UNITED STATES OF AMERICA

Before the

FEDERAL POWER COMMISSION

Volume V of V
Application of
El Paso Alaska Company
at Docket No. CP75-___
for a
Certificate of Public Convenience
and Necessity

Pursuant to § 7(c) of the
Natural Gas Act

Respecting the
Proposed
Trans-Alaska Gas Project

Dated: September 23, 1974 Filed: September 24, 1974

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3A ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION - ALASKA

3A.1 INTRODUCTION

In previous sections, the proposed action (Section 1) and the existing environment (Section 2A) have been described for the Alaskan Gas Pipeline, the LNG Plant, the Alaskan Marine Terminal, and the LNG Carrier Fleet. This section assesses anticipated impacts to the environment resulting from the construction and operation of such facilities.

Most impacts of the Alaskan Project will be superimposed on an environment which has already been impacted by the construction and operation of the Alyeska oil pipeline.1/ The impacts described in the following sections are frequently incremental, and in some cases represent relatively small, additional effects. Additionally, many of the impacts described can be attenuated or eliminated by proper mitigation techniques such as those described in Section 4.

The primary geographic divisions utilized in Section 2A of this report have been maintained for prediction of impact in this section. The Arctic Drainage Division extends from Prudhoe Bay to the Continental Divide in the Brooks Range; the Interior Basin Division covers the area between the Brooks Range and Thompson Pass in the Chugach Mountains; the South Coastal Division encompasses the Prince William Sound region, including Cordova and Valdez, and terminates at Hinchinbrook Entrance. Impacts attributable to the construction and operation of the LNG Carrier Fleet are described in Section 3F.

1/The environmental impacts of the Alyeska oil pipeline project have been found to be acceptable, both administratively and congressionally. Applicant believes that the impacts of its Alaskan Project will be less severe in number, kind, extent and duration.

SECTION 3A.2 - ARCTIC DRAINAGE DIVISION

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3A.2 ARCTIC DRAINAGE DIVISION

3A.2.1 Land Features

Impact to land features in the Arctic Drainage Division will occur in the form of vegetation changes, earthwork, gravel extraction, solid waste disposal, and other evidence of man's activities.

Impacts of pipeline construction and operation on vegetation in the Arctic are discussed under subsection 3A.2.4. In this section, the effects of vegetative change on land features will be treated.

In the Arctic, several phenomena are frequently associated with vegetative change. Vegetation insulates permafrost from summer warmth, thereby preventing thaw. Once it is thinned or removed, as it will be along the trench, over gravel borrow sites, and in any areas where grading is necessary, the likelihood of permafrost melt and active layer thickening is increased.

In the Arctic, the upper layers of permafrost are generally ice-rich; therefore, subsidence will almost invariably accompany thaw. Vegetative cover is also an excellent barrier against erosion. Between the time it is removed and revegetation occurs, the potential for erosion will be high.

Earth alteration during construction will occur as a result of grading, gravel extraction, stream and river control, disposal of excess material removed from the trench, and disposal of other solid wastes.

Grading may be necessary in the Arctic Foothills and the Brooks Range, but will probably not be needed on the Arctic Coastal Plain. In areas where the route passes through frost-susceptible material this material will have to be disposed of if it is unsuitable for use as backfill. It may be feasible to use this material as landfill cover, since solid waste disposal sites will be necessary--at least for noncombustibles--during both construction and operation of the proposed facilities.

In the Arctic the pipeline will be laid from snow pads, but gravel borrow sites will be needed for construction of compressor station and work camp gravel pads and their associated access roads. Gravel will also be needed as backfill for those sections where the route passes through frost-susceptible soils.

Thaw subsidence is expected at all sites for reasons discussed above. The resulting pits will probably fill with water during the warmer months, since the ground in permafrost regions is generally saturated with moisture

To minimize excessive scour and bank erosion at stream and river crossings it may be necessary to bring in riprap or to construct gabions. These actions may result in localized topographic changes in and around the stream beds.

In regions of moderate or high relief, the possibility of slope failure exists. Any terrain alteration (e.g., removal of vegetative cover, cutting and grading operations, or thawing of permafrost) increases this possibility.

The greatest visual impact will result from the man-made appearance of the pipeline and related facilities - the low linear berm over the line itself, the compressor stations and associated buildings, communication facilities, block valves and fences. The additional impact on the Arctic of these facilities over that of the Alyeska pipeline system will be minimal since both systems will be in the same corridor and, after construction is completed, overall disturbance of surface features from the gas pipeline will be less than from the oil line, due to the gas pipeline's buried mode, plans to revegetate the right-of-way and plans to conduct maintenance patrols from the air.

Once the gas pipeline is operating, and restoration and revegetation are completed, temporary disturbance of land features may occur as a result of repair and maintenance operations. These disturbances, however, are expected to be localized and short-term.

3A.2.2 Climate and Air Quality

The total impact upon air quality due to construction of the pipeline and compressor stations in the Arctic Division is expected to be minimal. Only minor emissions of air contaminants will occur, and will be limited to such sources as gasoline and diesel equipment, space heaters, and permitted debris burning. Inconsequential emissions of volatiles and dust may result from painting and insulation. Normal stabilization measures will be used to minimize dust while grading and filling. The generally windy conditions prevalent on the North Slope will facilitate rapid dispersion of air contaminants.

3A.2.3 Water Resources

Impact to water resources of the Arctic will occur primarily in two areas: (a) watersheds, and (b) streams. Watershed disturbances will result from activities associated with construction of the pipeline, roads, construction camps, compressor stations, and maintenance bases. Stream disturbances will result from pipeline and road crossings, borrow sites in streams, and waste discharges.

Potential effects to the water resources along the pipeline corridor resulting from construction, operation and maintenance, termination and abandonment, and accidents are expected to be insignificant on a long-term basis because of the inherent resiliency of the aquatic environment.

3A.2.3.1 Surface Water

Construction of the pipeline, access roads, and support facilities will result in some local alteration of surface drainage patterns. These effects will be most pronounced on the Arctic Coastal Plain, where construction of roads may bar normal water movement during spring breakup. In these regions, any obstruction to sheet flow may impound water over large uphill areas because of the low relief. These effects can be lessened by adequate drainage and culvert design. Elsewhere in a watershed, any disruption of the surface covering may result in sheet erosion until these areas are stabilized.

Trenching, pipe laying, and backfill operations at stream crossings will cause some physical disruption of the stream channel and flood plain. Construction in the Arctic Division is planned during the winter, when most streams are frozen solid. Therefore, erosion and sedimentation associated with pipe laying in a flowing stream will not occur until spring, when most streams on the North Slope have normally high suspended sediment concentration.

Impacts from operation and maintenance of the Project will generally be localized. Access roads within the flood plains of major streams may cause local floods during breakup. Roads may likewise result in minor modifications of drainage patterns. Minor alterations of stream channel geometry may also be required where bank protection structures are implemented. Quantitative assessment of these impacts cannot be undertaken until final design has been accomplished and construction completed.

In the event of a pipeline rupture at a stream crossing, impact to the stream hydrology will be short-term. Summer repair of a section of pipe that crosses a stream would result in some localized scour and downstream siltation. Winter repair should have lesser effects, since most streams will be frozen.

3A.2.3.2 Groundwater

The proposed construction activity will have little impact on the groundwater resources along the pipeline route. Possible effects of construction include drainage of areas having high groundwater levels by the excavation of the pipe trench and backfilling with a more permeable soil. Temporary drawdown in isolated areas may occur if groundwater is used for construction purposes or as a water supply for camps. Some contamination of groundwater may occur near holding ponds or sewage lagoons at construction camps, though precautions will be taken to minimize this situation (see Section 4).

The operation of a cold gas pipeline may have an impact on the groundwater in the active layer near the pipeline by creating a dam against groundwater flow by freezing the soil around the pipeline. Obstruction of groundwater flowing downslope could cause the water to be forced to the surface by hydraulic head, thus creating an icing during winter (Carey, 1973). The active layer in North Slope watersheds is typically shallow and these effects will in most cases be minimal except in the vicinity of lakes and streams.

3A.2.3.3 Water Quality and Uses

Erosion and its associated effects are considered to be the source of greatest impact to water quality. The quantity of water used is insignificant when compared to normal flow in streams along the pipeline route, but may be significant in local areas, particularly during winter.

Erosion resulting from watershed and stream disturbance will continue until all disturbed areas are stabilized. Pipeline excavation and backfill in unfrozen stream beds will cause considerable siltation and turbidity, as will the cut and fill operations for road crossings. It is expected that road crossings will cause longer-term erosion and generate more potential for greater siltation and turbidity in streams than will pipeline crossings. Increased turbidity and suspended solids levels resulting from watershed disturbances will be proportional to the amount of erosion, gradient, the distance from the disturbance to a stream, and erosion control techniques applied. Whatever the source of sediment, the effect on water quality will be an increase in suspended solids and turbidity, decrease in dissolved oxygen, and possible increase in nutrients. The magnitude and duration of these effects will vary with individual streams. The ultimate impact of these effects is measured in regard to their impact on aquatic biota, which is discussed in subsection 3A.2.4.2.

Some effect on water quality can be expected from water use and the disposal of treated sanitary wastes from pipeline-related facilities. It is anticipated that a construction camp with a peak manpower of 840 will be located within the Arctic. Approximate waste loading and water use can be calculated according to the following standard criteria:

(1) Domestic waste loading is 0.17 pounds of biochemical oxygen demand (BOD) per capita per day. Since sewage will be treated by secondary or physical-chemical treatment, a 70 percent reduction of BOD in the effluent can be assumed safely; and

(2) Water use is 100 gallons per capita per day.

The domestic waste from construction personnel in the Arctic Division will amount to a maximum of 43 pounds of BOD per day, and water use will be 84,000 gallons per day. The impact of these actions occurring during winter (winter construction in the Arctic) when stream flow is at a minimum could create local problems, depending upon the source of water (stream or groundwater) and flow in the receiving stream. The ultimate impact on water quality cannot be accurately assessed since the location of the construction camp has not yet been determined.

Operation and maintenance of the proposed Alaskan Gas Pipeline should have little effect on the quality and quantity of water resources along the proposed route. Manpower at compressor stations will consist of two operators per station, and maintenance bases are designed for 30 men per base. Since three compressor stations and one maintenance base will be located in the Arctic, the total maximum domestic waste load will be 1.8 pounds of BOD per day and water usage will be 3600 gallons per day (0.006 cfs). The waste effluent, after treatment, will be discharged to a watercourse, or to a storage field where it will be available for discharge during thaw periods.

Accidents such as fuel oil leaks or spills, upsets in waste treatment facilities, and pipeline breaks could effect water quality in local areas, as could human-ignited wildfires. Wildfires can affect water quality by introducing nutrients and suspended solids resulting from erosion in burned areas. Fire-fighting equipment and techniques also disturb watersheds, thereby causing an effect on water quality.

Natural gas pipeline breaks at stream crossings will probably have little effect on the water quality during open water periods, since the gas will dissipate to the atmosphere. Gas leaks under ice cover, however, could cause an impact, although the specific effects of this situation are not known.

Upsets in waste treatment facilities could increase the nutrient loading and possibly introduce undesirable elements into receiving waters. The magnitude of impact will be directly proportional to the volume of waste and duration of accident.

Spills or leaks of petroleum products (stored for equipment usage) reaching a water course will adversely affect water quality. The major factor is inhibition of atmospheric reaeration because of a film of petroleum on the water surface, thereby preventing gaseous exchange.

3A.2.4 Species and Ecosystems

Conceptually, the Alyeska oil pipeline must be considered in its latter stages of construction when construction commences on the gas pipeline. Many of the direct consequences, and some of the indirect effects on Alyeska's construction would be in force. The Alyeska Environmental Impact Statement (USDI, 1972) supplies extensive predictions on direct biotic consequences of: (a) construction, and (b) operations and maintenance phases of that entire project. Appropriate excerpts from that report are included herein as a basis for estimating some of the similar effects of the proposed natural gas project.

The spatial, temporal and compositional differences between the Alyeska crude oil pipeline and the proposed Alaskan Gas Pipeline projects present some problems for prediction of changes to biotic systems. Conceptually, Applicant's Project may result in effects that are: (a) increments over, (b) prolongations of, or (c) synergistic with aspects of the oil project.

The second major conceptual consideration is that of itemizing both the direct and indirect effects anticipated on biotic systems. Direct effects of perturbations can be generated at any of the several functional levels of the ecological system (e.g., primary production, decomposition), and these effects, when translated into other functional levels, become indirect effects. The Alyeska oil project, and any of the alternative proposals for extracting natural gas, all qualify as very large, even monumental projects when measured by either financial investment or areal extent involved. Past experience with such large undertakings have shown that indirect biological consequences are potentially more significant than the direct and more obvious ones. The functional dynamic baseline description (Section 2A.6) was adopted to maximize predictive ability for such indirect ecological reverberations.

The following sections have been organized to treat the impacts of construction, operations and maintenance, and accidents upon the biota. A modified matrix scheme of the type developed for impact analysis and decision-making studies by L. Leopold (1971) was adopted in the preparation of some of the following sections. The modifications to Leopold's matrix tables are:

(1) No value judgments were made as to ecological benefits or degradations of specific actions,

(2) No estimates of the magnitude of perturbations were made, and

(3) Direct, or short-term, and indirect, or long-term, ecological effects have been distinguished.

3A.2.4.1 Terrestrial Environment

3A.2.4.1.1 Construction

Construction activities will locally influence soil substrate, water, air, and snow conditions. Clearing will affect the relationship between the active layer and permafrost anywhere heavy equipment is used. Extraction of granular material for roads, pads, and backfill in ice-rich lowland soils will affect the sites from which gravel or other material is taken. Gravel borrow from rivers such as the Sagavanirtok can be expected to alter stream flow, and to temporarily increase turbidity at some borrow sites. The location of proposed gravel borrow sites are shown in the alignment sheets in the Appendix to Section 2A.2.

Dust and gravel raised by heavy equipment during the winter will settle downwind of exposed gravel pads and roads, decreasing the albedo of the snow in the fallout zone. Snow melt in spring will be speeded in this zone. Snow depths will also be influenced by drifting patterns (wind scour, wind deposit) near raised structures such as roadbeds and pads.

Local and complex changes in soil temperatures, active layer, soil chemistry, and surface water movement will result from the construction phase in this region. These changes will be similar in nature and probably similar in extent to those caused by the oil pipeline construction.

Physical disturbance to primary producers--vegetation--is unavoidable during the construction phase of the proposed project. Magnitude of disturbance, however, will vary according to:

(1) Intensity of initial disturbance,

(2) Areal extent of disturbance,

(3) Season of occurrence,

(4) Frequency of secondary disturbance,

(5) Plant community involved, and

(6) Soil type involved.

