Marine Terminal (VMT) areas. (These effects have been noted in several EISs, such as those prepared for NPR-A (BLM and MMS, 1998) and the Beaufort Sea Planning Area Oil and Gas Lease Sale 170 (MMS, 1998).) Additionally, thermokarst erosion along gravel roads and pads could result in degraded water quality that would last beyond the life of the fields (see, e.g., BLM and MMS, 1998). Water quality would be impacted for the duration of these activities and for some time afterward. However, there would be no irreversible or irretrievable effects on water quality if the proposed action is selected.

4.8.2.3 Air Quality

Considering direct, indirect, and cumulative effects, air quality would be affected by well drilling, construction activities, production, pipeline, and terminal operations. There would be no irreversible or irretrievable effects on air quality if the proposed action is selected.

4.8.3 Biological Environment

4.8.3.1 Vegetation

Considering direct, indirect, and cumulative effects, vegetation would be affected by well drilling, construction activities, production, pipeline, and terminal operations. Oil spills would also result in adverse, if temporary impacts. The authors of the NPR-A EIS (BLM and MMS, 1998) believe that burial of vegetation under gravel fill could produce lasting impacts and note that "the potential recovery of vegetation on these pads would take such a long time that, from a human perspective, this may be considered an irretrievable commitment of vegetation resources." However, the physical area covered by gravel fill areas is only a small fraction of the ANS area. There would be little or no irreversible or irretrievable effects on vegetation if the proposed action is selected.

4.8.3.2 Fish

Considering direct, indirect, and cumulative effects, fish could be disturbed by seismic surveys, vessel and aircraft traffic, construction and drilling activities, oil spills and/or degradation/loss of habitat from facility developments. Large oil spills, associated with ANS offshore facilities or VMT or marine transportation operations could result in greater impacts [e.g., lethal to a large portion of some near shore fish populations (MMS, 1996a, 1998)]. However, the

effects of even large spills are expected to be temporary (<7 years, see, e.g., MMS, 1996a). Fish populations are not expected to experience any irreversible and irretrievable effects if the proposed action is selected.

4.8.3.3 Birds

Considering direct, indirect, and cumulative effects, it is possible that various bird populations would be adversely affected by disturbance due to noise, movement of aircraft and vessels, and losses and/or deterioration of habitat due to facility developments. Oil spills, either on the ANS or in near the VMT could contaminate coastal wetlands (salt marshes) and other habitat and result in the loss of many thousands of birds. However, in keeping with the findings of other EISs (MMS, 1996a, 1998; BLM and MMS, 1998), these losses are not expected to be irretrievable.

4.8.3.4 Mammals

Terrestrial mammals such as caribou would be subjected to direct, indirect, and cumulative effects resulting from planned activities (e.g., noise, movement of motor vehicles, and aircraft, habitat loss caused by facility development) and inadvertent events (e.g., oil spills). In keeping with the findings of recent EISs (e.g., MMS, 1996a, 1998; BLM and MMS, 1998) it is not believed likely that permanent (irretrievable) losses will result.

Marine mammals, such as seals, walruses, polar bears, and belukha whales would be subject to direct, indirect, and cumulative effects noted in each of the above paragraphs. In keeping with the findings of recent EISs (e.g., MMS, 1996a, 1998; BLM and MMS, 1998) it is not believed likely that permanent (irretrievable) losses will result.

4.8.3.5 Endangered and Threatened Species

It is possible that bowhead whales could be subjected to direct, indirect, and cumulative effects of disturbance as a result of planned or inadvertent ANS activities. A large offshore oil spill in the Beaufort Sea (see MMS, 1996a, 1998; BLM and MMS, 1998) might result in lethal effects to a few individuals, with the population recovering within 1 to 3 years (<1 generation). It is unlikely that such effects would lead to permanent (irreversible) losses of bowhead whales.

It is also possible that Spectacled Eiders and Steller's Eiders could also be impacted. Facility siting for new ANS developments could result (BLM and MMS, 1998) in permanent (irreversible) loss of an insignificant portion of available eider-nesting habitat. Any substantial eider mortality is considered irreversible if the population status is declining as at present.

4.8.4 Social Systems

4.8.4.1 Economy

The economic benefits of the proposed action are discussed at length in other sections of this report. Following the convention established in other ANS EISs (see e.g., MMS, 1996a, 1998), it is customary to note that the commitment of human resources would be irretrievable and irreversible.

4.8.4.2 Cultural Resources

Cultural resources are nonrenewable. Oil spills and other activities have the potential to damage these resources, resulting in an irretrievable commitment of resources.

4.8.4.3 Recreational and Visual Resources

Recreational and visual resources can be adversely impacted by planned and inadvertent activities. However, upon completion of dismantling, removal, and restoration (DR&R) activities, these effects will disappear. Therefore, there is not anticipated to be any irreversible or irretrievable commitment of resources.

