Environmental Impact of 25 Years of Trans-Alaska Pipeline Operation

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Abstract

In 2001, the Trans Alaska Pipeline System (TAPS) owners produced a comprehensive analysis of the impacts associated with the renewal of the TAPS rights-of-way. The resulting report, *Environmental Report for the Trans Alaska Pipeline System Right-of-Way Renewal*, (TAPS Owners, 2001) described the physical, biological, and socio-economic impacts of right-of-way renewal — and of non-renewal. The Environmental Report followed the guidelines of the Council on Environmental Quality for preparing environmental impact statements (EISs). Since projections of future impact of TAPS operation closely follow post-construction impacts since 1977, an assessment of the impact of 25 years of operation of a warm oil pipeline in cold regions can be described. This paper reviews the results of the report with special emphasis on physical impacts.

Because the pipeline system has been in continuous operation since 1977 and is under stringent regulatory controls, its effects on the physical environment — terrestrial, air quality, and water quality — are known to be relatively minor and can reasonably be expected to continue without significant change. Justification for predictions of low impact 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;
- 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 extent technically feasible;
- Declining throughput could result in lower emissions and discharges affecting air and water quality.

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Introduction

In 2001, the Trans Alaska Pipeline System (TAPS) owners produced a comprehensive analysis of the impacts associated with the renewal of the TAPS rights-of-way (ROW). The resulting report, *Environmental Report for the Trans Alaska Pipeline System Right-of-Way Renewal*, describes the physical, biological, and socio-economic impacts of right-of-way renewal — and of non-renewal.

The proposed action (right-of-way renewal), considered in the Environmental Report is unusual in that the action does not involve construction of a project but rather its continued existence and operation. As a result, the report describes the affected environment as it now exists following construction and 25 years of operation of TAPS. That report is based on a review of TAPS operational impacts to date and forms the basis for this paper.

Background

The trans-Alaska pipeline is an 800-mile (1288 km), 48-inch (1.2 m) diameter crude oil pipeline that is elevated above ground for 420 miles (676 km) of its length and buried for the other 380 miles (612 km). Eleven pump stations were built to move the oil through the pipeline, and four of these are now on operational standby. The marine terminal at Valdez has storage facilities for over 9 million barrels of oil and four tanker-loading berths. The peak average daily throughput of 2.03 millions barrels per day was reached in 1988. The current rate is approximately 1 million barrels per day.

TAPS is unique among pipelines both for its engineering achievements and for the public controversy generated at the time it was originally proposed. Debates surrounding land claims by Alaska Natives and preparation of an Environmental Impact Statement (EIS) under the newly enacted National Environmental Policy Act (NEPA) delayed construction from 1969 until 1974.

The Department of the Interior released a 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. These federal and state rights-of-way, issued in 1974 for 30-year terms, expire in 2004. The TAPS Owners' application for renewal of these federal and state rights-of-way seeks the maximum duration for the renewals, 30 years.

Summary of Environmental Consequences of TAPS ROW Renewal

Most environmental assessments and EISs deal largely or exclusively with future projects. The principal focus of the analysis in the Environmental Report is the continuation of a system that has been in operation since 1977. Years of operations data and experience with TAPS allowed for the development of accurate estimates of future effects. The following sections summarize the effects predicted for renewal and non-renewal of the TAPS ROW.

Effects of Continuing TAPS Operations until 2034

The renewal of TAPS ROW agreements 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

Because the pipeline system has been in continuous operation since 1977 and is under stringent regulatory controls, its effects on the physical environment — terrestrial, air quality, and water quality — are known to be relatively minor and can reasonably be expected to continue without significant change under the proposed action. Justification for predictions of low impacts 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 right-of-way 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;
- Declining throughput will result in lower emissions and discharges affecting air and water quality.

Biological Resources

Biological resources potentially affected by continued TAPS operation include vegetation and wetlands, fish, birds, and terrestrial and marine mammals. The ecosystems affected by the operation of TAPS and associated activity for almost 25 years are healthy. With the exception of very limited local impacts, the vegetation, fish, and wildlife along TAPS have not been impacted at the resource population level. TAPS, as it exists today, is simply another feature on the landscape, to which the flora and fauna have habituated. Even Alaska's North Slope, 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. 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 toxicity from residual oil, populations are generally recovered or recovering. In all three areas — the TAPS right-of-way, the Alaska North Slope, 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.