Within the Arctic Division, four plant community types will be affected to various degrees with respect to acreage (see subsection 2A.6.1, Table 2A.6-1). In order of sensitivity to disturbance, these are:

(1) Eriophorum tussock,

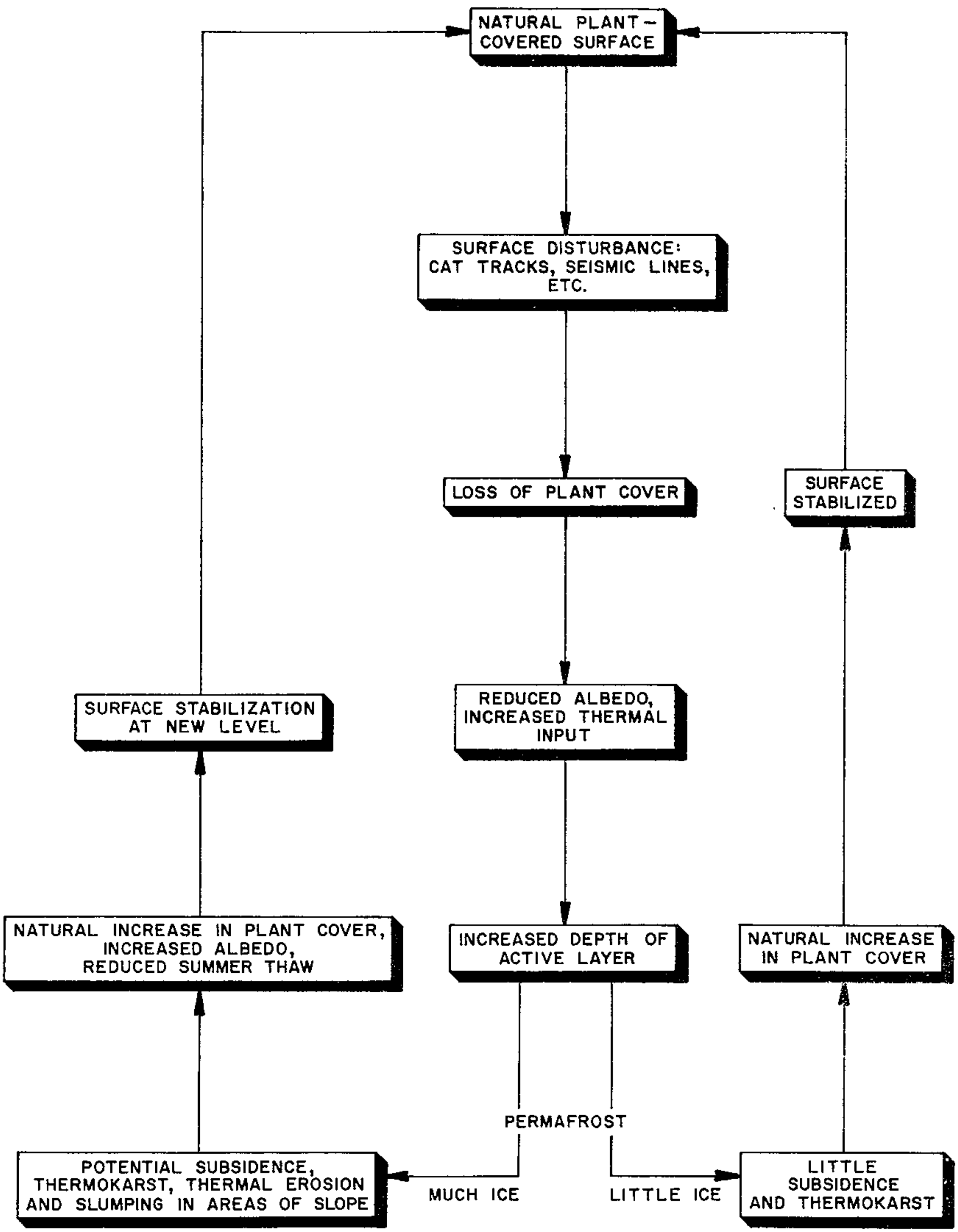
(2) Eriophorum-Carex wet sedge meadow,

(3) Gravel bar and bench, and

(4) Dryas, fell-field.

Approximately 113 miles (82 percent) of the right-of-way between Milepost 0 and Milepost 137 crosses Eriophorum tussock. Approximately 24 miles (17.5 percent) crosses Eriophorum-Carex wet sedge meadows. The remaining 0.5 percent of this sector crosses gravel bar and bench communities. Ditching will destroy aboveground and below ground components of any vegetation encountered. Surface action (blading, vehicular movement) exclusive of the ditch within the right-of-way is inevitable, but the level of disturbance to vegetation will vary according to the six factors listed above. 7.

The initial magnitude of disturbance in areas of ice-rich soil will be directly proportional to perturbation of the vegetation-active layer system. This system can be disturbed when the active layer is either thawed or frozen, but disturbing a frozen layer results in considerably less damage than disturbing a thawed layer (Bliss & Wein, 1972). Disturbance of primary producers in areas of ice-rich soil results in thermokarst subsidence and, in extreme cases, thermal erosion and slumping (MacKay, 1970; Bliss & Wein, 1971; 1972; Hernandez, 1973) (see Figure 3A.2-1). The chain of events presented in Figure 3A.2-1 will vary according to site physiography. Different plant community-topographic-soil-ground ice landscape units, or systems, respond differently to surficial disturbance (Bliss & Wein, 1971; 1972; Hernandez, 1973).



REF: BLISS, 1970

TRANS-ALASKA GAS PROJECT

FLOW DIAGRAM OF EVENTS FOLLOWING DISTURBANCE OF PLANT COMMUNITIES GROWING ON ICE-RICH SOIL

FIGURE 3A.2 – 1

Since construction between Milepost 0 and Milepost 137 is scheduled during the winter, the probability of initial damage to primary producers is minimized, but not altogether nullified. The mode of construction is important. Activities within the first 137 miles are to be staged from a snow pad approximately two feet thick. Bliss and Wein (1972) concur that using snow roads minimizes disturbance of vegetation. Constructing the snow road, or pad, however, can seriously damage plant communities if activity is begun prior to freezing of the active layer. In the event of an early snowfall, the proposed action will be to clear snow from the appropriate area to accelerate freezing of the active layer, using rubber-tired, low-ground-pressure vehicles with snowplow attachments. The concept of utilizing such vehicles is valid; however, the blading of snow off an unfrozen active layer will be accomplished with extreme care. If the active layer is thawed and subsequently disturbed, more damage will occur (Bliss & Wein, 1972).

With the exception of 2-1/2 miles through Atigun Pass (which requires summer construction) the remainder of the pipeline route through the Arctic Drainage Division is on a winter construction schedule. Milepost 160 to 162.5 encounters _Dryas_ fell-field communities, but perturbation to this type may be expected to result in little net biological damage (Bliss & Wein, 1972).

Microwave repeater stations will be built on sites lying outside compressor stations. These communications facilities will be situated on uplands, most likely on ridgetops or similar habitats characterized by _Dryas_ fell-field and the associated Arctic brown soil. This plant community-soil type complex is found on sites highly desirable for construction, since essentially no ground ice is associated with it. The level of impact will consequently be quite low.

If construction of a snow pad takes place prior to freeze-up, then severe damage to primary producers will occur. This is especially true with respect to the _Eriophorum-Carex_ wet sedge meadow (Bellamy _et al._, 1971; Hernandez, 1973a).

Within this community type, movement of vehicles and blading prior to freeze-up results in severe rutting, exposure of ice wedges, and bare soil. Thermokarst formation is consequently pronounced. If any slope at all exists, then thermal erosion and slumping may be expected.

Disturbance of _Eriophorum_ tussock communities results in greater thaw depths than are found in wet meadows (Bliss & Wein, 1972; Hernandez, 1973a). Thus, thermokarst formation will be common in sectors of the pipeline within this community type.

Since this community is found on uplands and slopes, severe surficial disturbance will result in thermal erosion (MacKay, 1970) and slumping (Hernandez, 1973a). The probability of severe surficial disturbance will be high in the event snow removal to speed freezing of the active layer and to collect snow for snow pad construction is employed.

Where the pipeline crosses streams such as the Kuparuk River, deep thaw will occur on slopes covered by gravel bar and bench communities.

Consequently, thermal erosion followed by slumping may be expected. Again, any activity prior to freezing of the active layer will induce more severe damage than activity after freeze-up.

Frequency of disturbance (as stated previously) plays a major role in determining the level of initial and secondary disturbance. Generally, the more times a piece of machinery moves over tundra surfaces, the greater the resulting disturbances (MacKay, 1970; Bliss & Wein, 1972; Hernandez, 1973a). It may be predicted that the frequency of disturbance will be higher than that which has resulted in the past from seismic exploration operations. Since these operations on thawed tundra have resulted in major initial and secondary environmental degradation (MacKay, 1970; Bliss & Wein, 1972; Hernandez, 1973a), the probability of disturbance is quite likely to be higher in construction zones such as the right-of-way. It must be emphasized that the level will, as stated above, be a function of several variables in which the season of construction, vegetation type, and soil characteristics are of prime importance.

The results of construction activities directly affecting consumers within the Arctic Division will be varied. Outright extirpations of small animals will occur within the right-of-way and at construction pads, roads, and gravel sites. Larger and more mobile animals will largely avoid active construction sites and busy road systems, and can be expected to react negatively to aircraft operations, blasting, and other noise sources. A fairly broad zone surrounding construction activities will therefore be avoided by those animals intolerant of intensive human activity, such as Dall sheep, wolves, moose, waterfowl, and birds of prey (cf USDI, 1972). The degree of overlap between Alyeska's construction period and that proposed will determine whether many consumers vacate this zone continuously for a number of years.

Several species may not avoid construction activities. Past experience has shown that brown/grizzly bears are inquisitive, to their own detriment. Inquisitive or nuisance grizzlies will be removed by the Alaska Department of Fish and Game during the construction phase of Alyeska's project. Arctic foxes at Prudhoe Bay became a nuisance in 1970-71 in spite of careful garbage disposal methods (Norton, et al., in press) and are likely to do so again, particularly near the coast. Caribou, representing intermingling members of the two Arctic Division herds in the Sagavanirktok Valley (Child, 1973), are notoriously unpredictable animals. Construction activities may affect local caribou in two ways in addition to those cited above. Human activities and structures may obstruct movements of these migratory animals (USDI, 1972; Child, 1973). Alyeska's experience in relation to these two problems will be helpful in finding means of preventing injury or death to these animals.

The construction zone will largely be denied to birds normally breeding there. Large species, such as swans, geese, and raptors may initiate nesting, but fail to raise young, owing to disturbances. Smaller species such as passerines and shorebirds will probably be more tolerant of noise, dust, and the presence of workers.

Experience at Prudhoe Bay indicates that arctic ground squirrels may colonize roads, gravel pads, and borrow pits where vegetation-free soils develop a sufficiently deep active layer to permit their extensive underground burrowing.

Potentially, the most significant, long-term, and widely felt impact of construction in the Arctic will be the introduction of numbers of people into the region. The regional force will exceed 500 workers at peak demand. These men will be generally too busy (and subject to special camp regulations barring firearms) to interact with the ecosystem other than through their construction activities (cf USDI, 1972).

Decomposer organisms respond profoundly to soil disturbance, changes in soil abiotic parameters, and to fertilization (Scarborough & Flanagan, 1973; Lindholm & Norrell, 1972). Severe disturbance (digging and destruction of vegetation mat above and below ground) leads to replacement of fungi by bacteria, and to a higher soil pH in some previously peaty soils. But the permanence of this change is not known (S.A. Norrell, personal communication). Severe disturbance will occur within the right-of-way at roads, gravel borrow sites, and facilities pads in this region.

Where moderate mechanical disturbance occurs, increasing depths of the active layer will produce higher soil temperatures and greater nutrient availability to decomposers, and produce a relaxation in the limitations upon decomposition and nutrient flux rates. The resulting bloom of decomposers (and secondarily of primary producers) particularly in poorly drained tundra soils gives rise to the "green belt" appearance of old vehicle tracks (Gersper et al., 1970). Moderate disturbances that do not destroy the vegetative mat will nevertheless result in marked substrate changes. In poorly drained soils, the tundra becomes in effect a small shallow pond in the area of disturbance (Gersper et al., 1970; Hobbie, 1972). Such ponds will develop under vehicle tracks if the tundra is not entirely frozen at the time traffic occurs, or if repeated passes are made over the same track, even in winter. Ponding will also occur next to gravel pads and roadbeds as a result of impeded water flow and increased water input from wind-drifted snowbanks (Parrish, 1974). Decomposition in shallow pond sediments is more rapid than in terrestrial soils, and may proceed at rates exceeding primary production and accumulation of organic matter. If the humus decomposes faster than it is accumulated, deeper, expanding ponds will result.

Fertilization of revegetation plots could have a substantial effect on decomposition rates, both on nearby tundra, and in aquatic systems, because nutrient levels are otherwise low in both situations (Bilgin & Douglas, 1972; Hobbie, 1972). Nitrogen, phosphorus, and potassium targeted for improving revegetation of disturbed sites may leak into undisturbed areas. If decomposers show a faster response than do primary producers to nutrient availability, the resulting imbalance could result in instability of highly organic (peaty) soils, surface subsidence, devegetation, and ponding. At present, there are no adequate means for predicting the areal extent or duration of such changes, but there is growing awareness of the possible indirect effects growing out of revegetation efforts and associated fertilization attempts (K. Van Cleve, personal communication).

3A.2.4.1.2 <u>Operations and Maintenance</u>

Factors expected to affect ecological systems primarily during the operations and maintenance phase include:

(1) Compressor stations operations

  (a) Emissions

  (b) Noise

  (c) Traffic between stations

  (d) Effects of a buried cold pipe

(2) Line Operations

  (a) Patrol and maintenance

  (b) Revegetation

3A.2.4.1.2.1 <u>Emissions</u>

The typical compressor station particulate emission level will be less than one pound per thousand pounds of fuel used. Peak exhaust stack SO_2 emmisions will be below 0.5 ppm. Oxides of nitrogen are expected to be present, but exact quantities are not known. Similar operations have oxides of nitrogen emissions 11 to 12 pounds per thousand pounds of fuel consumed at maximum power level.

3A.2.4.1.2.2 <u>Noise</u>

Compressor stations are expected to generate noise levels of 67 dBA at 400 ft. It cannot be assumed that safe or tolerable noise levels for humans represent tolerable levels for other vertebrate consumers. Therefore, birds and mammals may to some extent shy away from compressor stations, at least temporarily.

3A.2.4.1.2.3 <u>Traffic Associated with Stations Operations</u>

No estimates have been made of the type or volume of traffic to and from compressor stations during the operations and maintenance phase of the Project. It is therefore impossible to predict the ecological consequences of such traffic with any certainty. To the extent that the haul road will be used, Klein's (USDI, 1972) comments apply:

Some mortality of moose and caribou could be anticipated from traffic accidents on the haul road. Both species would likely be attracted to the road right-of-way. Revegetation of disturbed areas along the road, utilizing fertilizers, could produce forage of high nutritive quality which would be an attractant to herbivores. Blowing dust from the road surface in spring would cause premature melting of snow adjacent to the road and vegetation in these early snow-free areas would initiate growth earlier than in areas unaffected by road dust. This phenomenon has been observed adjacent to gravel roads in the Prudhoe Bay area (Personal communication to D.R. Klein from G.C. West, 1971). In spring when new-growth vegetation is in limited supply, moose, caribou, bison, musk-oxen and bears would likely be attracted to the road right-of-way wherever it transects their habitat. In winter, caribou and moose, and possibly other species, would tend to concentrate on the road surface when snow conditions made travel difficult elsewhere. Highway mortality of moose throughout Alaska is appreciable and it exceeded previous levels during the winter of 1970-71 in which record snow falls occurred (ADF & G, 1971)(Vol. 4, p 163).

If the predominant traffic is aircraft (helicopter or fixed wing), then some disturbance to wildlife may occur. Disturbance from supply and transport flight would be similar in nature, but far less severe than that described later under Patrol and Maintenance.

3A.2.4.1.2.4 Effects of Buried Cold Pipe

The possibility of ponding created by damming along some segments of the pipeline was previously discussed under Section 3A.2.3.2, Groundwater. In such cases, the vegetation affected would be submerged. This could result in dieback--depending on vegetation type--and might affect subsequent revegetation success.