4.8.4.4 Subsistence Harvest Patterns

As discussed at length in Sections 3 and 4, subsistence is a key feature of the lifestyle of Alaska Natives. Disruption of subsistence harvest patterns, such as might occur with one or more large oil spills, would result in a significant negative impact. In recent EISs (see e.g., MMS, 1996a, 1998; BLM and MMS, 1998) the inability to harvest sufficient quantities of subsistence resources is viewed as an irreversible and irretrievable effect. This said, the analyses presented in this report conclude that such disruptions would be temporary, rather than permanent, if the proposed action were selected.

4.8.4.5 Sociocultural Systems

The direct, indirect, and cumulative effects of the proposed action are discussed at length in the section on cumulative effects. There it is argued that social changes — some adverse and others beneficial — are taking place which may have irreversible and irretrievable effects. However, ANS oil development is only one of many causes of these social changes. Perhaps more to the point, selection of the no-action alternative will probably not prevent additional social changes from occurring. Indeed, selection of the no-action alternative is certain to create significant and adverse economic — and social — effects.

4.8.5 Resources Used in Construction and Operations

The construction and operation of TAPS required large amounts of pipe, gravel, fuel, etc. These materials are essentially gone because the majority will not be salvaged during DR&R. During DR&R, gravel will not be recovered and only a small portion of the pipe will be salvaged. Relatively small amounts of pipe and gravel will be used in the future and these too will be irretrievably committed.

4.9 Energy Requirements and Conservation Potential

By L.D. Maxim

This section provides information on the energy requirements of the TAPS and the associated marine transportation link. Comparative data on energy efficiency are provided for other modes of transportation.

4.9.1 TAPS Energy Usage

TAPS carries oil from Pump Station 1 on the edge of the Alaska North Slope (ANS) oil fields south some 800 miles to Valdez. The system requires energy to run the pump stations along the pipeline, support Valdez Marine Terminal (VMT) operations, and for miscellaneous other activities/functions (e.g., lighting, heat, air conditioning, other machinery). Two major energy sources are used for TAPS:

- Fuel gas is carried from North Slope fields to fuel pump stations (Pump Stations 1 through 4) north of the Brooks Range. The fuel gas is transported in a 149-mile long fuel gas line of varying diameter (between 8 and 10 inches).
- Liquid turbine fuel is used to fuel pump stations south of the Brooks Range and to power electrical generators at various places in the system (including those at pump stations and VMT). The liquid turbine fuel is purchased from commercial fuel vendors and delivered in tank trucks.[1] (A small amount of commercial electrical power is purchased at Pump Stations 8, 9, and 12.)[2]

TAPS pioneered the use of drag reducing agent (DRA — a long-chain hydrocarbon polymer injected into the oil to reduce the energy loss due to turbulence in the oil), having first injected DRA at Pump Station 1 on 1 July 1979 (APSC, 1999c). DRA injection facilities are located at Pump Stations 7 and 9, and at Milepost 238 (see Section 2.2). As the name implies, use of DRA reduces the drag, permitting more oil throughput at any given pumping horsepower. Thus, use of DRA conserves energy. The amount (and location) of DRA to be injected is determined by an economic balance between the cost of the DRA and the cost of operating pump stations.

In 1999 (Johnson, J., 2000, pers. comm.), Alyeska Pipeline Service Company (APSC) consumed 7.776 billion standard cubic feet (scf) of fuel gas, purchased 46 million gallons of turbine fuel, and 0.585 million gallons of DRA.

4.9.2 Energy Intensity

Based on the above energy usage figures and traffic, the estimated *energy intensity*, measured in British Thermal Units per ton-mile of crude oil transported (BTU/ton-m)— a standard benchmark used to measure the energy intensity of freight transport — for TAPS was approximately 280 BTU/ton-m, as shown in the calculation detailed in Table 4.9-1. (Data on the heat content of various fuels can be found in ORNL, 1999).

Figure 4.9-1 shows the average energy intensity for various modes of freight transport (ORNL, 1999) in the United States in 1997, including crude and product pipelines, waterborne commerce, Class 1 railroads, and motor freight. Crude oil is shipped by all these transportation modes in the United States. Figure 4.9-2 shows the relative shares (in ton-miles) of crude and refined products carried by each mode over the period from 1977 to 1997 (Association of Oil Pipelines, 1999). In 1997, the respective modal shares were pipeline (64.45 percent);[3] water carrier (30.90 percent); truck (2.90 percent); and rail (1.75 percent). As a practical matter, most crude and product shipments are made via pipeline and ship or tug and barge.