Social Systems

The renewal of the TAPS right-of-way will provide the opportunity to produce an additional estimated 7 billion barrels of oil from the existing North Slope oil fields and will increase the likelihood of commercializing some 30 trillion cubic feet of currently "stranded" natural gas. It will also result in great economic benefits for the

U.S., the state of Alaska, local governments, and residents of Alaska. Because TAPS transports a significant portion of the oil produced in the U.S., TAPS' continued operation will reduce the U.S. balance-of-trade deficit by an estimated $112 billion dollars during the renewal period. (This projection does not include potential gas commercialization and is based on a low oil price of $16 per barrel.) Employment opportunities will be enhanced. 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 TAPS Ship Escort/Response Vessel System and the phase-in of double-hull tankers greatly reduce the risk of such an event.

Effects of Closing TAPS after 2004

The no-action alternative involves the termination 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 Alaska North Slope oil production. Following is a summary of the physical, biological, and social effects of the no-action alternative.

Physical Characteristics

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

Biological Resources

As long as there are mitigation and prevention measures, 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. The ecosystems along TAPS, on the North Slope, and in Prince William Sound have fared well during the last 25 years of oil-industry operations. With the exception of some disturbance during the DR&R period, the environment 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. However, it is also possible that the human population (and fish and wildlife harvests) will decrease in response to the economic decline.

Social Systems

Non-renewal of the TAPS right-of-way would have devastating effects on the economy of Alaska and would significantly impact the U.S. balance of trade. The opportunity to produce additional oil from the North Slope oil fields will be eliminated, and the U.S. balance-of-trade deficit would increase by an estimated $112 billion dollars between 2004 and 2034. The likelihood of commercializing North Slope natural gas 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.

Physical Effects of Continued TAPS Operation

The remainder of this paper provides additional summary emphasis on physical effects of TAPS operation on the terrestrial, water, and air environments. In this way the impact of 25 years of operation can be assessed.

Soils and Permafrost. 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 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.

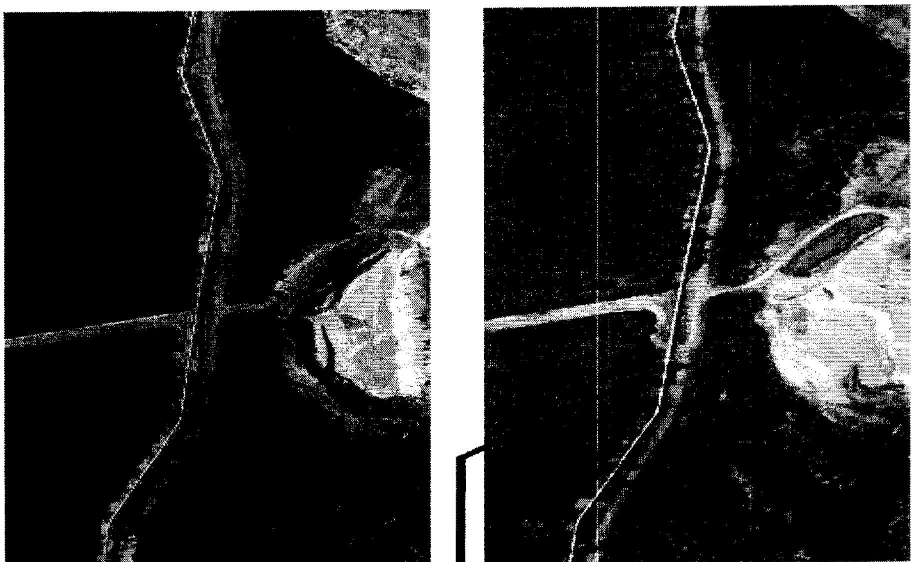
With respect to soils and permafrost, the impacts of continued TAPS operation are minimal. Most of the thermal impacts have already occurred or are significantly slowing. Continued monitoring and maintenance will identify and repair any areas where settlement or heave may exceed operational standards.

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 some permafrost areas 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. 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. This is especially evident in areas of above ground pipeline mode (Photo 1).

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. 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. In the future, localized repairs will likely be necessary. VSM movements have generally been mitigated by adjusting and providing uniform support to the pipe, adding free-standing heat pipes, and using other techniques such as applying wood chips to insulate the workpad.



7/3/82 *Photo 1* - Depressions caused by thawing permafrost between bends 6/8/92

Monitoring programs report that about 200 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 aboveground pipeline support system. Many of these VSMs are on slopes in marginal permafrost areas and may have to be replaced with longer VSMs installed to a greater depth. All of these impacts have been, and will continue to be, mitigated through Alyeska's routine monitoring and maintenance program.

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 at milepost (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 pipeline 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.