In areas where permafrost is absent, ice encapsulation of the pipeline may result. Water in the surrounding soil matrix would then be bound as ice, leaving a dry soil. Again, revegetation success would be affected adversely.

The buried chilled gas pipeline permits maximum freedom in the selection of alignment, thus allowing avoidance of some ecologically sensitive areas. It also allows the use of a more direct route thereby minimizing pipeline length.

The gas to be transported in the proposed Alaskan Gas Pipeline is to be chilled. In some combinations of soil moisture and temperature conditions, the pipe may in fact become encapsulated in ice and the active layer thickness may decrease.

Decreasing the active layer will cause ice damming and hence ponding on the uphill side of the pipe. Such ponding can be expected to be extensive, since a large percentage of the pipe will "side-hill" along upland terraces that are ice rich and that gradually slope toward river valleys.

If such ponding as results from the situation outlined above for roads occurs, a cycle of decomposition, drainage channel formation, and final erosion of (in this case the pipeline ditch) is quite probable. Such a situation would be detrimental to the integrity of the pipeline.

Ice encapsulation will also have an effect on revegetation procedures. The water that will be bound in ice will be derived from the surrounding soil matrix. Thus the soil will dry as it cools following chilling of the pipe.

3A.2.4.1.2.5 Patrol and Maintenance

Patrolling the line for leaks, erosion, and other problems will require the use of low-flying aircraft.

The following consideration (USDI, 1972) of Alyeska surveillance and general aviation flights applies equally to the proposed gas pipeline project.

> ...Helicopters, which would be employed in pipeline surveillance and operation, and servicing of communication sites, appear to be much more disturbing to wildlife than fixed-wing aircraft (D.R. Klein, personal observation). Species occurring in low densities, such as the grizzly bear, wolf and musk-ox, and those with restricted distribution, such as the mountain sheep, would be most detrimentally affected by aircraft harassment because their uniqueness increases the likelihood that individual animals would be repeatedly hazed in attempts at photography and close observation. This type of harassment may be reduced through establishment and enforcement of regulations, but experience on Alaska's North Slope suggests that it will continue to be an important source of wildlife disturbance (D.R. Klein, personal observation).
>
> Disturbance to wildlife would disrupt normal behavior patterns, would generate increased physiological stress and would force less adaptable species from the areas of activity. Because of the limited research that has been done to date on the behavior of wild animals, the significance of the disruption of behavior patterns on the well-being of wildlife cannot be fully evaluated. It is known, however, that disturbance during and immediately following birth can result in substantial decrease in survival of the new born young in moose (LeResche, 1966), mountain sheep (Pitzman, 1970) and caribou (Skoog, 1968). The impact of physiological stress, resulting from animals being run by helicopters or other aircraft, has been calculated for animals such as caribou and mountain sheep (Geist, 1971). A single disturbance in which

animals are chased for a ten-minute period will result in an approximate increase of 20 percent over the normal daily energy expenditure. In mid-winter, the daily energy expenditure of a harassed caribou may exceed the energy present in the total forage that the animal could possibly consume, thus placing the animal in a negative energy balance. Such incidences of harassment normally can be compensated for by the animals; however, if repeated during a short period of time the effect could be significant increases in mortality. If compensated for by increased food consumption by the animals, there would be an overall increase in pressure of animals on their food resources with a corresponding reduction in the number of animals that could be supported by the habitat. Experience in the USSR with domestic reindeer indicates that disturbance by aircraft during late pregnancy or calving may result in abortions or calf mortality and stress by aircraft during periods of extreme cold can cause pulmonary emphysema which may lead to pneumonia (Zhigunov, 1968). (Vol. 4, pp 148-150).

3A.2.4.1.2.6 Revegetation

Absence of revegetation could cause erosion and indirect impact on the terrestrial and aquatic environment. Therefore, following construction of the pipeline and support facilities, all areas of the right-of-way that have been disturbed will be revegetated. The proposed method is to spread grass seed from all-terrain vehicles. Prior to this, however, specialists will be consulted in the selection of seed and method of sowing.

3A.2.4.1.2.7 Fertilizers and Other Compounds

Throughout the life of the proposed Project, a number of chemical substances will be introduced into northern ecosystems. Some of these are synthetic and do not occur in nature, while others occur naturally only in trace quantities.

Commercial fertilizers may need to be used in quantity to provide short-term success in revegetation of disturbed ground. The persistence of nitrogen compounds and their effects on plant communities in cold soils can be noted at a 10-year old experimental fertilizer plot near Point Barrow (D.W. Norton, personal observation) and in the vicinity of native village sites in the Arctic Division, which were abandoned 200 or more years ago (S. Young, personal communication).

Other compounds that may be used during the Project are herbicides, which may need to be applied to discourage shrub growth (e.g., willows, alders) alongside the haul road and near the buried pipe. No specific plans exist regarding the use of herbicides in any of the Alaskan systems.

Although "long-lived" pesticides (e.g., DDT) will not be used in connection with construction, the use of shorter-lived organophosphate pesticides (i.e., Malathion) has recently been authorized at construction camps for the Alyeska project by Alaska's Commissioner of Environmental Conservation. The toxicity, persistence, circulation through trophic components to the ecosystem, and the action of the breakdown products of Malathion are largely or completely unknown in arctic and sub-arctic biotic systems. Pyrethrin-based insecticides were also authorized in the same action.

The foregoing substances will be deliberately applied only after careful evaluation of side effects on biotic systems.

The trophic structure and systems dynamics of Alaskan ecological systems will profoundly influence the fate of chemicals and biocides released into the environment, to the degree that these substances tend to follow normal pathways of nutrient and energy flow. Little is presently known about the behavior of these compounds in high latitude systems.

3A.2.4.1.3 Accidents

The ecological effects of potential unintentional events associated with the proposed Project in northern Alaska will by and large not be substantial. Accidental events include oil spills during construction or operation, rupture of the operating pipeline, ignitions of wildfire, and vandalism. In general, human reactions to accidents are more significant in altering biotic systems than are the accidents themselves.

3A.2.4.1.3.1 Fuel Oil Spills

Fuel oil spills, particularly during construction, may occur, as they do in any operation. The volumes involved will generally be small, the extent limited, and the ecological effects minor.

The effects of such spills will depend upon:

(1) Volume of spilled material,

(2) Areal extent of the spill,

(3) Season of spill,

(4) Plant community involved, and

(5) Type of material spilled.

Winter spill damage will be minimized, since gelled petroleum products will remain, for the most part, in the top 5 to 10 cm of the snow pack (Wein & Bliss, 1973). Thus, it will be relatively easy to scrape up the gelled oil with minimal damage to primary producers (Bliss & Wein, 1973). A summer spill may be more difficult to control because of deep penetration of the active layer (Wein & Bliss, 1973) and the potential adverse effects of conventional oil removal schemes, such as burning, when applied to permafrost soils (Bliss & Wein, 1973).

The direct impact of petroleum and petroleum derivatives on vegetation has been studied on Arctic Regions by Bliss and Wein (1972; 1973) and Wein and Bliss (1973). They have found that petroleum and petroleum derivatives are toxic to plants (phytotoxic). The toxicity of straight chain paraffins is less than that of ring compounds, and low molecular weight hydrocarbons of both groups are more toxic than high molecular weight hydrocarbons (Wein & Bliss, 1973).

Vascular plants show some recovery following a spill, whereas cryptogams show little or no recovery. Mean recovery of total vascular plant cover ranges from 20 to 55 percent, with Eriophorum-Carex wet meadows showing the most rapid recovery. As the woody component increases (Eriophorum tussock and gravel bar and bench communities), total survival declines (Wein & Bliss, 1973).

Secondary effects of perturbation by oil were expected to be similar to those discussed in relation to physical perturbation--that is, thermokarst formation and so forth. This does not seem to be the case. Since the insulating peat mat is not disrupted, no clear increase in depth of the active layer followed the initial disturbance (Bliss & Wein, 1972).

This may not be the case with minor spills associated with equipment operation. Under those conditions, spills and physical perturbation may act synergistically to increase the probability of thermokarst formation and related phenomena such as thermal erosion.

Once oil or petroleum products enter the soil profile, there will be perturbation of soil microbial populations--decomposers. The primary result of saturation of the soil by petroleum hydrocarbons is a shift in dominant taxa of decomposers and a decrease in diversity (fungi dominance is replaced by bacterial dominance) (Cambell, et al., 1973; Scarborough & Flanagan, 1973; Wein & Bliss, 1973).

Accompanying the above changes in the decomposer community is a trend toward increased respiration of the decomposer component. This indicates that microbial breakdown of petroleum hydrocarbons follows saturation of tundra soils by such compounds (Cambell et al., 1973; Scarborough & Flanagan, 1973). The rate of breakdown may, however, be expected to be less than that of mid-latitude situations because of limitation of such processes to approximately a four-month season (Cambell, et al., 1973).

Stimulation of decomposer activity by petroleum and petroleum products will probably affect the nutritional status of the soils involved (Bliss & Wein, 1973). Although not much data are available regarding such perturbations, denitrification seems to increase and nitrification decreases. In the typically nitrate and ammonia-poor arctic soils, such a perturbation may prove particularly perplexing with respect to the very important nitrogen cycle (Lindholm & Norrell, 1973).

Since North Slope soils are characteristically ice rich, and since hydrocarbon breakdown may be slow, some movement of hydrocarbons following a spill is expected. This movement will be by mass flow through the active layer and by sheet or rill flow over the tundra surface. The result of such a flow will be the accumulation of hydrocarbons in depressions such as ponds, drainage channels, polygon troughs, and polygon centers (Cambell et al., 1973). Such a mass flow of petroleum products usually results in a "quick cleanup" program. Such a program will result in disturbance to the primary producer mat and will therefore result in serious site degradation of the type discussed under physical disturbance of primary producers. It may therefore be more desirable to leave such spills alone than to attempt a speedy cleanup (Cambell, et al., 1973).

As with any noxious or toxic substance, oil may be retained by primary producers and consumed by herbivores. The herbivores may either die from oil ingestion or serve as transmitters of lethal quantities of toxins to higher trophic levels, such as birds of prey (USDI, 1972). Physical contact with spilled fuels and lubricants may result in contamination of pelage or plumage of consumers, leading to death through reduced insulation (USDI, 1972).

3A.2.4.1.3.2 Natural Gas Spills

Rupture of the gas pipeline may follow natural catastrophes, corrosion, damage by vandals, failure of welds, or other structural flaws.

Although no experimentation has been carried out on natural gas spills in cold-dominated soils, work by Adams and Ellis (1960) indicates that saturation of soils by natural gas may retard or completely eliminate primary producers in the area affected. The areal extent of such damage is limited, however. Lateral penetration by natural gas depends on soil structure, but rarely extends more than a few feet beyond the source of gas (Adams & Ellis, 1960).

Following control of leaks, invasion of the site is quite rapid in midlatitude situations (Adams & Ellis, 1960). Presumably, the same would be true in cold-dominated soils.

In conjunction with perturbation of primary producers is perturbation of decomposers. There are indications that propane may be utilized as an energy source by soil microbes until nitrogen becomes limiting. This tendency toward upset of the nitrogen cycle when soil microbes utilize hydrocarbons as an energy source has also been noticed in cold-dominated soils (Lindholm & Norrell, 1973). Therefore, one of the major considerations with respect to perturbation by natural gas may be the effect of breakdown of hydrocarbons on the nitrogen cycle.

3A.2.4.1.3.3 Wildfires

As in the case of accidental oil spills, wildfires will be generally more ecologically tolerable than attempts to contain them with heavy equipment or chemical retardants. Overall, the probability of setting the tundra afire will be restricted to summer months, when construction activities will be limited. Wildfire occurrence will also be limited by the lack of combustible materials in tundra. Only when accidental fire and oil spills occur in conjunction will there be serious cause for alarm. Mandatory containment of such fires will introduce local distrubance by heavy equipment, later long-term thermal erosion, and may introduce toxic chemicals into biotic systems over a wide area of terrestrial and aquatic environments (cf Lotspeich, et al., 1970)

Chemical retardants used in aerial fire suppression currently are Phos-Chek 202(R) and Fire-trol 934(R). These substances are primarily diammonium phosphate and ammonium sulfate, respectively, hence they presumably have significant effects as fertilizers. While not necessarily intolerable in arctic systems, fertilizers and fertilizer-like substances are likely to produce substantial long-term changes in the balance of primary production and decomposition. Moreover, Phos-Check in particular contains unspecified additives for thickness, anti-corrosion, and coloring (cf Hartong, 1971) that may have more to do with occasional observations of animal mortality following application than do the principal compounds in the retardants.

3A.2.4.1.3.4 Vandalism

The probability of wanton disruption of any phase of the proposed action in the Arctic Division is considered remote.

3A.2.4.2 Aquatic Environment

3A.2.4.2.1 Construction

Construction of the proposed pipeline will affect certain ponds, lakes, rivers, and streams in the Arctic Division more so than waters along the remainder of the route because of the relatively pristine quality of the arctic wilderness. Several potential effects of construction are expected including:

(1) Disruption of habitat through excavation, fill and gravel borrow,
(2) Hydrologic disruption through channel modification,
(3) Habitat modification through increased siltation,
(4) Eutrophication through possible input of sewage effluents and terrestrially-derived nutrients,
(5) Addition of toxins from such sources as sewage effluent, and machinery, and
(6) Withdrawal of water for camp use.

Certain actions will produce combinations of the above. Pipeline excavation and burial, for example, may produce effects (1), (2), (3), and (5).

The magnitude of disturbance in a particular location will depend on several factors, which include:

(1) Types of disturbances,
(2) Initial intensity of disturbances,
(3) Areal extent of disturbances,
(4) Duration of disturbances,
(5) Interaction among types of disturbances,
(6) Initial water quality,
(7) Hydrologic characteristics,
(8) Community involved,
(9) Season of occurrence, and
(10) Frequency of repeated disturbances.

The complexity of these variables and the limited knowledge of aquatic ecosystems prevent specific prediction of magnitude and duration of impact. Additionally, construction of the Alyeska pipeline will have been completed in some areas, but may take place concurrently in others. As mentioned earlier, impacts of Applicant's pipeline will be superimposed on that of the Alyeska pipeline. The resulting ecological interactions are difficult to accurately quantify.

The addition of some 840 workers (peak manpower predicted) in the arctic zone during the construction phase of the proposed project should not have a major effect upon fish resources.

Nonetheless, the concept of community integrity must be stressed. When aspects of water quality or hydrology are changed, the biological community responds accordingly. This response is a natural process, which occurs constantly on a daily, seasonal, annual, and long-term basis. All communities have a certain resiliency that allows them to survive constantly changing conditions. The level of resiliency in arctic ecosystems seems to be particularly high, presumably because of the magnitude of natural oscillations. Conditions normally change within certain bounds, however, and the ability of arctic aquatic ecosystems to absorb unusual stress is unknown.

Ecological simplicity and slow growth and development of organisms increase the vulnerability of these systems. Where the primary consumer--not infrequently a single species of crustacean--is removed from an arctic lake, all higher trophic organisms can be expected to disappear. In contrast to terrestrial systems depending on the vastness of the area to promote survival of some populations and allow reinvasion into disturbed areas, lakes may be isolated and not subject to reinvasion for some time. On the Coastal Plain, however, spring run-off may promote distribution of species among neighboring lakes and ponds. Rivers and streams have the advantage of reinvasion from undisturbed upstream or downstream areas (cf Dunbar, 1973).

Recovery after disturbance depends on the substrate and water quality remaining. If either is changed, a different community can be expected to develop. Biological factors also affect recovery. Primary production is the fuel for any community, and development of animal populations depends largely on establishment of plants. Development of organisms at any trophic level in fact depends on development of all lower trophic levels.