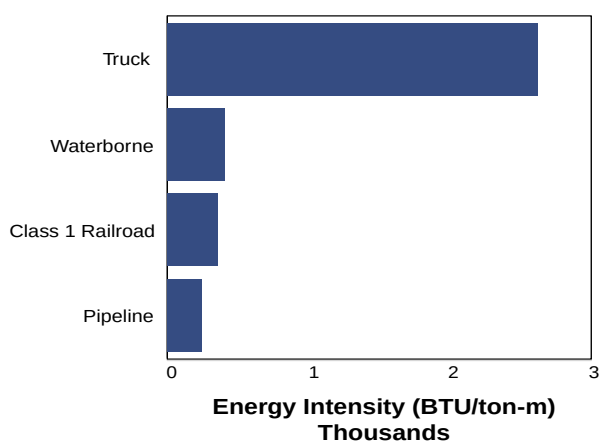
[1] At one time *topping units* were used. A topping unit is a mini-refinery that draws crude off the line and produces turbine fuel to power the pump station. Topping units were used at Pump Stations 6, 8, and 10, but all were placed in standby during 1996 (PS 8, 10) or 1997 (PS 6).

[2] Pump Stations 1, 3, 4, 7, 9, and 12 are presently in operation. As part of the rampdown plan (see Section 2.2) several of these pump stations will be shut down in the coming years.

[3] For crude oil shipments, 69.3 percent of the total ton-miles was carried in pipelines, 30.3 percent by water carriers, 0.3 percent by motor carriers, and only 0.1 percent by rail.

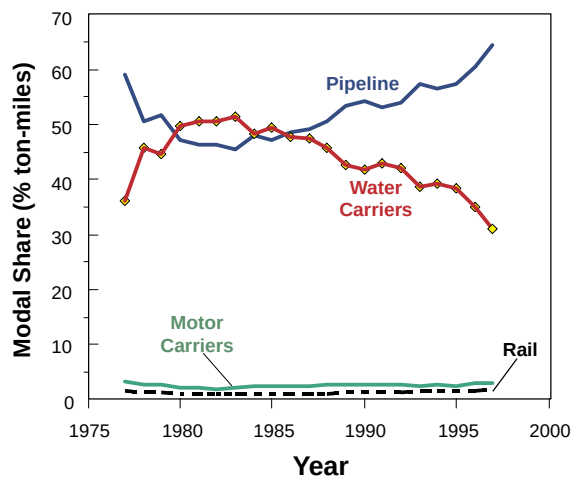
Table 4.9-1. *Energy intensity, BTU/ton-m for TAPS, 1999.*

Item	Units	Value	Source
Fuel gas consumption	scf	$7.776 \times 10^{+9}$	Alyeska for year 1999
Heat content natural gas	BTU/scf	1,031	ORNL (1999, Table B-1)
Gas energy input	BTU	$8.017 \times 10^{+12}$	Multiplication
Turbine fuel usage	gal	$4.60 \times 10^{+7}$	Alyeska for year 1999
Heat content crude	BTU/gal	$1.318 \times 10^{+5}$	ORNL (1999, Table B-1)
Crude energy input	BTU	$6.063 \times 10^{+12}$	Multiplication
Annual throughput	bbl	$4.4 \times 10^{+8}$	Alyeska for year 1999
Unit conversion	bbl/ton	$7.0 \times 10^{+0}$	APSC (1999c)
Annual throughput	tons	$6.3 \times 10^{+7}$	Division
Average haul distance	miles	800	TAPS length, neglects minor offtakes
Annual traffic	ton-m	$5.0 \times 10^{+10}$	Product of annual throughput (tons) and haul distance
Energy consumption	BTU/ton-m	160	Gas
Energy consumption	BTU/ton-m	121	Turbine fuel
Energy consumption	BTU/ton-m	81	Total



Source: ORNL (1990, Table 2-13)

Figure 4.9-1. *Energy intensity for freight shipments, 1997. Crude oil and product pipelines are relatively efficient.*



Source: Association of Oil Pipelines (1999)

Figure 4.9-2. *Crude oil and product shipments in the United States by mode. Pipelines have the largest share (percent of ton-miles).*

As shown in Figure 4.9-1, pipelines are relatively energy efficient when compared to other transportation modes, a finding confirmed by several studies (Hooker, 1981, 1982; Kennedy, 1993; ORNL, various; DOT, 1994).