Rivers and Floodplains

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 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 trenches during the first year due to the voids created by thawing of frozen backfill. With the first moderate to high flow during spring runoff or rainfall, the natural bedload 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.

Water Resources

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. Each active pump station typically consumes between 4,500 and 7,500 gallons per day, mostly for domestic uses.

The Valdez Marine Terminal (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, 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 PS 1, for tank cleaning and testing at Pump Station 1.

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.

Water Use and Sanitary Discharge at Pump Stations. 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.

At Pump Stations 1, 3, and 4 wastewater is disposed by injecting it into the exhaust stacks of the pump turbines. This means of disposal 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 hauling wastewater or by on-site package treatment plants.

Secondary biological sewage treatment and effluent disposal to wetlands are expected to continue for 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 system 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 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. Discharges result from dewatering of excavations, which could be required for:

- Follow-up investigations from corrosion survey data analysis,
- Mainline valve inspections,
- Mainline cathodic-protection monitoring and remediation,
- Maintenance of existing river-training structures or the addition of new structures, or
- Maintenance and repair of the fuel gas line.

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. 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. 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, currently about 14 million gallons per day (53,000 m^3/day). 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. The pollutant loading is expected to continue to decrease with reduced TAPS throughput.

Other oily wastewaters derived from VMT operations (Non-Ballast water) will continue to be routed through the ballast water treatment facility (BWTF). These include blowdowns, steamrack discharge, and stormwater. Discharges from these VMT operations currently account for approximately 1.36 million gallons per day (5,300 m^3/day) of the wastewater treated and discharged by the BWTF.

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. Alyeska sponsors 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).

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 25 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. A third aspect is to search for and to evaluate any dynamic effects that may cause future impacts that significantly differ from past effects.

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, 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 control system.

Ambient air-pollutant levels at North Slope production 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 air pollution levels prior to 1986 due to exploration and new 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.

Also, it is incorrect to assume that actual increase in SO_2 emissions would automatically cause a proportionate increase in measurable ambient impacts. As discussed 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. 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 the ambient standards evaluated in the modeling study.

Global Climate Change

There are numerous ongoing debates on the rate and duration of the current apparent warming trend in Alaska. Global-warming forecasts indicate that the high latitudes of the earth may warm by several degrees by the middle of this 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 (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.

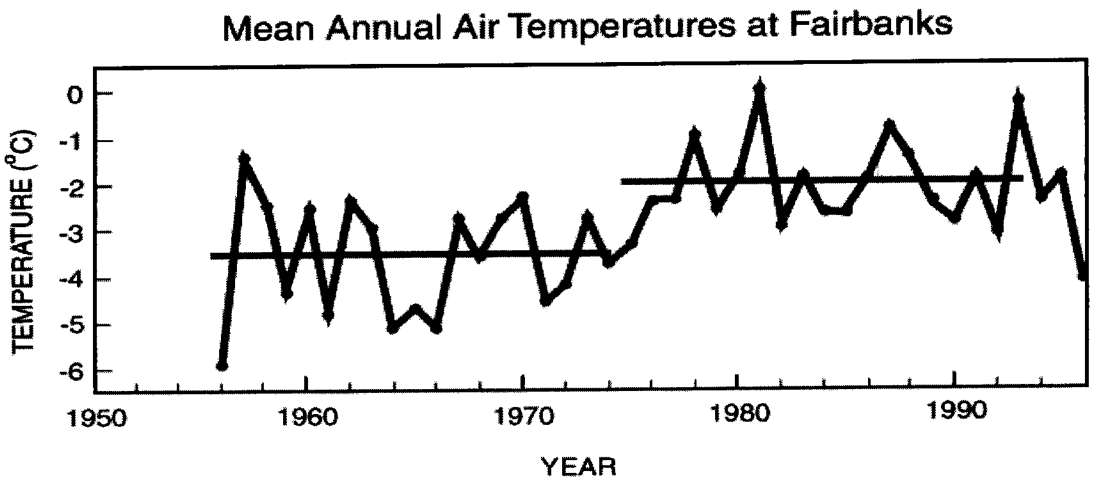


Figure 1 - Air Temp

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. A gradual increase in the size of 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 most likely 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.

Conclusion

Continued operation of TAPS is expected to have only minor impact on the physical environment. Justification for prediction of low impact is based on the fact that pipeline facilities have been in place for 25 years with known effects and observable impacts. Major changes to the pipeline system are not expected, new surface-disturbance areas will be small and isolated, and unavoidable adverse effects would be mitigated to the extent technically feasible. Moreover, declining throughput could result in lower emissions and discharges affecting air and water quality.

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