Most construction in the Arctic Division will take place in winter. Importance of this scheduling for the oil pipeline has been emphasized by McCart, et al., (1973). Although the proposed gas pipeline routing is somewhat different, the discussion is generally applicable.

> Alyeska is required to protect fish spawning beds and to provide for the uninterrupted passage of fish during the course of their migrations. In part, this can be accomplished by the proper scheduling of pipeline construction. (Winter construction) has a number of advantages:
>
> (1) Construction would not interfere with the major movements of Arctic char, the seaward migration in the spring or the upstream migration of spawning and overwintering fish in the middle and late summer.
>
> (2) There would be no interference with the spawning movements of grayling.
>
> (3) Most of the foothill streams crossed by the pipeline and road would be frozen and devoid of fish or their eggs. There would be no problem with siltation resulting from construction activity and damage to the streambed would be confined to the crossing site itself.
>
> (4) Much of the active flood plains of both the Sagavanirktok and Atigun Rivers would be either frozen or have only small flows. Here again, siltation would be reduced to that produced during stream crossings and that from material sources which lie close to the streambed at summer discharge levels.
>
> (5) Damage to the active layer of the tundra is less likely under winter conditions.
>
> Any choice of construction period must be a compromise between the needs of many various species. There would be some conflict between winter construction and the well-being of fish populations if the pipeline were to pass through the overwintering or spawning areas of substantial populations of fish. As we have previously indicated, there is reason to believe that streams along the road and pipeline routes are generally unsuitable for overwinter survival. However, we do not feel that the available data on winter distributions of fish are yet adequate.

Construction activity may inevitably result in some loss of aquatic habitat. Pipeline excavation and burial, road fill in stream channels, gravel borrow operations, channel diversion, and training works are the major causes of loss. Borrow and channel diversion might affect an area some acres in extent in some locations. It is not known how much channel diversion, if any, will be required, or if any borrow will be done in active stream channels. Any borrow in a flood plain will eventually have some effect on hydrology and water quality. Pipeline burial and road fill should result in relatively little loss of habitat.

Any channel modifications which change depth and velocity of water will result in a change in the biotic community. Many plants, and both invertebrates and fishes, frequently have narrow tolerances for current. This is often related to the difference between a sessile and an active existence, or to feeding mechanisms. Species composition will change as flow patterns change. In addition, the particular problem of culvert installation in road crossings of streams may restrict migration of fish. This problem is discussed in McCart _et al._, (1973) for the Alyeska pipeline. Although the gas pipeline routing is somewhat different, the discussion presented below applies to stream crossings in general.

> Alyeska anticipates the use of culverts on many of the smaller streams crossed by the haul road. In our area, these streams include Tee Lake outlet in the Upper Atigun Valley and a number of foothill streams including the Kuparuk and Tookik Rivers, Oksrukuvik Creek, Happy Valley Creek, Island Creek and several unnamed streams.
>
> These streams serve as migratory pathways for grayling moving up and downstream to feeding, spawning and overwintering areas. Round whitefish, sculpine and the occasional juvenile Arctic char may also occur. We foresee two potential problems associated with culverts: first, the culvert may act as a velocity barrier impeding the upstream migration of fish; second, erosion in the vicinity of culverts may damage streams through siltation of the stream bottom.
>
> Culverts must be designed with fish passage as a primary objective. Failure to adequately consider fish passage may result in a long term, detrimental effect on populations (_e.g._, disruption of spawning, feeding or overwintering migrations). Mistakes are not easily rectified and "Culverts not designed for fish passage often require drastic, costly corrective measures" (Metsker, 1970). The Department of the Interior has defined minimum standards for culvert construction at water crossings including gradients, erosion control devices and a stipulation that "Water velocities at medium discharge will not exceed four (4) feet per second in any part of the culvert". We feel that even if other criteria are met, the velocity requirement is inadequate to assure the safe upstream passage of a large proportion of the grayling inhabiting the smaller streams in our area.

In reviewing the problem of culverts as a barrier to fish passage, Metsker (1970) suggests that "The Magnitude of the culvert average cross-section velocity should be less than the sustained swimming speed of the smallest fish in the stream." Nothing is yet known of the swimming performance of grayling or other species in our area. In those species for which data is available, performance has been found to be positively correlated with length so that larger fish perform better than smaller ones. Performance is also influenced by temperature and, for salmon and trout, tends to be better at high (more than 60°F) than at low (less than 40°F) temperatures. Brett et al., (1958) found, for example, that underyearling coho salmon 54 mm in length were able to maintain a maximum rate of 1.0 feet per second at 68°F but only 0.2 fps at 32°F. Water temperature is an important consideration in grayling migrations because both the spring spawning run and the late summer-early winter movement to overwintering areas take place when water temperatures are low.

As we have indicated, there have been no studies of the swimming performance of grayling or other fish species inhabiting our area. As a rough index of sustainable swimming speed, Metsker used Bainbridge's (1958) formula according to which the maximum sustainable swimming speed is approximately four (4) times fish length. The relationship does not take into account differences in performance due to temperature or species differences. However, it is a useful guide in assessing the practical consequences of culvert construction.

...While adult grayling might be able to pass upstream through a culvert requiring a sustained swimming speed approaching four (4) fps, juveniles and fry would be unable to do so. While we have no indication of an extensive upstream migration of fry to Happy Valley Creek, we do have evidence of such movements for adult and juvenile grayling. In order to ensure the passage of both these groups, the average cross-sectional velocity in the culvert should probably be less than two (2) fps to accommodate juveniles of average size, and less than (1) fps to accommodate the smallest juveniles. Where there are upstream movements of fry, the mean velocity should probably not exceed 0.6 fps. We suspect that such movements of fry occur in the Tee Lake System where grayling spawn in the outlet stream and fry presumably undertake an upstream migration to overwinter in the Lake. A similar pattern may occur in the upper Kuparuk River. Both streams will be crossed by the haul road.

In many situations it may not be possible to achieve mean cross-sectional current speeds in the lower range using conventional culvert design. In these instances baffles or other structures within the culvert may be necessary to provide areas in which fish, particularly small ones, may rest during their upstream migration. Where this cannot be done, bridges are the obvious alternative...

From the point of view of the fisheries biologist, bridges are generally preferable to culverts in streams inhabited by fish because they result in less disruption to the continuity of the flow. Metsker (1970) has pointed out that in areas (like the North Slope) where run-off pattern information is lacking, bridges should be constructed rather than culverts.

It is our opinion that culverts are potentially more damaging to stream dwelling populations of fish, particularly grayling, than any other aspect of pipeline-related activity.

Excavation, fill, borrow operations, and channel modification in streams will cause considerable siltation to occur. Run-off influenced by terrestrial activity may increase the silt load long after construction ceases, if permafrost degradation is induced. Erosion in all areas of disturbance in a watershed can be expected to produce siltation for a period measured in years in some cases. The presence of silt in general modifies aquatic habitat by reducing light penetration (and therefore photosynthesis), modifying the substrate, smothering organisms, causing abrasion damage, reducing oxygen content of the water, and interfering with feeding of grazers, filter-feeders, detritovores and carnivores. The following discussion from the Alyeska Impact Statement (USDI, 1972), though oriented to fishery resources, presents the problem in considerable detail:

> Erosion is a natural occurring process and all streams carry some level of silt load but any activity that causes additional erosion and siltation can affect streams in a variety of ways. These include: (1) a reduction in light penetration (McKee & Wolf, 1963); (2) a reduction of total productivity (Cordone & Kelly, 1961); (3) a reduction of benthic organisms (Smith, 1940); (4) mortality in salmonid eggs and embryos (Peters, 1965); and (5) interference with the feeding of and occasionally even the smothering of mussels (Ellis, 1936). "Construction of any kind almost inevitably results in some erosion, and even small amounts of mineral matter cause changes in the Fauna." (Haynes, 1970).
>
> The effects of high turbidities are often quite subtle but generally they affect production. Minimum fatal turbidities were 16,500 to 175,000 mg/l to a series of warm water fishes (Wallen, 1951). Although symptoms of distress appeared at much lower levels, it is improbable that actual fish fatalities would occur because of turbidity caused by pipeline construction. The exact levels that can safely be tolerated are unknown. Griffin (1938) reported on experiments of 3 to 4 weeks duration where trout and salmon fingerlings fed and apparently grew well in waters carrying a constant silt load of 300 to 750 mg/l. Van Oosten (1945) concluded that fish lived and thrived in waters with turbidities that ranged above 400 ppm and averaged 200 ppm. Higher turbidities, even though tolerated, have a detrimental effect as Buck (1956) found that fish yeilds were over 5 times greater and plankton volumes were about 13 times greater in clear ponds than in turbid ponds.

Streams along the proposed pipeline route vary tremendously in their physical, chemical and biological characteristics. Because of this fact, each stream must be considered separately in final design of the pipeline system. Some streams, such as Phelan Creek, carry a very high natural silt load and it is highly improbable that added siltation caused by planned construction activities would have any effect on the fishery resources. On the other hand, a clear stream with spawning salmonids, such as the Little Tonsina River, would be very vulnerable to even small amounts of silt.

Each stream has an inherent capacity to recover from damages caused by siltation. The natural flushing or recovery action depends primarily on the velocity of flow and particle size and varies with each individual stream and situation. Extensive silt banks in the Chena River present in 1953-54 disappeared by 1966-67 after cessation of mining and other activities causing serious siltation (Frey, 1969). Sheridan and McNeil (1968) reported that the amount of fine particles in spawning beds increased temporarily but was not significantly greater five years after logging than before logging. However, in spite of this recovery capability, all sediments are ultimately deposited somewhere further down stream, in the mainstream, or in the ocean.

With respect to the Beaufort Sea, there would be an increase in sediment deposition at the mouths of rivers which have upstream gravel removal or other operations. However, the mouths of rivers and other shallow areas along the coastline naturally exhibit relatively unstable bottoms due to the mechanisms of ice scour and shoreline erosion (Personal communication to N. Netsch from J. Brooks, 1971). Therefore, sedimentation caused by construction activities would not be expected to have a significant impact upon the marine environment of the Beaufort Sea, although anadromous fish species could be affected while in their freshwater habitat stages.

Pipeline and road construction activities would result in erosion and stream siltation. The most obvious include:

Stream crossings. Certain measures presented in the stipulations are designed to keep erosion and siltation at the lowest practical level while maintaining an economically efficient construction operation. However, even with the most optimistic outlook, some siltation would occur at all crossings. The most critical period for erosion at the pipeline crossings would be during construction. Excavating the trench, laying the pipe and covering the trench again in the stream bed would cause considerable siltation which would continue until the cuts and fills were stabilized. With the planned bank stabilization and stream protection measures (APSC, 1971c; Section 1.3), induced siltation would probably occur at some crossings for a period of 2 or more years after completion of construction.

Road crossings have more potential than pipeline crossings for longer term erosion and siltation problems. These would generally involve a fill or cut requirement which, until stabilized, would erode. Culverts, which would be used for the smaller streams, could constrict stream flow and create erosion problems immediately above and for a considerable distance below by altering the natural stream hydrology. Appropriate final design measures should prevent this. Probably the most serious siltation potential concerns washout of such road crossings. If this occurred, the fill would be washing downstream and could cause more siltation than the original construction. Reconstruction would add additional silt to the stream. Bridges are generally more desirable than culverts from the fisheries standpoint. However, these too, can cause erosion and siltation problems if final design were to result in channel width constriction or piling too close together to pass debris. This has occurred at the Hess Creek bridge on the already completed Livengood to Yukon road (Watson, 1971). These same problems are considered in the water resources section of this volume.

Material sites in streams. The adverse affects of any type of activity in active stream beds are well documented. A gravel removal dragline operation caused greatly increased turbidities and suspended solids and reduced aquatic insect productivity by 85 percent in one documented case (Wagner, 1959; Ziebell, 1960). Placer mining operations in Alaska have degraded downstream water quality as evidenced by an increase in turbidity and a reduction in dissolved oxygen which resulted in a significant reduction of fish and fish-food organisms (FWQA, 1969). It was also found that changes in stream gradients resulting from mining operations have in some cases caused erosion to persist for many years.

One hundred material sites are planned on river bars of braided streams or flood plains (APSC, 1971c; Section 1.2.4.16). Most of these are on the Middle Fork of the Koyukuk, Dietrich, Atigun and Sagavanirktok Rivers. Gravel removal or any other disturbance in an active stream channel will cause siltation. Where the stream channel is avoided or is rerouted through an alternate channel, there should be only very short term siltation during periods of normal flow. However, during floods, additional induced silting would occur. If the sheer forces changed by gravel removal exceed those which formerly existed, the stream hydrology would be changed resulting in accelerated erosion and shifting of bottom materials in the stream bed (Personal communication to N. Netsch from M. McDonald, 1971).

Construction in the flood plain. The importance of locating roads out of and away from streams is well established (Cordone, 1956; Burns, 1970). Tebo (1955) found that an average of 5.34 cubic feet of soil per linear foot of road surface was eroded from a logging road in a two year period. Roads and other construction activities should be kept out of and away from streams whenever possible.

There are many areas where the road and pipeline would be in the flood plain. The most extensive area would be approximately 47 miles of (oil) pipeline buried within Sagavanirktok River flood plain (APSC, 1971c; Section 1.3.4.2). The trench would be parallel to stream flow and would be quite vulnerable to cutting. The amount of excavating required in the Sagavanirktok, Atigun, Dietrich, and to a lesser extent, the Middle Fork of the Koyukuk would cause considerable immediate siltation unless work were limited to periods when rivers are completely frozen, or where stream flow is diverted into abandoned channels during construction. The best of timing and techniques would reduce but not eliminate the siltation problem. Of these streams, the Dietrich is assigned a stream classification of II (fair to moderate productivity) and the others class III (good to excellent productivity), (Alaska, State of, 1971).

Watershed disturbances. Virtually all activities related to pipeline and road construction have the potential of causing erosion through disturbance of the watershed. Although certain requirements are specified in the Stipulations and a number of control measures outlined in Alyeska Project Description, erosion generally would continue until all disturbed areas are stablized. The time required to do this would vary but several places along the Livengood to Yukon road are still experiencing thermal erosion and bank cutting over two years after completion of construction (N. Netsch, personal observations).

The amount of stream siltation resulting from watershed disturbance would depend upon several factors including amount of erosion, gradient, and distance from the eroding area to a stream. In general, the further from the stream, the less the amount of sedimentation which will occur in the stream (Lull & Reinhard, 1965; Burns, 1970). [Vol 4, pp 126-132]

Further discussion pertaining to the Alyeska pipeline is found in McCart, et al., (1973):

> Permafrost degradation and erosion can have particularly serious consequences for the aquatic environment where eroded materials enter lakes and streams smothering the spawning beds of fish and decimating the invertebrate populations on which they depend for food. Such effects would be greatest on smaller streams and lakes where the amount of eroded material would be large in relation to total area. Populations of fish might be seriously affected by even short term erosion but the effects are more likely to be serious where it continues over a period of years. Nevertheless, the emphasis must be on preventing degradation and erosion rather than reestablishing ground stability after they occur. . . . However, despite every precaution, we can expect that some trouble spots will develop, particularly in the early years of operation before soil conditions have stabilized. . . . [Regular inspections of stream crossings are] especially important in the spring when surface run-off is at a peak and erosion likely to be most severe. Grayling spawning

> in the small, foothill streams would be particularly affected by erosion occurring at this time. . . .
>
> [A major] problem associated with culverts is erosion and consequent siltation of the stream bed. Erosion is most likely to occur if water flows exceed the design capacity of the culvert during the spring flood, a critical period for grayling which utilize the small streams in our area for spawning. In order to ensure sufficient capacity, the culvert design must relate to the run-off characteristics of the stream in which it is placed. At the present time, a few years' discharge data are available for two large streams in the vicinity of the pipeline (the Sagavanirktok and lower Kuparuk Rivers) but to our knowledge there are no comparable data for the smaller streams on which culverts are normally constructed. These smaller streams include streams utilized as spawning and summer feeding areas by grayling (and to a lesser extent by other species) and ephemeral streams which run only during periods of excessive run-off and are otherwise dry. For most of these streams, assessments of their maximum flow must be indirect, based on photo interpretation and flood levels indicated by debris left on banks, or calculated from formulae developed in more southerly areas. We are concerned that culvert designs based on such information might be inadequate. Underestimates of probable flows are most likely on ephemeral streams. Erosion from these may affect conditions in permanent drainages further downstream.