Considering only pipelines, energy efficiency is a complex function of throughput, capacity, elevation gradient along the pipeline, pipeline diameter, use of DRA, crude or product viscosity and density, temperature and temperature gradient, type of pumps (e.g., electric versus turbine), and other factors (Hooker, 1981, 1982; Kennedy, 1993; Uren, 1953; Cookenboo, 1955). For example, other factors held constant, energy intensity is lower (i.e., the pipeline is *more* energy efficient) the greater the diameter of the pipeline.[4] TAPS is a large diameter pipeline, but employs turbines rather than electric pump motors, crosses three mountain ranges and is presently operated well beneath capacity. Overall, the energy intensity for TAPS in 1999 (280 BTU/

[4]Kennedy (1993) reports that energy consumption for crude oil ranges from about 550 BTU/ton-mile for a 6-inch-diameter pipeline to about 180 BTU/ton-mile for a 40-inch-dameter pipeline.

ton-m) is comparable to that for the average of domestic crude and product pipelines (300 BTU/ton-m).[5]

4.9.3 Marine Transportation

No discussion of TAPS energy efficiency would be complete without mention of the marine transportation link. Although a small amount of North Slope oil is exported to Asian ports, the majority is shipped from VMT to ports on the U.S. West Coast and Hawaii. Illustrative haul distances for ANS crude are: Valdez to Port Angeles, WA, 1,200 nautical miles; Valdez to Long Beach, CA, 2074 nautical miles; Valdez to Barber's Point, HI, 3,421 nautical miles.

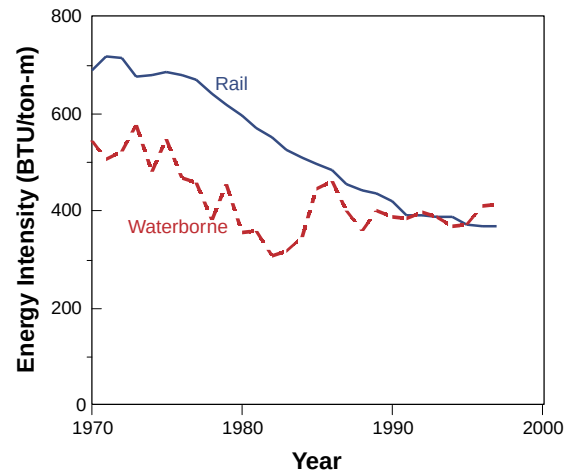
Data on the energy intensity (BTU/ton-m) of waterborne commerce in the United States are readily available (e.g., DOT, 1994; ORNL, various). For example, Figure 4.9-3 shows the time trend in energy intensity for both rail and waterborne commerce from 1970 to 1997. Although the time series for waterborne commerce is more variable than that for railroads, both modes have become more energy efficient over this period. In 1997, the energy intensity for domestic waterborne commerce averaged approximately 415 BTU/ton-m, slightly less efficient than that for pipelines generally or for TAPS in particular.

One difficulty with the data shown in Figure 4.9-3 is that these are year-to-year averages for all waterborne commerce, including the contribution of oceangoing tankers, coastal tankers, integrated tank barges (ITB), and various tug-barge combinations, carrying both crude and product. These energy intensity averages are not likely to be representative of the energy efficiency of vessels engaged in the ANS trade. Just as there are economies of scale with respect to capital and operating costs of tankers (see, e.g., NRC, 1991, 1998), so too are there economies of scale with respect to energy intensity (USDOE, 1994). Tankers engaged in the ANS trade are larger on average than those engaged in product shipping.

However, there is no readily available statistical compilation of energy efficiency data for vessels engaged in the ANS trade. Accordingly, a series of calculations is made to provide a plausible range of estimates. Table 4.9-2 contains two sets of calculations of energy intensity of tankers of various sizes:

- Table 4.9-2a presents estimates of cruising speed and fuel consumption for double-hull tankers of three sizes taken from an earlier NRC study (NRC, 1991). Calculated energy intensities based on these estimates range from 35 BTU/ton-m to 67 BTU/ton-m. As expected, larger tankers are more energy efficient.
- Table 4.9-2b presents estimates of cruising speed and fuel consumption for the same size tankers as given in Table 4.9-2a based on a 1994 Department of Energy study on the effects of lifting the export ban on ANS crude (USDOE, 1994). This study was based upon actual data supplied by experts from the U.S. Maritime Administration (MARAD). Calculated energy intensities based upon these estimates range from 74 BTU/ton-m to 202 BTU/ton-m, depending upon tanker size. In accord with the results given in Table 4.9-2a, larger tankers are more energy efficient.

Data on cruising speed and fuel consumption are presented for the 120,357 deadweight ton (DWT) *Arco Anchorage* (one of the vessels in the ANS trade) in one recent book (Nadler, 1994). Based on a quoted fuel burn rate of 31,000 gallons/day and a cruise speed of 16 knots for this steam turbine-powered ship, an energy intensity of 81 BTU/



Source: ORNL (1999).

Figure 4.9-3. *Time trends in energy intensity (BTU/ton-m) for rail and waterborne commerce.*

[5]According to data from ORNL, the estimated energy intensity for crude and product pipelines in 1997 was 252 BTU/ton-m. Although estimates of energy intensity are calculated for each year by ORNL, the time series is not useful because no recent data are available on total energy consumption of crude and product pipelines. Therefore, ORNL (Davis, 2000, pers. comm.) simply assumes that total energy consumption of these pipelines is the same as that estimated years ago and calculates energy intensity by dividing this consumption estimate by the ton-m of crude and product traffic. The most recent independent estimate of energy intensity was made in the early 1980s (Hooker, 1981, 1982; Kennedy, 1993; DOT, 1994) and was approximately 300 BTU/ton-m on average.

Table 4.9-2a. *Calculation of energy intensity for oil tankers based on data published by the National Research Council.*

Item	Units	Value			Source/Remarks
Vessel DWT	tons	40,000	80,000	240,000	NRC (1991) for double-hull tanker
Fuel consumption	tons/day	25	45	75	NRC (1991) for double-hull tanker
Fuel heat content	BTU/gal	138,400	138,400	138,400	ORNL (1999, Table B.1)
Fuel heat content	BTU/ton	$4.4645 \times 10^{+7}$	$4.4645 \times 10^{+7}$	$4.4645 \times 10^{+7}$	Conversion
Fuel input	BTU/day	$1.1161 \times 10^{+9}$	$2.0090 \times 10^{+9}$	$3.3484 \times 10^{+9}$	Fuel consumption times heat content
Speed average	knots	15	15	14.6	NRC (1991) for double-hull tanker
Statute miles/day	miles/day	414	414	403	Conversion
Traffic	ton-m/day	$1.66 \times 10^{+7}$	$3.31 \times 10^{+7}$	$9.67 \times 10^{+7}$	DWT times daily advance
Energy intensity	BTU/ton-m	67	61	35	Calculation

Table 4.9-2b. *Calculation of energy intensity for oil tankers based on data published by the U.S. Department of Energy.*

Item	Units	Value			Source/Remarks
Vessel DWT	tons	40,000	80,000	240,000	NRC (1991) for double-hull tanker
Fuel rate	$/sea day	5,625	5,625	12,000	USDOE (1994)
Fuel cost	$75/metric ton	75	75	75	USDOE (1994)
Fuel consumption	tons/day	75	75	160	Calculation
Fuel heat content	BTU/gal	138,400	138,400	138,400	ORNL (1999, Table B.1)
Fuel heat content	BTU/ton	$4.4645 \times 10^{+7}$	$4.4645 \times 10^{+7}$	$4.4645 \times 10^{+7}$	Conversion
Fuel input	BTU/day	$3.3484 \times 10^{+9}$	$3.3484 \times 10^{+9}$	$7.1432 \times 10^{+9}$	Fuel consumption times heat content
Speed average	knots	15	15	14.6	NRC (1991) for double-hull tanker
Statute miles/day	miles/day	414	414	403	Conversion
Traffic	ton-m/day	$1.66 \times 10^{+7}$	$3.31 \times 10^{+7}$	$9.67 \times 10^{+7}$	DWT times daily advance
Energy intensity	BTU/ton-m	202	101	74	Calculation

Table 4.9-3. *Energy requirements as percentage of energy shipped (based on one ton of crude transported).*

Item	Units	Value	Source/Remarks
Throughput	tons crude	1	Basis for calculation
Heat content	BTU/gal	131,800	ORNL (1999, Table B-1)
Unit conversion	gal/bbl	42	APSC (1999c)
Unit conversion	bbl/ton	7.07	APSC (1999c)
Heat content	BTU	39,136,692	Heat content of crude shipped
Pipeline energy intensity	BTU/ton-m	280	TAPS estimate
Land haul distance	statute miles	800	TAPS length
Pipeline energy required	BTU	224,000	Product of energy intensity, load, and length
Marine transport energy intensity	BTU/ton-m	80	Midpoint of range given in text
Haul distance	NM	2,074	Valdez to Long Beach, CA
Haul distance	statute miles	2,385	Unit conversion
Tanker energy required	BTU	190,808	Product of energy intensity, load, and length
Total energy required	BTU	414,808	Sum of pipeline and tanker transportation
Required as percentage of load	%	1.06	Total energy required divided by heat content of crude

ton-m can be calculated. Estimates based on information from these various sources are not identical, but all point to energy intensities less than 100 BTU/ton-m,[6] approximately four times as efficient as the value estimated for all waterborne commerce. Thus, onward ocean shipping from VMT is assumed to have an energy requirement ranging from 60 BTU/ton-m to 100 BTU/ton-m.

4.9.4 Synthesis

The energy requirements for shipping crude along the pipeline average 280 BTU/ton-m in 1999. Onward shipment of ANS crude from VMT to U.S. West Coast ports probably requires between 60 BTU/ton-m and 100 BTU/ton-m.