Emphasis should be placed on the importance of the organisms that support fish populations (plants and invertebrates). Other than being disturbed by perturbation of their spawning grounds, fishes are probably less susceptible to damage from siltation than are organisms of lower trophic levels. Productivity in fishes is a reflection on the productivity of food organisms. Applicant plans to minimize the problem of siltation in flowing streams by employing settling ponds and other, similar protective measures dictated by the particular stream conditions encountered (see Section 4).

Three sources of nutrient enrichment can be expected during construction: (a) sewage effluent, (b) nutrients introduced following disturbance of terrestrial vegetation, and (c) nutrient material applied to the land surface during revegetation programs that subsequently enters the aquatic environment through run-off.

The initial effect of nutrient enrichment is an increase in primary productivity (eutrophication). If the level of nutrient input is not great, increased productivity may continue as long as the input continues. In cases of severe eutrophication, after the standing crop of plants has increased beyond a certain level, extensive death of plants can occur, resulting in rapid decomposition and depletion of oxygen in the water. In some cases, faunal communities are largely destroyed through this process.

The effects of eutrophication resulting from pipeline construction will depend on the individual situation. In general, it is felt that eutrophication resulting from nutrients introduced by run-off will be mild, and that there will be negligible eutrophication from treated sewage effluent.

Substances which may inhibit productivity include sewage treatment chemicals and petroleum by-products of machinery operation. The effects upon an aquatic ecosystem will depend largely upon the particular substance and its concentration in the water. However, since Applicant will take appropriate precautions to reduce input of these substances during construction, impact should be mild.

Water can be in short supply in winter months in the Arctic. Lakes and water remaining in rivers should be preserved at all times. These areas are the only available overwintering habitat for fish.

Water withdrawal at any time, however small the volume, has some ecological effect at the site of withdrawal, and later when it is reintroduced into the environment. The effect will be negligible, except where the volume is relatively great and in the case of critical overwintering habitats.

3A.2.4.2.2 Operation and Maintenance

The effects of operation and maintenance of the proposed pipeline on aquatic ecosystems in the Arctic Division should be minor. A discussion of possible specific effects closely follows a discussion of the impact of construction.

The life of the pipeline may run several decades, and during this time it is possible that the extent of maintenance of stream crossings in some locations will approximate initial construction activity. For the most part in the early years, extensive maintenance of stream crossings is not expected.

The effects of construction will continue into the operation and maintenance phase, mainly through erosion where construction activity has taken place in streams and ponds, and particularly at stream crossings by road and pipeline. Stabilization around bridges, culverts, training works, and settling ponds may require several years. The effects of siltation resulting from erosion will depend on the increase in silt load relative to the natural level, and upon its duration.

Treated sewage input from compressor stations, maintenance stations, or other camps will occur throughout the life of the pipeline. Specific disposal sites have not been identified. Eutrophication resulting from nutrient enrichment should be mild and limited to localized areas immediately downstream of the effluent discharge.

Low level addition of toxins to waters may occur from chemicals used in sewage treatment and from petroleum by-products of machinery operation; effects should be minor, however, except in the case of accidents.

Withdrawal of water for camp use is discussed under construction. The quantities involved are expected to be smaller because of the smaller numbers of permanent personnel at stations.

Human pressure on aquatic resources is expected to increase with the opening of the Alyeska haul road, following completion of construction. The quality of resources (fish populations, recreational areas) may decline in newly accessible areas to the level currently found in similarly accessible areas of interior Alaska.

3A.2.4.2.3 Accidents

Petroleum and many derivatives are toxic to plants, invertebrates, and fishes; therefore accidental spillage during any phase of the proposed project could have a detrimental effect on the aquatic environment. Damage to organisms occurs through oxygen depletion of the water by prevention of surface gaseous exchange, coating of gill filaments by suspended oil globules, and the presence of toxic soluble fractions (Wiebe, 1935).

Influence to aquatic systems by wildfire occurs through introduction of nutrients and solids by run-off resulting from erosion in burned areas. Attempts to contain fire by use of heavy equipment can have greater ecological impact than the fire itself, since surface disturbance precipitates erosion. Additionally, fire-fighting chemicals may subsequently appear in the aquatic environment.

3A.2.5 Socioeconomic Considerations

This section addresses the potential socioeconomic impacts of construction and operation of the proposed Alaskan Gas Pipeline, the LNG Plant and the Alaskan Marine Terminal on the Alaskan population and economy. The analysis proceeds from the baseline of land use, population and economic characteristics developed in Sections 2A.7-2A.9, which was predicated heavily on projections of impacts of the Trans-Alaska (Oil) Pipeline. The baseline year for this impact assessment is 1977, which is the year assumed for the commencement of extensive on-site construction activities for the gas pipeline system. On the basis of this schedule, the system would start up in mid-1980, and would commence full scale commercial operations some 18 months later.

As with the Baseline descriptions in Section 2, this section is organized in terms of those study areas generally corresponding to the three geographical divisions developed for geological and ecological analysis, i.e., the Arctic, Interior, and South Coastal Study Areas. Such format is however, somewhat artificial for economic analysis purposes, because in a number of instances Project impacts are not allocatable to a specific geographical area.

In the short-term, construction of the Alaskan Gas Pipeline will have its own direct effects. However, there is no reason to assume that they will be dissimilar from the short-term direct effects produced by the construction and operation of the Alyeska oil pipeline. From a macro-perspective, the same is true in the long-term. Therefore, for purposes of making population, labor force, and certain other impact estimates, the two projects must be considered as extensions of each other. Generally, however, this analysis of socioeconomic impacts is an assessment of the additional and incremental changes in economic and social trends already set in motion by the Alyeska pipeline.

Construction and operation of the Alaskan Gas Pipeline system will have diverse impacts on various goods-and services-producing sectors of the Alaskan economy (including the state and local government sectors), which will tend to be distributed in a non-uniform fashion among the regions and population of the state. For example, the transportation sector is more sensitive to Project construction activities than it is to operations, compared to other sectors, and such impacts are most pronounced along the pipeline corridor. In contrast, the mining, agriculture, and forestry sectors are relatively little affected by either construction or operations. With the possible exceptions of potential impacts on state and local government finances, and impacts of LNG tanker operations on fishing in Prince William Sound, long-term effects tend to be diffused. To economize on presentation of the analyses of sector impacts; the discussions have been consolidated into a single subsection, General Impacts on Public Finances and Economic Output (3A.2.5.2), where they are presented with the following headings:

Subsection	Title
3A.2.5.2.1	Taxes and Public Finances
3A.2.5.2.2	Petroleum Development
3A.2.5.2.3	Mining
3A.2.5.2.4	Fisheries
3A.2.5.2.5	Agriculture
3A.2.5.2.6	Forestry
3A.2.5.2.7	Electric Power
3A.2.5.2.8	Transportation

In the case of public finances, subsection 3A.2.5.2.1 assesses likely impacts on state-wide public finances. This is necessary for an adequate appreciation of specific impacts on the public finances of each of the study areas. Specific local and regional fiscal impacts are subsequently addressed in each of the Study Area subsections (Arctic-3A.2.5.5.5; Interior - 3A.3.5.3.5; and South Coastal - 3A.4.6.3.5).

Preceding the impact analysis for each study area is a brief description of gas pipeline construction and operational characteristics having an impact on the socioeconomic environment (e.g., numbers of workers, estimated share of capital investment and operating costs, major facilities, and the like). Concluding each study area subsection is a brief summary of the major population, economic and land use impacts that the respective Study Area will experience as a result of the implementation of Applicant's Alaskan Project.

3A.2.5.1 Analytical Approach to Impact Assessment

The general approach to assessment of the socioeconomic impacts of the Alaskan Project has been to develop estimates of changes in land uses, employment and population directly and indirectly caused by the project, and to identify their effects on the state in terms of the three Study Areas. The analysis focuses primarily on the construction period, 1977-1981, but long-term impacts are identified and assessed as appropriate.

3A.2.5.1.1 Projection of Population and Employment Changes, 1977-1982

The analysis of the population and economic impacts of the Alaskan Project is built upon two basic assumptions:

1) That both the construction of transportation systems for North Slope oil and gas, and the ultimate production and transportation of these products, will be basically similar in an economic sense, so that the social impacts of both oil and gas development will take roughly the same form and have roughly the same geographical distribution; and,

2) That no changes unrelated to the gas pipeline, will occur during the time frame of this study which could stimulate other major changes in Alaska's population and economy.

As previously stated, this study projects a socioeconomic baseline in 1977 which considers the oil pipeline project only, and not any additional factors that could have a profound influence on the economic situation in the same time frame. For example, significant changes in world prices for gold, copper, and coal; the success of state and international efforts to rehabilitate the salmon and shellfish industry; national demand for Alaska's recreational resources; congressional and bureaucratic decisions regarding D-1 and D-2 lands in Alaska; and other similar forces could all alter the picture of Alaska's future. However, to construct alternative development scenarios for Alaska around these and other possibilities would be a difficult and highly speculative undertaking.

To arrive at population estimates for the years 1977-1982, a method was developed to extrapolate from past patterns of employment and labor force size in the state. The relative proportion of construction workers in the total labor force is known, as is the historic level of unemployment. Also known is the relationship of the total labor force to the total population. With these data, it was possible to make projections from the year 1977 on the basis of estimates of future manpower requirements in the construction sector. These estimates were developed from the econometric study prepared by the Human Resources Planning Institute (HRPI) for the University of Alaska's Institute for Social, Economic and Government Research (Human Resources Planning Institute, 1974), which developed projections of permanent changes through 1983 in employment and population to be induced by the Alyeska oil pipeline. Using the HRPI study projections of construction sector employment to the year 1983 as a baseline, the direct employment related to the Alaskan Project, derived from engineering estimates, was superimposed. An estimate of the induced increase in permanent construction employment was then developed on the basis of the HRPI study projection of changes in sector employment to be induced by the Alyeska project. For example, it was estimated that during periods of pipeline construction force build-up, a level of induced employment equivalent to 60 percent of the preceding year's change in direct employment would develop, and after direct employment peaked, induced employment would eventually stabilize at a permanently higher level than before the project, the assumption being that the pipeline project was of such great magnitude that it would cause a permanent increase in the level of Alaska's population and economic activity.

Data used to develop the construction employment projections are presented in Table 3A.2-1, and are depicted graphically in Figure 3A.2-2 following. The increases in permanent construction employment that result from the surges of direct employment for the pipelines are indicated by the shaded areas. The data for baseline (permanent) construction employment, in turn, were the basis for population increase projections, which were developed by expanding the level of the permanent construction labor force in each year to its corresponding level of total employed persons, total labor force and, finally, total population on the basis of observed numerical relationships between the groups. The projections of total population are presented in Table 3A.2-2. Population projections which result lie in the middleground of population projections made by other agencies, such as the Department of Labor's Research and Analysis Section (Dept. of Labor, 1974), the state governor's Division of Planning and Research (1974), and the State Legislature's Special Petroleum Impact Committee (Legislative Affairs Agency, 1974).

Differences in population estimates vary with such things as the number of dependents per member of the labor force, level of employment, and the share of employed labor force accounted for by the construction sector. The estimates used herein (ranging from 1.1 to 1.2 dependents per working-age person in the labor force; 10 to 12 percent unemployment; and a gradually rising share of employed labor force accounted for by the construction sector, from 6.5 percent in 1973, to 8.2 percent in 1977, and 8.7 percent in 1982) appear to be reasonable in light of the state's recent economic and demographic evolution. A major shift in, for instance, the number of families migrating to the state, or in the level of investment in new construction, could change the overall population growth picture.

Impacts upon social services, such as education, police, protection and health services, are treated in much the same manner as population projections. That is, data for the 1977 baseline are projected, and the Alaskan Project impacts are then based upon these projections.

TABLE 3A.2-1

ALASKA PROJECTED CONSTRUCTION EMPLOYMENT, 1973-1983
(Average Annual Number of Workers)

Year	Long-Term Baseline Trend[1]	Long-Term Employment Impact of Alyeska Pipeline (Col. 1 plus Induced)[2]	Employment Impact of Alaskan Project			Total Projected Construction Employment	
			Direct	Induced[3]	Cumulative Induced	Baseline[4]	Total[5]
1973	7,700	7,700	0	0	0	7,700	7,700
1974	8,450	8,450	0	0	0	8,450	12,300
1975	8,800	11,000	0	0	0	11,000	18,200
1976	9,150	12,750	0	0	0	12,750	18,300
1977	9,525	14,000	1,300	0	0	14,000	14,000
1978	9,875	13,650	6,200	750	750	14,400	20,600
1979	10,225	14,000	7,700	2,900	3,650	17,650	25,350
1980	10,575	14,360	4,300	290	3,940	18,300	22,600
1981	10,950	14,720	1,900	40	3,980	18,700	20,600
1982	11,300	15,100	0	20	4,000	19,100	19,100
1983	11,650	15,400	0	0	4,000	19,400	19,400

1/ Derived from sector projections in Human Resources Planning Institute, Inc., 1974, Vol. I, pp 39-41. Baseline trend extrapolated from 1866-1972 historical series.

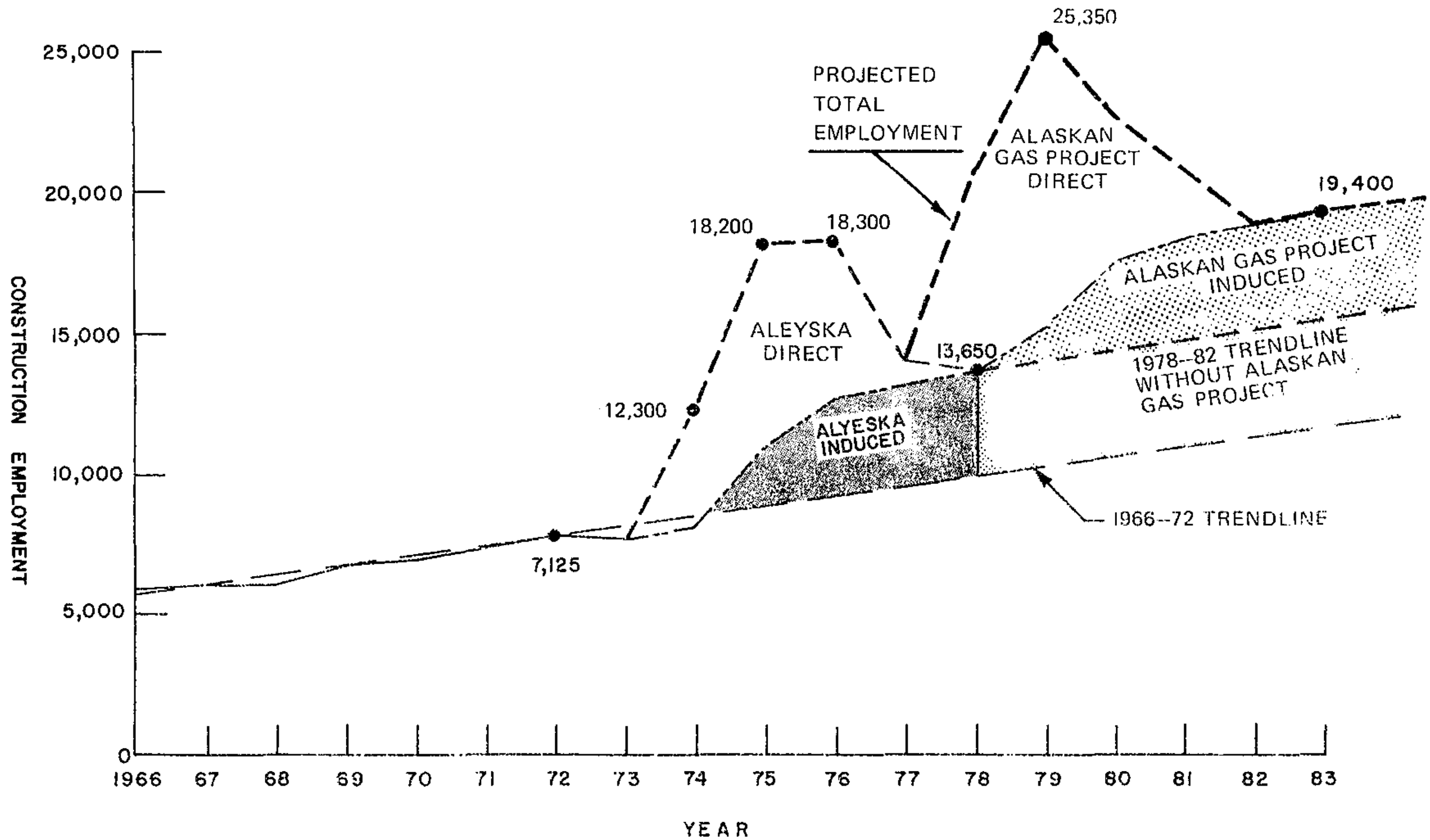
2/ Ibid. Alyeska direct employment averages: 1974 - 4200; 1975 - 7200; 1976 - 5600; 1977 - 800. Induced employment estimated as residual from subtracting Alyeska direct employment from Human Resources projection of total sector employment. (See cited reference). Data after 1977 are extrapolation using slope of 1966-72 trend.

3/ Induced component estimated at approximately 60 percent of preceding year's direct component during buildup of project work force. During decline of direct component of construction force, induced component estimated at approximately 10 percent of preceding year's increment.

4/ Represents permanent, baseline construction sector labor force net of pipeline construction workers (considered as short-term workers); consists of long-term baseline trend plus Alyeska induced employment (col. 2) added to Alaskan Gas Pipeline Project induced employment in sector (col. 5).

5/ Total construction sector employment (short-term plus permanent).

REF: DAMES & MOORE



NOTE:

HISTORICAL: 1966 - 1972

PROJECTED: 1973 - 1983

TRANS-ALASKA GAS PROJECT

ALASKA:
CONSTRUCTION EMPLOYMENT

FIGURE 3A.2 2

TABLE 3A.2-2

PROJECTED EMPLOYMENT AND POPULATION IMPACTS OF THE ALASKAN PROJECT, 1977-1983

Year	Baseline Construction Employment 1/	Percent Total Employment 2/	Projected Total Employment 3/	Projected Unemployed Rate 4/	Projected Civilian Labor Force 5/	Projected Total Population 6/
1977	14,000	8.24%	170,000	11%	190,000	426,000
1978	14,400	8.27%	174,000	12%	198,000	437,000
1979	17,650	8.37%	210,000	12%	238,000	500,000
1980	18,300	8.47%	216,000	12%	245,000	515,000
1981	18,700	8.57%	218,200	12%	246,500	520,000
1982	19,100	8.67%	220,300	11%	247,500	535,000
1983	19,400	8.67%	223,800	10%	248,700	547,100

1/ Table 3A.2-1. Estimated from trend of construction force 1966-72 incorporating projected change in sector permanent employment per Human Resources Planning Institute, 1974.

2/ Estimated on basis of observed and projected change in sector's share of total employment (HRPI, Vol. 1, pp. 39, 40).

3/ Column 1 ÷ Column 2 (equivalent to multiplying construction employment by the reciprocal of the sector's percentage of total employment).

4/ Per Alaska Department of Labor projected trends *i.e.*, that employment and unemployment rates change in the same direction.

5/ Column 3 ÷ Column 4

6/ Calculated by multiplying Column 5 by worker dependency factor; the long-term trend in Alaska has been 1.2 dependents per civilian worker. During the build-up of Construction on the Alaskan Project, this ratio is expected to drop temporarily as a result of the projected large influx of single men. Worker-dependency factors used were: 1977 and 1978-1.20; 1979, 1980 and 1981 - 1.10; 1982 - 1.15; 1983 - 1.20.

Estimates of potential project impact on the quality of life for various population groups in Alaska have been developed. While it is recognized that such concepts as life-style and community cohesion are not really quantifiable, it is nonetheless true that changes in them, as perceived by a community, can be more profound than the easily quantified physical and economic impacts of a project. Subjective judgments have been made of qualitative changes in community cultural characteristics likely to occur from the Alaskan Project. This has been done in the expectation that such assessment will be more closely associated with and useful to the people of Alaska, and will thus be more than a mere analysis of statistically quantifiable characteristics.

3A.2.5.1.2 Scope of Impact Assessment

As was indicated in Chapter 2 with respect to projecting changes from the present (mid-1974) to the baseline year of 1977, the impact analysis does not attempt to generate forecasts or predictions of conditions during and after the gas pipeline construction that take growth factors other than the proposed Alaskan Project into account. While the Project will be a major force in Alaska's development, it will not be the only growth factor, since government spending will continue for many years to be the prime mover of the economy. The projections of land use changes, population and employment growth, and changes in social and other economic characteristics represent estimates of likely developments attributable primarily to the Project; the long-term horizon for the Project, the paucity of reliable statistical data at the local level on population, social and economic activity and characteristics, and the highly aggregated nature of Project description data have all served to increase the difficulty of precise impact assessments. Accordingly, the findings and conclusions drawn in this Report are primarily useful for their indication of the direction and general magnitude of changes induced by the Project, and not for the precise values cited.

3A.2.5.2 General Impacts on Public Finances and Economic Output

3A.2.5.2.1 Taxes and Public Finances

Tax and Revenue Requirements

The Alaskan Gas Pipeline will generate large increases in revenues for the state and local governments of Alaska. The accelerated growth of the economy from the Alyeska oil pipeline project, along with the growth impacts of the Alaskan Project, will result in more and larger demands for public services as well as more tax and royalty revenues with which to finance a rapidly expanding scope and scale of public sector activity.

By 1980, the population of the state is projected at more than 500,000 persons. This represents a 200,000-person increase over

1970 census levels.[1/] It is estimated that in 1980 at least 50,000 persons will be directly or indirectly involved with the Alaskan Project (including workers and their dependents plus others who will have immigrated to Alaska because of growth induced by the Project). The related government and public service costs for this influx of people are enormous. As an indication of the magnitude of public expenditure increases that will be induced by the Project for additional costs of operation and capital development, the actions of the state government in 1974 are instructive.

Early in that year the state legislature approved legislation calling for a "Pipeline Impact Budget" to deal with public sector impacts of the Alyeska project. A total of $33.1 million was approved to be expended over the following two fiscal years in the areas of education, health, and social services, manpower training, natural resources, public safety, transportation and various public works. As of July 1974, the bill had not yet been signed into law. In a separate action, a Pipeline Impact Agency was approved (but not yet signed into existence) with an intial budget of $10.1 million. This agency would operate within the Department of Community and Regional Affairs. Also, impact funds totaling $10 million were appropriated and later disbursed to the Boroughs of Fairbanks (North Star), Anchorage, and North Slope, and to the Cities of Fairbanks, North Pole, Anchorage, Valdez, Delta Junction, and Barrow.[2/]

At the local level of government, borough and city governments were, in 1973 and 1974 projecting large increases in costs due to the Alyeska project (similar plans are likely in the late 1970's in anticipation of the Alaskan Gas Pipeline). As an example, in late 1973 the Greater Anchorage Area Borough (GAAB) (projected 1974 population, about 160,000) was estimating that, between 1974 and 1978, it would need to spend an additional $22.4 million to absorb a 24,000-person increase in population due to the Trans-Alaska Oil Pipeline (Greater Anchorage Area Borough, 1973). In the Fairbanks Area, The North Star Borough and the City of Fairbanks were estimating that nearly 11,000 persons would relocate to the area between 1974 and 1978. The public sector needs of these additional residents were estimated at almost $4 million in increased operating costs, and $26.5 million in capital outlays in fiscal years 1974, 1975 and 1976 (Alaska Legislative Council, February 1974). The data include provisions for construction of more than 100 additional classrooms costing $17 million.

Local governments will be able eventually to fund the increased operating and capital cost requirements through property taxes, sales taxes, user fees and state and federal revenue sharing. State revenue sharing is of particular importance because it is the means by which the state passes through its revenues from oil and gas production

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[1/] See subsection 3A.2.5.5.1 for projections of study area and state populations for 1977-1981.

[2/] See discussions of baseline public sector finances in subsections 2A.7.2.2, 2A.7.2.3 and 2A.7.2.4.

and property taxes and lease royalties. The local governments are currently (1974) facing a serious cash flow problem with respect to raising capital for facility expansion, however, owing to the time lag between the capital outlay and the receipt of increased tax revenues from the economic expansion of the area. It is in this area of interim capital financing that the state plays an instrumental role in securing capital at lower cost than can local jurisdictions.

Besides emergency impact appropriations, the state should stand ready to provide medium- to long-term capital to local governments requiring capital development assistance. The oil and gas revenues that the state will eventually receive when the pipelines are in full operation are excellent collateral and should assure the state of high bond ratings and low borrowing costs. It will be recalled from the discussion of baseline public sector finances (subsection 2A.7.2.2.2.7), that by 1977 the state is projecting its oil and gas tax and royalties at nearly $310 million per year, compared to only slightly more than $40 million in 1974. To anticipate slightly the discussion of specific government budget and revenue impacts of Prudhoe Bay gas production and the Alaskan Project, its full operation will generate an additional $89.1 million per year in gas production tax and royalty revenues, an increase over the projected 1977 level of nearly 30 percent. Proper debt management can assure all levels of government in Alaska of minimum cost debt capital; the oil and gas pipelines virtually guarantee the state's ability to secure highly advantageous credit terms.

State Policy Options for Royalty Gas Use

The State of Alaska may adopt any one of a variety of policy options in the use of its gas, which may be generally classified into two categories:

1. The state can take the cash value of the royalty gas and let the original owners of the gas distribute and sell it, or

2. The state can take its royalty gas in kind, and either sell it or use it as an input for various state-sponsored programs, from manufacturing petrochemicals to space heating.

Revenue computations in this Report are based on the assumption that the state would exercise the first option.

Overall Tax and Revenue Impact of the Alaskan Gas Pipeline

While the Alaskan Project in its entirety--pipeline, liquefaction plant, and marine terminal--approximates the Alyeska oil pipeline project in terms of manpower effort and capital investment, its social and economic impact in the aggregate probably will be significantly less than Alyeska's. The major reasons are; (1) the gas pipeline will be installed in the same Utility Corridor as the oil pipeline, and there will thus be a lesser net increment of disturbance of local conditions than occurred from the Alyeska project; (2) the gas pipeline project will be superimposed on an economic environment that will be substantially expanded (and will still be expanding) because of the Alyeska project; (3) many of the capital improvements in public service facilities and systems made necessary by the influx of people stimulated by the Alyeska project will have been constructed for much higher service levels than the peak of the Alyeska-induced population would require (capital expansion tends to be "lumpy" and not easily accomplished in small increments because of attendant operating cost diseconomies); and (4) it is expected that a much higher proportion of the construction force on the gas pipeline project will be Alaskan residents than was the case for Alyeska (many of the workers no doubt will have migrated to Alaska for the Alyeska project, however). Thus, when the proposed Alaskan Project is mobilizing and adding on to its work force, the number of short-term or long-term immigrant construction workers is likely to be significantly less than will be the case with Alyeska. Consequently, the aggregate additional burden on the public sector of the Alaskan Project-induced population growth should be relatively less than with the oil pipeline.

Government tax income from Prudhoe Bay gas production and the operation of the Alaskan Project will come from three principal sources: taxes on production (state); royalties on land leased by the state to producers; corporate income taxes (state); and property taxes (state and local).

Production taxes and lease royalties are based on the wellhead value of production and are levied on the producers. At present (mid-1974), estimates of the price of the Prudhoe Bay gas production have not been finalized (full production is not projected to commence until the end of 1981 at the earliest). Accordingly, for purposes of illustration, a nominal field selling price at the outlet of the producers' plant of 40 cents per million Btu has been selected (this value is related to fourth quarter 1973 prices and costs). Daily production after the achievement of full throughput is scheduled at 3,710,560 billion Btu per calendar day, or its equivalent, 3,283.20 million standard cubic feet per calendar day (MMcf/cd). At $0.40 per million Btu the total value of production per year would be $541.74 million. Assuming an annual full rate wellhead production value of, say $540 million, the gas production tax, at the current rate of 4.0 percent, would amount to $21.6 million per year. The lease royalties are figured at 12 1/2 percent of wellhead value; this would yield $67.5 million per year.

It should be noted that the production tax and lease royalties are not the liability of Applicant. Applicant's liabilities extend to property taxes and corporate income taxes only.

The state's corporate income tax is computed on the basis of six percent of taxable income. Applicant has provisionally estimated that after allowances for, depreciation, local taxes and other expenses chargeable to the Alaskan operation, Alaska State income taxes for the pipeline, gas liquefaction and loading operations would average about $24 million per year (1973 prices and costs) over the 25-year economic life of the system. This value represents the income tax on the average value added from transmission of the gas from the North Slope to the LNG Plant at Gravina Point, its liquefaction, and its loading on board the LNG carriers, net of operation expenses and allowable deductions. Federal income taxes for the overall Alaskan Project are projected to average $110 million per year.

Taxes on Applicant's real properties in the state are projected to total $63 million per year (on the basis of 1973 values of construction and equipment). Table 3A.2-3 presents rough estimates of system property taxes and their corresponding bases. These tax values are computed on the basis that ad valorem taxes will amount to approximately 1.75 percent of original capital investment. Inflation and tax rate increases could, of course, markedly increase the net dollar yields.

Most property taxes will be collected by the state under its uniform system for assessment of oil and gas properties. Current laws fix the state rate at 20 mills, with assessed value at 100 percent of full value. Local jurisdictions will receive most of the proceeds in the form of revenue sharing (which extends to production, taxes, and lease royalties as well). Local jurisdictions may also levy a tax equal to $1,000 per capita or, alternatively, equal to the product of multiplying 225 percent of the average per capita assessed value of property in the state by the number of residents in the community (State of Alaska, 1973). The geographical distribution of property taxes among the three Project Study Areas has been estimated on the basis of the location of the various facilities, and is presented in Table 3A.2-4.