Table 4.9-3 provides an illustrative calculation of the energy required to ship one ton of crude oil the length of the TAPS pipeline and then onward via tanker from Valdez, AK, to Long Beach, CA (nearly 2,400 statute miles distant). The energy intensity assumed for the pipeline is 280 BTU/ton-m and for that ocean transit the midpoint of the range of estimates provided above, 80 BTU/ton-m. This trip would require 414,808 BTU, approximately 1.06 percent of the energy contained in one ton of crude. Thus, the energy penalty for transportation is quite small.

For the proposed action, future energy requirements are likely to be similar to those in the recent past. TAPS operators have a strong economic incentive to conserve energy. In the past, TAPS operators implemented DRAs to minimize the amount of energy spent on moving the oil through the pipeline. When throughput decreased, pump stations that were no longer necessary were shut down. Due to the economic incentive, fuel conservation strategies will continue in the future.

For the no-action alternative, the ANS fields, pipeline, and marine transportation system would be shut down and dismantled. Additional oil would have to be imported from foreign sources to make up for the shortfall caused by cessation of ANS production (unless a national conservation policy is implemented to reduce consumption). Energy requirements of the TAPS pipeline and the marine transportation link would be reduced to zero. However, energy would still be required to supply incremental foreign imports. Transportation energy requirements would vary depending upon the origin of these incremental crude oil imports. Transportation energy requirements are unlikely to be appreciably smaller than those at present. TAPS energy efficiency is approximately equal to the average for domestic pipelines, as are marine transportation efficiencies.

[6]The calculated range is 35 BTU/ton-m to 202 BTU/ton-m. However, the average size tanker engaged in the ANS trade is close to 120,000 DWT.

4.10 Environmental Justice

By L.D. Maxim

4.10.1 Proposed Action

Executive Order 12898 signed by President Clinton on February 11, 1994, requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects of its actions on minority populations and low-income populations in the United States and its possessions (Executive Order 12898, 1994). The purpose of this Executive Order is to promote fair treatment of all races and the poor so that no one demographic group suffers adverse environmental impacts disproportionately. Section 4-4 of EO 12898 directs federal agencies, whenever practicable and appropriate to collect, maintain, and analyze information patterns of populations who principally rely on fish and/or wildlife for subsistence. Section 6-606 of this order specifically notes that federal agency responsibilities shall apply equally to Native American programs. This topic has been addressed in recent EISs (e.g., BLM and MMS 1998; USACE, 1999).

Some of the potential environmental impacts of both the proposed and the no-action alternatives raise environmental justice issues. Subsistence users, including Alaska Native and rural residents who principally rely on subsistence could be disproportionately affected as a result of adverse impacts on subsistence that might occur from oil spills if the proposed action is selected. Such adverse impacts would be temporary and could be partially offset by wage income from spill cleanup activities. Moreover, the Trans Alaska Pipeline Authorization Act established strict liability (except in cases where damages are caused by an act of war or negligence of the United States, other government entity, or the damaged party) for all damages [Section 1653 (a)(1)] in connection with or resulting from activities along or in the vicinity of the ROW. Other laws (e.g., OPA 90) also address liability and/or the establishment of funds to pay claims for spills associated with the production and/or transportation of oil. For example, under OPA 90, responsible parties are responsible for removal costs and damages (including damage for loss of subsistence use of natural resources) [OPA 90, Section 2702 (a),(b)]. In the past (e.g., in the case of EVOS), subsistence users have been compensated for the monetary value of lost subsistence harvest.

4.10.2 No-Action Alternative

The no-action alternative also raises environmental justice issues. These are linked to economic impacts and, in particular, the effects of revenue reductions on the various social programs of state and local government. Funds from North Slope developments provide for health care and education of many Alaska Natives; these funds would be sharply reduced in the event that the no-action alternative was selected. Employment losses might also have an environmental justice component because, although Alaska Natives are not employed in large numbers by the oil industry, the effective shutdown of this industry in Alaska would eliminate the future benefits of Alyeska's Section 29 initiatives and also because government is a large employer of Alaska Natives in certain geographic areas such as in the North Slope Borough. (Under Section 29 of the Federal Agreement and Grant of Right-of-Way, Alyeska is committed to hiring Alaska Natives.)

As noted in Section 4.4, the sharp reduction in state revenues that would occur under the no-action alternative is assumed to trigger elimination of the Permanent Fund Dividend. This dividend is provided to all eligible persons, regardless of income. Elimination of this dividend would have proportionately greater adverse impacts on large, low-income families.