As can be seen, the South Coastal Study Area could collect the largest portion of total taxes due mainly to the LNG Plant. The Interior Study Area would collect almost as much tax as the South Coastal, but the proceeds would be distributed over a greater area and population base. The Arctic Study Area would collect the least tax. It should be noted that the estimated taxes in Table 3A.2-4 probably are much lower than would actually be assessed, inasmuch as they are based on 1973 construction cost estimates which are likely to increase substantially as time passes. Also, the distribution of the proceeds of the state's portion of the property tax (which would be the large majority of the tax) may not be proportional to the location of the Project facilities. Some funds may be allocated to other parts of the state, for example, and some funds may be transferred between the Study Areas. No data upon which adjustments to these estimates can be made are available.

In total, the State of Alaska, including its various local governments, would receive additional direct tax and royalty income from the Prudhoe Bay gas production and transportation activities totalling more than $176.1 million per year on the basis of 1973 prices and costs.

TABLE 3A.2-3

ESTIMATED PROPERTY TAXES ON ALASKAN PROJECT
(1973 Dollars)

Facility	Estimated Capital Investment ($ Million)	Estimated Property Taxes ($ Million)
Pipeline	$1,940.0	$33.0
LNG Plant	1,600.0	29.0
Marine Terminal	58.0	1.0
Total	$3,598.0	$63.0

TABLE 3A.2-4

DISTRIBUTION OF ESTIMATED PROPERTY TAXES ON ALASKAN PROJECT, BY STUDY AREA
(Millions of Dollars per Year)

Facility[1/]	Total Tax	Arctic	Interior	South Coastal
Pipeline	$33.0	$6.6	$24.1	$ 2.3
LNG Plant	29.0	-	-	29.0
Marine Terminal	1.0	-	-	1.0
Total	$63.0	$6.6	$24.1	$32.3

1/Pipeline Tax proportioned according to distance within study area (Arctic-163 miles, Interior-592 miles, South Coastal-55 miles).

3A.2.5.2.2 Petroleum Development

The Alaskan Project's principal long-term economic impact on the Alaska petroleum section will be to stimulate continued development of Prudhoe Bay and other North Slope oil and gas reserve. Since much of the Prudhoe Bay gas occurs as casinghead gas (i.e., in association with oil), it is an inevitable by-product of oil production. Without a transmission system, the gas must be flared or reinjected into the reservoir. However, flaring is not permitted except in emergencies, and reinjection may not always be economical or desirable, since water pressure may provide sufficient driving force for the oil reservoir. Thus, the gas pipeline will permit a practical and economical means for the realization of the oil production potential of the Prudhoe Bay reserves, as well as provide a needed vehicle for transporting energy for consumption in the Lower 48 States.

It is projected that petroleum-related employment on the North Slope subsequent to 1977 will rise from about 1,500 workers to 1,650, and then gradually decline to a stable level of 1,100 men after the Project is completed in 1981.[1]

According to various studies by the University of Alaska (ISEGR, 1971a, 1971b, 1972) the capital intensive nature of Alaska's petroleum development implies relatively small employment impacts. Most of the benefits from development of the oil and gas resources will be from the revenues generated by severance and property taxes and royalties. One study estimates that oil fields discovered up through 1969 could be developed and produced with less than 3,000 workers, including pipeline and terminal work forces as well as personnel involved in the distribution of products for local consumption (ISEGR, 1971b). To quote the author:

> If other fields comparable to the Prudhoe Bay field were found nearby, five thousand permanent workers in drilling, production, pipeline and harbor service could deliver as much as one-third of North America's energy requirements for two or three decades.

Given the particular production characteristics of Prudhoe Bay natural gas, the Alaskan Project forms an integral part of the development process for the entire reserve. The pipeline will not generate a significant amount of direct employment; however, indirectly, the production and property taxes and the royalties it generates are of major importance to the state, and the ultimate benefits of the gas pipeline will be determined by the uses to which the state and local governments put the revenues.

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[1] see subsection 3A.2.5.4.3 for a more complete assessment of employment impacts on the North Slope.

3A.2.5.2.3 Mining

Hardrock mining in Alaska will probably not be affected in a significant, positive way by the construction and operation of the Alaskan Project. The future of the mining industry in the state hinges on the world price of metals; a determination of land ownership and management status (native selections, disposition of D-2 lands, and classification and disposition of D-1 lands[1/]); and the administration of various environmental regulations. The decision to pursue the development of the more promising ore deposits in the state (e.g., the fluoride-tin-tungsten deposit at Klukwan, the Kennecott Copper claims at Bornite, and the Wrangell Mountain copper deposits) will be largely determined by these three factors.

Construction of the Alaskan Project may work a temporary hardship on new mining ventures. Project construction activities will keep inflationary pressure on the state's economy, and it will force increased costs of manpower and materials needed by the mining industry. Also, Alaska's water, surface, and air transportation facilities would be oriented to pipeline construction needs, often to the disadvantage of other traffic. Most of the valuable ore deposits in Alaska are remote, and even without competition from pipeline construction, operating costs are higher in Alaska than elsewhere in the United States by a factor of two to three. Following construction, however, the presence of natural gas fuel for equipment operation, heating, and ore processing in the relatively remote areas of Alaska to be crossed by the proposed pipeline may spur new mining activity.

Coal mining is another activity that could be affected if natural gas replaced coal as boiler fuel in the Fairbanks area as it did in the Anchorage area in the late 1960's and early 1970's. The Usibelli Coal Mine at Healy (the only active coal mine in Alaska at the present time) could, in the 1980's experience the fate of the Evans Jones Coal Mine of the Matanuska field in south central Alaska, which closed in the early 1970's.

Export markets for coal could offset a decline in local demand. Coal has a large potential export market in Japan, where it is valuable as low sulphur boiler fuel (Alaska coal is not of metalurgical coking quality). Additionally, as gasification and other new coal reduction processes are perfected and made operational on a large scale, Alaska's coal fields may be worked more intensively regardless of the potential negative impacts of the Alaskan Project.

3A.2.5.2.4 Fisheries

The only potential direct impact upon the state's fishing industry of the Alaskan Project is the threat posed to fishing gear and small boat traffic in Prince William Sound from ocean-going LNG carriers. There may be negative indirect effects as well. In the

[1/] Public interest and national interest lands held by the federal government; see subsection 2A.7.3.1.1.

Interior, the increased accessibility of rivers and lakes for recreational fishing provided by the access roads may bring pressure on native subsistence and commercial fishing resources. Degradation of aethestic and ecological qualities in the bush near good fishing grounds is also a risk.

In the South Coastal Study Area, the high prices and employment opportunities created by the LNG Plant and marine terminal near Cordova may work hardships on the local fishing industry by increasing processing costs and drawing fishermen away from their traditional livelihood. However, these negative impacts, direct and indirect, even if fully realized, would only affect one of the five major fishing regions of the state, and would amount to only a marginal impact on the aggregate value of the state's fishing activity.

3A.2.5.2.5 Agriculture

It is unlikely that Alaska's agricultural industry will be affected significantly by the Alaskan Gas Pipeline and LNG Plant near Cordova. Conceivably, the gas pipeline could have some positive benefits for local agriculture on a very small scale: for example, waste heat from a gas-fueled electric power generation site might be utilized in hothouses to support vegetable growing. Such an operation would be inconsequential in a regional or statewide perspective, however. Also, gas sold locally might be used as feedstock for the manufacture of artificial fertilizers. The local market would probably not be large enough to support such a facility, however, at prices competitive with imported fertilizers. It will be recalled that the state must import 95 percent of its foodstuffs.

3A.2.5.2.6 Forestry

Construction of the Alaskan Project will create demand for sawn lumber, timbers and piling, some of which could be met by Interior Alaska sawmills; but neither the amount of lumber needed in 1977-81 nor the future capacity of Alaska's sawmills can be foreseen with any accuracy at this time.

Alaska's lumber industry (exclusive of the southeastern and south central regions) is very small, fragmented, undiversified, and technologically backward. This industry was not equipped to supply all of the demand created for lumber by exploration and early development work on the North Slope. In part, this was because Interior mills could only offer the local grade of spruce, which was unfamiliar to many contractors. Also, North Slope demand was not sufficiently developed to justify heavy indebtedness by Interior mills to modernize their plants and expand inventories. In June 1970, a forestry economist at the University of Alaska wrote:

> "The Interior Alaska suppliers have provided lumber, timber, and piling for the North Slope development, but to a large degree this new market has been only a supplement

to the existing local markets, and no producer could survive if his sole sales . . . were on the North Slope" (Snyder, 1970).

From this experience, it is evident that the fortunes of the forest products industry in Alaska is by no means tied to the oil and gas industry and pipeline construction. Indeed, all indications are that this industry will be only a peripheral source of demand, and that the Japanese will continue to be the major buyers of Alaska's wood products (spruce cants and spruce and birch chips).

3A.2.5.2.7 Electric Power

Natural gas from the North Slope fields has potential value as fuel for electric power generation in Alaska.[1/] Because it burns cleaner than coal and oil, natural gas is especially desirable boiler fuel in Interior Alaska where ice fog and winter air pollution are major problems; but the extent to which the Alaskan Gas Pipeline would be tapped for electrical power generation, and possibly residential use as well, is presently unknown. That is, the simple availability of this desirable fuel would not dictate the extent of its use. Comparative price and alternative energy sources, of which there are several in Alaska, would be decisive factors. Fairbanks is the most likely domestic market for natural gas utilization, so it is useful to examine its fuels situation in some detail.

Electric power generation in the Fairbanks area is presently from thermal generators fired by either coal or liquid fuel oil. Power plants on the three nearby military bases (Fort Wainwright, Eielson AFB, and the Clear Radar Site) all burn coal. The Fairbanks Municipal Utilities System (MUS) boilers are partially coal- and partially oil-fired, as are the boilers of the Golden Valley Electric Cooperative (GVEA). Both the MUS and GVEA have peaking power facilities and standby diesel generators. Comparatively inexpensive coal will be available for decades from the Healy fields, and there are now plans for a fully integrated crude oil refinery and electric power generation complex to be built in the Fairbanks area which will utilize North Slope crude. This facility is scheduled to go on stream at the same time the oil pipeline becomes operational, and it will be capable of supplying some 65 percent of the electrical needs for Fairbanks (in addition to gasoline, home heating fuel, and other refined petroleum products). This facility alone could satisfy the market for new energy demand in Fairbanks for the decade ahead.

By 1980, it is very likely that a hydroelectric site on the Susitna River midway between Anchorage and Fairbanks will be developed (the Devil Canyon site). Hydroelectric power is an attractive long-term energy alternative because its costs are virtually all fixed, and

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[1/]Natural gas (so-called "lease fuel") will be used to heat most of the North Slope production facilities and for the generation of electrical power for pipeline operations.

the power source is renewable. Fossil fuels, on the other hand, are expensive and will likely become more so in years ahead, and they are ultimately exhaustible. Hydroelectric power is also attractive to local utilities because it does not require new capital expenditures; the distribution companies simply buy the power delivered to their grids. In Fairbanks, hydroelectric power has an additional advantage because it does not contribute to air pollution. In Anchorage, some 70 percent of power generation is currently from gas-fired boilers. Much of this fuel is dry gas from the nearby Beluga and Kenai gas fields, but some also is casinghead gas that is a by-product of oil production in Cook Inlet, where oil operators have been prohibited by the Alaska Oil and Gas Conservation Committee from flaring casinghead gas. Cook Inlet oil fields are now in decline, and the availability of casinghead gas will decrease also. Moreover, gas is being injected into some Cook Inlet oil wells for secondary recovery, further limiting the supply. Without new gas and oil discoveries in Cook Inlet, Anchorage utilities may need North Slope gas in the 1980's. However, there appear to be good prospects for new discoveries in Cook Inlet, especially the lower Cook Inlet. Therefore, Anchorage does not appear to be a potential beneficiary of the Alaskan Project for electrical generation.

3A.2.5.2.8 Transportation

Construction of the trans-Alaska oil pipeline will produce major, direct impacts on the transportation industry in the state. Indeed, this industry has burgeoned in response to the demand of oil development, with equipment inventories and services expanding in every sector--truck, rail, air and barge. The transportation industry is one of the major benefactors of the Alaskan oil and gas industry.

Construction of a gas pipeline within the designated Utility Corridor would result in the maintenance of high levels of transport demand after the oil pipeline project winds down. However, because much of the infrastructure of the oil and gas industry is being presently assembled in conjunction with the Alyeska oil pipeline, transportation demand after 1977, for which the Alaskan Project is alone responsible, will not match current levels.

Indirectly, of course, the transportation industry will benefit from oil and gas development to the extent that these industries will lead the state into a period of general economic prosperity. At current rates of expansion (7 percent per year in air transport services and an estimated doubling in highway traffic levels during the peak of work on the oil pipeline). It appears likely that, by the early 1980's, transport activities by all modes will be several times larger than during the early 1970's. The proposed Alaskan Project will have been a significant contributor to the overall growth of the transportation sector.

3A.2.5.3 Project Activities Affecting the Arctic Study Area

Project activities in the Arctic Study Area will consist of construction and operation of a 162.5 mile segment of the Alaskan Gas Pipeline from Prudhoe Bay to the crest of the Brooks Range. Related facilities will include three compressor stations, a maintenance base, and various support facilities (communications stations, helicopter pads, access roads, etc.).

The total cost of the pipeline (exclusive of the LNG Plant and marine terminal at Gravina Point) is projected at $1.94 billion, of which $373.5 million is labor cost.[1/] If it is assumed that costs are generally proportional to the length of pipeline, the 162.5-mile Arctic section would account for 20.1 percent of the 809.2-mile total pipeline length, and therefore account for about $389.8 million of total capital costs. By the same reasoning, payroll costs would exceed $75 million.

On-site construction activities are scheduled over a 4-1/2 year period for the entire project, and the peak number of workers on the entire pipeline is projected to range from about 3,200 in late 1977 to 4,200 in late 1978 and early 1979 and to about 1,500 throughout 1980 and 1981. During the 1978-79 period of maximum employment, it is likely that over 800 pipeline construction workers would be active on the Arctic Study Area portion of the project.

After the gas pipeline becomes fully operational in 1981, a total of 268 operations personnel will be required. These personnel will be distributed among the 12 compressor stations and four maintenance bases along the pipeline. The Arctic Study Area's share of these personnel would be about one-fourth of the total, or 65-70 men, who would be working on a rotational basis. However, only 36 of these personnel would actually reside in the Arctic area at any one time. The households and families of these operations personnel would be located in Fairbanks or Anchorage as no dependent's quarters are to be provided on the North Slope.

The total annual operating and maintenance expenses for the pipeline are projected at $71.1 million (1973 prices and costs), of which $9.0 million are for labor. Ad valorem taxes of about $33 million per year are an additional expense. Projecting the Arctic Area's share of total costs at 20.1 percent, payroll and other operating and maintenance expenses for the North Slope section of the Project are estimated at $14.3 million per year, with $1.8 million for labor and $12.5 million for materials, lease fuel (gas drawn off to fuel compressors and power generators) and other supplies. For convenience the foregoing project characteristics are summarized in Table 3A.2-5.

[1/] Costs include ad valorem and sales and use taxes, but exclude interest during construction.

The proposed gas pipeline has a projected economic life of 25 years. The 25-year economic life is an arbitrary figure, of course, and in the event more gas reserves are added to the North Slope supply, the Project's life would be extended. At the end of that time, the system would be dismantled and, to the extent possible, the land restored to its native state.