Because this dividend is a flat sum given to all eligible residents, the proportional significance of the dividend is greatest for large, low-income families. Alaska Natives, among others, would be disproportionately affected. Iñupiat households have lower average incomes than non-Iñupiat households for most villages and for the NSB as a whole. Iñupiat households also have a larger number of persons on average than non-Iñupiat households (NSB,

1999). Thus, elimination of the Permanent Fund Dividend (PFD) would have a disproportionate impact on Iñupiats on the North Slope.

Other environmental justice issues associated with the selection of the no-action alternative are the adverse impacts on Native corporations. For example, the Arctic Slope Regional Corporation (ASRC) is one of the largest private businesses in Alaska. ASRC derives revenues from outright ownership or joint venture arrangements with oil industry and oil-field service companies, engineering, and construction firms. ASRC owns the subsurface resources underlying Kuukpik surface lands (USACE, 1997). If commercial quantities of oil and gas are discovered and produced from those lands, the principal economic beneficiary would be ASRC. Many residents of the North Slope are also shareholders in ASRC and would be adversely affected if its revenues were to decline.

4.10.3 Cumulative Effects

Some of the potential cumulative effects associated with the proposed action have implications for "environmental justice," because they may have disproportionate impacts on particular demographic subgroups. Some of these effects are beneficial. For example, the PFD, which is funded by oil and gas revenues, is distributed to all Alaskans who satisfy residency and other minimal requirements. The impact of the PFD on household income is proportionately greater for larger families and for low-income families. Other effects of oil and gas development may have disproportionately adverse consequences. For example, an oil spill could disrupt subsistence harvests, with the potential to have greater impacts on low-income and/or minority families.

4.11 Impact on Sacred Sites

By ClearWater Environmental, Inc. staff

No known Alaska Native sacred sites (Executive Order 13007, 1996) in the study area have been directly impacted by TAPS construction and operation. Some adjacent localities, such as an area near Stevens Village, may be considered sacred by local residents because of the birth of ancestral tribal chiefs and other important tribal leaders. One example of an area that may be claimed as sacred is the mouth of the Dall River, called Ch'edohno' ("the river that sustains life," or "the river that saves people from starvation") in the Koyukon Athabaskan language. Village land-use planning documents state that sites in this area (4.5 miles downstream from Stevens Village) have been vandalized through recreational hunting and fishing activities (Stevens Village Council, 1999).

Mitigation of any impacts from TAPS could be accomplished through the Section 106 process already in place for identification, evaluation, and mitigation of historic and traditional cultural properties. Consultation with affected Alaska Native groups would be an integral part of the process (36 CFR 800).

4.12 Invasive Species

By B. Haley, D. Funk, and J. McKendrick

4.12.1 Tanker Traffic

In 1998, the Smithsonian Environmental Research Center coordinated a study to assess the invasion of nonindigenous species associated with oil tanker traffic (particularly management of water ballast) in Prince William Sound (Hines and Ruiz, 2000). Tankers in Port Valdez released 17,000,000 m^3 of segregated (non-oily) ballast water in 1998 — the third largest volume in any U.S. port. Most of the segregated ballast water (96 percent) released in Valdez comes from domestic ports. Of the domestic arrivals, 82.7 percent were from the ports of Puget Sound, San Francisco and Long Beach. Domestic tankers offload their ballast directly into Prince William Sound, whereas foreign tankers replace their coastal ballast water with an open-ocean exchange before they arrive.

On average, the total density of organisms was greater (10 and 100 times greater) in segregated ballast water from domestic ports compared to foreign arrivals. Total density of organisms in the ballast water decreased with increased travel duration. Fourteen nonindigenous species were identified in segregated ballast water in oil tankers arriving in Port Valdez. However, this is probably an underestimate because only a subset of the plankton can be identified to species and only the largest planktonic organisms were included in the analysis. All of the identified nonindigenous species were in ballast water from San Francisco Bay and Long Beach. These organisms have a high potential of initial survival in the seasonal cycles of salinity and temperature in Port Valdez.

A total of 15 nonindigenous species have been recorded in Prince William Sound. The majority of the species appear to be associated with boat harbors and aquaculture activities. Although several nonindigenous species are found in ballast water arriving in Port Valdez, none is clearly associated with ballast water of oil tankers as a primary means of introduction. Other means of transport were recognized in the study. Some tanker hulls carried fouling organisms and bottom dwellers that were introduced with sediment drawn into the hold during ballasting.

4.12.2 Revegetation

Commercial grasses used for revegetation will introduce new or exotic species. This direct effect of revegetation almost always occurs and will very likely follow any seeding conducted to reduce the potential for erosion. The introduction of exotic plants with seed application, however, has been reduced as greater quality-control measures have been developed for producing seed mixtures for construction sites in arctic and subarctic environments. The result of introducing exotics on the North Slope and along the TAPS ROW has usually been benign and has not led to large-scale replacement of indigenous plant species.

Studies of the presence and distribution of introduced weed species along the TAPS ROW are discussed in detail in Section 4.3.2.2. As discussed there, most exotic species found were seeded grasses, with broad-leaved weeds (forbs) more common in the Interior south of TAPS MP 250. The numbers of exotic species were higher near human settlement, suggesting that introductions on the ROW were related to various human activities in the area and not just to revegetation.

Seeding the ROW with grasses — and other disturbances — may interfere with the recovery of natural vegetation on such sites. Generally, invasion by native plants was greater in locations where seeded grasses did not persist. Seeded indigenous gramminoids can also dominate open ground and prevent other species from recolonizing. Ideally, species used in revegetation to control erosion will establish easily but will be short-lived or poorly adapted to the environment and thus not compete with indigenous species.

4.13 Impact on Wetlands

By J. McKendrick, D. Funk, T. Jorgenson, and J. Kidd

4.13.1 Vegetation and Wetlands

Section 4.3.2.2 discusses impact to wetlands from the proposed action of a 30-year renewal of the TAPS ROW. The following is excerpted from that section.

Loss of wetlands associated with the TAPS ROW can occur as a result of pipeline replacement, pipeline reroutes, workpad maintenance and construction, and the development of material sites (JMM, 1990). Loss is primarily due to the placement of fill, but also may occur from dredging and excavation of wetlands or oil spills. Wetland loss from pipeline replacement and workpad construction typically occurs within the ROW, whereas pipeline reroutes, material sites, and oil spills also may include wetlands outside the ROW.

Only three pipeline replacements/reroutes have occurred along the TAPS ROW since startup: Dietrich River (1985), Atigun Pass (1987), and Atigun River (1991). The frequency of pipeline replacements/reroutes is expected to continue to be rare for the next 30 years because of advancements in pipeline integrity monitoring. No data are currently available for the area of wetlands that were affected at the Dietrich River and Atigun Pass sites, but less than 1 mile (1.2 km) of pipeline was involved for both of these projects (Section 4.1). Assuming a mean construction width of 80 ft (24 m), a maximum of 7 acres (15.4 ha) would have been effected for both sites if the two project areas included only wetlands. The pipeline replacement at Atigun Pass in the Brooks Range affected up to 11.9 acres (26.18 ha) (JMM, 1990). The losses were attributable to work pad, trench, and access road construction.

The development of material sites was one of the greatest impacts to wetlands, mostly riverine and palustrine, during pipeline construction, because many of the borrow pits were located in floodplains (Pamplin, 1979). During construction, the Joint State/Federal Fish and Wildlife Advisory Team found numerous problems associated with the selection and development of several TAPS borrow sites (Burger and Swenson, 1977). The most common problems included alteration of hydrology and increased siltation, but the loss of riparian habitat also occurred.

Because future maintenance of the ROW is not expected to require frequent pipeline replacements or reroutes, wetland losses should be minimal. The development of new borrow sites is expected to be limited as large volumes of gravel fill will not be needed for future ROW maintenance activities.

The alteration of wetland habitats along the TAPS ROW can occur from de-watering, water impoundment, thin gravel fill or dust outfall, compaction, and contamination from oil spills. Natural occurrences such as stream migration or erosion can also impact wetland habitat. No surveys of wetland alteration have been conducted along the ROW, but studies in the Prudhoe and Kuparuk oil fields (Walker, Cate et al., 1987; Kertell, 1993) found localized impacts to wetlands. It is reasonable to expect similar impacts from structures or activities that occur along the ROW.

Wetlands may be enhanced in areas adjacent to roads and pads where soil temperatures are higher and water impoundments have formed. Impoundments alter both the hydrology and species composition of wetlands. Plant productivity may increase biomass in a few species, or productivity may decrease as plants are lost to the development of deep open-water areas. In most cases, impoundments lead to a decrease in plant species richness (Klinger et al., 1983; Walker, Cate et al., 1987).

Hydrocarbon spills affect wetland communities by physically covering and killing vegetation, creating toxic soil conditions (Haag and Bliss, 1973; Deneke et al., 1974; Brown, J. and Grave, 1979; Jorgenson and Cater, 1996; Everett, 1978) and increasing the depth of the active layer in permafrost soils (Brown, J. and Grave, 1979; Lawson, D.E. et al., 1978). The effects of oil spills on vegetation are detailed under a separate heading in this section.

4.13.2 No-Action Alternative

Section 4.4.4.2 discusses wetland impacts from the no-action alternative. The following is from that discussion.

Impact to wetlands from DR&R should be minimal, although impoundments associated with workpads are likely to persist unless efforts to breach them are made. Since culverts will be converted to low-water crossings, any sedimentation or erosion should be minimized. It is possible that permafrost areas covered with fine-grained soils could be restored to wetlands over the long term by thermokarst, but the process would likely take several decades.