TABLE 3A.2-5

PRINCIPAL PROJECT CONSTRUCTION AND OPERATIONS CHARACTERISTICS, ARCTIC STUDY AREA

Length of pipeline in area -	162.5 Miles
Number of compressor stations -	3
Number of maintenance bases -	1
Estimated capital costs ($ 1973) -	$389.9 Million
Estimated direct construction labor costs ($ 1973) -	$ 75.0 Million
Estimated maximum construction labor force (1978-79) -	840
Estimated annual operation costs ($ 1973) -	14.3 Million
Estimated annual operating payroll (65-70 men) -	$ 1.8 Million
Estimated annual ad valorem taxes -	$ 6.6 Million

3A.2.5.4 Land Use Impacts

3A.2.5.4.1 Land Ownership Changes

General Background

For the Alaskan Project in general, the total initial land requirement will amount to about 17,000 acres, of which some 5,750 acres will be permanently (for the life of the Project) removed from present uses. The 809-mile-long and 150-foot-wide pipeline right-of-way will consume an estimated 14,713 acres, of which some 9,465 acres will be restored and returned to original uses following construction (see Table 3A.2-6).

Other permanent land requirements are: roads-145 acres; 12 compressor station sites-216 acres; the LNG Plant and marine terminal site-450 acres; tunnel sites (storage of excavated material) -100 acres; four maintenance base sites-26 acres; 15 communication sites-8 acres; and 50 helicopter pad sites-10 acres.

TABLE 3A.2-6

LAND USE REQUIREMENTS FOR ALASKAN PROJECT: PERMANENT USES

Requirements		Acres
Twelve compressor station sites,		216 acres
Pipeline right-of-way (809.2 miles long and 53.5 feet wide),		5,247 acres
Fifty sites for helicopter pads,		10 acres
Fifteen sites for communication facilities,		8 acres
Sites for four maintenance bases and two meter stations,		26 acres
Sites for permanent storage of spoil from tunnel construction,		100 acres
Roads providing continuous access to compressor stations (22 miles long and 50 feet wide),	133 acres	
Roads providing access to construction camps and temporary pipe storage yards (50 feet wide and 2 miles in length)	12 acres	
Total permanent road area	145 acres	
Total permanent land area		5,752 acres

Temporary use lands (for which permits must be secured), construction camps (132 acres), material source sites (60 acres) work space at river crossings (36 acres), the restored pipeline right-of-way (9,465 acres) and access roads (1370 acres) represent the total temporary land needs.

Arctic Study Area

The project will have little impact on private land ownership patterns in the immediate impact zone. Wherever possible, the right-of-way for the proposed pipeline is located within the designated Utility Corridor, which fact will serve to facilitate land acquisition and minimize impacts resulting from acquisition.

There is not expected to be any impact upon land ownership in the Arctic Study Area for the extended zone (land adjacent to the right-of-way). As of mid-1974, the state had no plans for any land sales on the North Slope. Lands are normally offered for sale as a result of demonstrated interest by the public, and no such public interest is expected to develop as a result of the proposed pipeline.

3A.2.5.4.2 Land Use Pattern Changes

In the immediate effect zone (i.e., the right-of-way of the pipeline), the land use changes produced by the Project in the Arctic Study Area involve the clearing of the right-of-way, and the establishment of sites for three compressor stations, three communication facilities, one maintenance base, and service roads to various facilities. Additional acreage will be needed for helicopter pads, an operations base and a meter station. For a listing of land use by acreage for the Project, see Table 3A.2-6. Where possible, the construction camps built by Alyeska will be used by crews working on the Alaskan Gas Pipeline. Borrow sites for gravel have not yet been specifically located, but will be designated by permitting agencies having such responsibility.

The present pattern of land use for the right-of-way may be termed one of "energy transportation," because the area was set aside specifically for that purpose (the "Utility Corridor"). The building of the proposed natural gas pipeline would be in keeping with that land use. The buried, refrigerated pipeline is not expected to interfere with the wildlife or with hunting activities once it is in place, but construction activities are likely to be temporarily disruptive to subsistence hunting.

Access roads would be used to connect the pipeline right-of-way to the State-Alyeska Road, construction camps, material storage sites, and telecommunications systems. The total length of proposed access roads for the Project is 250 miles (both temporary and permanent).

The proposed gas pipeline, though contained within the Utility Corridor, would deviate in its course from that of the Trans-Alaska oil pipeline in the Arctic Study Area. The gas pipeline will in in most cases be one to three miles west of the oil line, on higher ground above the Sagavanirktok River.

River crossings will generally present no problem other than a need, in some cases, for extra work width. In the Arctic Study Area, only one stream, the Putuligayuk, will require extra work space.[1]

The Project is not expected to have an impact upon the extended effect zone in the Arctic Study Area. There are no communities or other forms of intensive land use adjacent to the right-of-way. The nature of the climate, the present land use, and public ownership have deterred any changes. The building of the pipeline would not change these factors, and there are not expected to be any effects upon the land use pattern of the communities of Prudhoe Bay and Deadhorse.

Impact of the project on the land use pattern of the diffused impact area in the Arctic Study Area are likely to be indirect, in the sense that tax and royalty revenues levied on gas production will benefit the North Slope Borough and the City of Barrow through state-local revenue sharing. The development of the haul road for construction of the Alyeska oil pipeline will have had the most significant direct impact on Study Area land use patterns, by increasing the accessability of the area to recreation and tourism.

3A.2.5.4.3 Community Changes

The gas pipeline right-of-way does not pass through any communities in the Arctic Study Area. The four communities of Barrow, Kaktovik, Nooiksut and Anaktuvuk Pass are likely to feel the effects of the proposed gas pipeline such effects will include sustaining the increased incomes which some native families will have achieved as a result of prior employment by Alyeska. Changes in lifestyle as a result of pipeline construction employment may cause changes in homesites and home construction styles, as well as in the building of new residential areas, additional road and sewerage facilities and schools.

Service-related establishments (e.g. restaurants, drugstores, bowling alleys) for local people, as well as for tourists may increase as the level of income rises. Barrow and Deadhorse are most likely to experience these changes. Native claims settlement payments to natives and the North Slope Borough, together with expanded state support of local welfare and development programs, will also stimulate commercial and residential growth in Barrow and other native villages.

[1] Some stream crossings will require extra work width. The use of this land, estimated at 36 acres, is only temporary and will be returned to its natural state following construction.

TABLE 3A.2-7

BASELINE PROPULATION PROJECTIONS FOR STUDY AREAS, 1977-1983
WITHOUT ALASKAN PROJECT
(Thousands of Persons)

Study Area	Year 1977	1978	1979	1980	1981	1982	1983
Arctic	5.5	5.5	5.5	5.4	5.4	5.5	5.5
Interior	66.2	67.0	68.1	69.6	70.5	71.1	71.7
South Coastal	209.0	210.8	212.6	215.6	223.0	230.2	238.0
Other	145.4	148.7	157.8	157.4	162.3	167.7	172.8
Total Alaska	426.0	432.0	444.0	448.0	461.2	474.4	488.0

Source: Derived from Department of Labor, 1974.

Note: Totals may not add due to rounding.

TABLE 3A.2-8

IMPACT POPULATION PROJECTIONS FOR STUDY AREAS, 1977-1983
WITH ALASKAN PROJECT
(Thousands of Persons)

Study Area	Year 1977	1978	1979	1980	1981	1982	1983
Arctic	5.5	5.5	6.1	6.0	5.7	5.7	5.6
Interior	66.2	69.9	83.8	90.0	89.9	89.7	89.5
South Coastal	209.0	215.3	257.6	261.8	266.3	273.3	279.2
Other	145.4	146.3	152.5	157.2	158.1	166.3	172.8
Total Alaska	426.0	437.0	500.0	515.0	520.0	535.0	547.1

Note: Above table based on projected changes in construction employment. See subsections 3A.2.5.1.1 and 3A.2.5.1.2. Totals may not add due to rounding.

3A.2.5.4.4 Land Use Planning Changes

No substantial immigration into the Arctic Study Area is foreseen which would require land use planning as a result of the construction and operation of the proposed pipeline. One of the principal agents for land use planning in the Arctic Study Area is the Joint State - Federal Land Use planning Commission. This 10-member commission will be instrumental in deciding how the vast federal and state holdings on the North Slope will be used, and is currently (1974) directing a study of land management systems in Alaska. The Commission has been active in assisting native groups in making land selections, and has conducted hearings relative to the Utility Corridor in the past (Joint State Federal Land Use Planning Commission, (1974).

The construction and operation of the proposed Alaskan Gas Pipeline may accelerate the need for local land use planning in some of the communities of the North Slope. Increased incomes may, as noted earlier, lead to residential expansion, which such communities as Barrow would want to control in order to reduce problems associated with providing utilities and other community services.

An increased need for planning in North Slope communities would have an obvious impact upon the North Slope Borough government. A planning department for the Borough is currently being organized (1974) and should soon be equipped to handle the needs of its communities. Adequate planning by the Borough can greatly enhance the benefits of native settlement claims payments, and make better use of state oil and gas revenue-sharing funds.

3A.2.5.5 Population and Economic Impacts

3A.2.5.5.1 Population Changes

Tables 3A.2-7 and 3A.2-8 present the projected population growth of the various Project areas including the Arctic Study Area, both with and without the Alaskan Project. Projections are not provided for individual communities because of the difficulty in allocating area-wide growth aggregates to individual small villages. Table 3A.2-9 shows the projected net changes in population due to the Alaskan Project during construction.

The figures presented in Table 3A.2-9 represent those persons needed for pipeline construction work in the Arctic area. Secondary, induced population growth of the kind that will occur in Fairbanks and other communities in Alaska will probably not occur at Deadhorse or Prudhoe Bay, because these settlements are company-owned

TABLE 3A.2-9

ESTIMATED ANNUAL CHANGE IN POPULATION DUE TO ALASKAN PROJECT CONSTRUCTION, 1977-1983 ARCTIC STUDY AREA

	Year						
	1977	1978	1979	1980	1981	1982	1983
With Project	5,500	5,500	6,100	6,000	5,700	5,700	5,600
Without Project	5,500	5,500	5,400	5,400	5,400	5,500	5,500
Impact	0	0	700	600	300	200	100

Note: Above data are computed by subtracting data in Table 3A.2-7 from corresponding figures in Table 3A.2-8.

and directed, and all growth will be controlled by industry. There are no plans to develop "company towns" like those once planned for the Lost River fluorite mine on the Seward peninsula.

It is probable that induced, secondary growth will occur in Barrow and the other Eskimo settlements in the Arctic area, which will be only partly a function of the oil and gas industry 200 miles east. It will also be a function of the political and economic development spurred by the Alaska Native Claims Settlement Act (ANCSA), the North Slope Borough, and the Arctic Slope Native Association. Pipeline work will be the source of income for a significant number of local residents, which will have a salutory effect on the economy of Barrow and the Arctic area. The expectation is that, throughout Alaska, the regional social and economic activity stimulated by ANCSA will promote out-migration of working-age males and females. The assumption is that greater opportunities for employment and meaningful leadership roles will attract motivated and educated youth back to the villages and regional centers. This will doubtless occur in the Arctic area, and the proximity of the oil and gas industry will surely amplify it. It is conceivable that the rate of growth in Arctic communities could reach 3 percent a year.

The rate of population growth during Project construction should peak in about 1979. According to existing plans, construction workers will be housed in temporary facilities provided by pipeline contractors, and all needs for personnel health services, police protection, and transportation will be provided by the companies involved. During both construction and operation, dependents will not be allowed in the camps, and construction personnel (other than supervisors who will remain in Alaska for the duration of construction) will be discouraged from bringing their dependents to Alaska. Dependents of supervisory personnel in the Arctic will most likely reside in either Anchorage or Fairbanks.

Once construction is completed, it is estimated that some 51 persons will be involved in the maintenance and operation of the Arctic area portion of the Alaskan Gas Pipeline.[1/] Maintenance and operating personnel will not keep their families at the maintenance camp or the three compressor stations located north of the Brooks Range; the families will probably live in Fairbanks or Anchorage. Thus, in 1982 there should be no more than 51 persons associated with the Alaskan Gas Pipeline in the Arctic area, and this level should remain constant for the 25 year lifetime of the Project.

Age Distribution

The impact of the Alaskan Project upon age distribution will generally be that of increasing the proportion of persons in the working ages, decreasing the Demographic Dependency Ratio[2/] and decreasing the relative numbers of elderly. These changes are for the entire Arctic Study Region population; however, the DDR for natives may remain high, since most pipeline-related people will be in Deadhorse, Prudhoe Bay, the maintenance camp, and the three compressor stations. The communities of Barrow, Anaktuvuk Pass, and Kaktovik may not have any appreciable age distribution changes due to the presence of the proposed gas pipeline.

Sex Ratio

The Sex Ratio for the Arctic Study Area may become even greater than that shown in Section 2A.7.3.2. Most of the employees of the Alaskan Gas Pipeline in the Arctic area will be males. Since there is no corresponding growth of employment opportunities for females, and because pipeline employees' families will be located elsewhere, the area's Sex Ratio will increase. However, for native villages (Barrow, Anaktuvuk Pass, and Kaktovik) the long-term Sex Ratio will probably remain about the same.

1/ Not all 51 operating personnel will be working in the Arctic Study Area at the same time. Of the 51 men proposed only 36 men will be present at any given time in the Arctic. Of these 36 men, 30 will be stationed at Maintenance Base A and Compressor Station Number 3, and two each will be functioning as operators of the three compressor facilities in the Study Area. Of the remaining 15 men, 6 will be stationed at control headquarters outside the Arctic, and 9 will be off duty, presumably on R & R in Fairbanks or Anchorage.

2/ The Demographic Dependency Ratio (DDR) is the ratio of the number of persons younger than 16 plus the persons 60 and older, divided by the number of persons between the ages of 16 and 60 years; the quotent is then multiplied by 100.

Vital Statistics

The Birth Rate[3] statistics for the Arctic Study Area will show a decline because of the Alaskan Gas Pipeline; however, this is purely a statistical phenomenon, in that the denominator (total population) will change without a corresponding change in the numerator (number of births). In point of fact, the Project should have no direct impact upon fertility, and the rate of natural increase of the native population should remain high.

Educational Characteristics

The educational level of all citizens of the Arctic Study Area should generally increase in the future. Part of the increase will be the result of educational programs for natives, and part will be due to the in-migration of persons associated with the Alaskan Gas Pipeline, many of whom will have higher levels of education than are now common in the Arctic.

3A.2.5.5.2 Quality of Living Changes

The Alaskan Gas Pipeline will, of itself, have little impact upon the lifestyles, social and public services, and community cohesion of residents living in the Arctic Study Area. Construction of the Trans-Alaska Oil Pipeline will have had the initial and major impact upon life-styles in the area influenced by the pipeline and the effect of the gas pipeline project will be to extend and prolong the forces of change. The primary life-style affected in the Arctic would be that of the Eskimo.

The oil and gas pipelines will increase the rate of cultural change experience by the Eskimo and other natives residing in the area. The increased rate of interaction between natives and non-natives, together with the circulation of comparatively large amounts of money, will tend to erode traditional folkways and mores of these people. It is also predictable that traditional reliance on subsistence resources will be reduced as the availability of cash increases. Because the traditional Eskimo culture has been based upon a subsistence life-style, further inroads into this existence will inevitably hasten the passing of the distinctive Eskimo culture.

The State-Alyeska haul road paralleling the pipelines probably will bring more tourists and hunters to the area, and increased hunting

[3] The birth rate is the number of live births in a year divided by the mid-year population (1,000's).

pressure on wildlife by non-natives will, if not properly controlled, reduce the availability of animals upon which the many native groups base their subsistence economy.

The Alaskan Project should, of itself, have no direct impact upon public safety, public health, or public education in the Arctic Study Area outside of the work camps. The construction camps, maintenance camps and compressor stations are designed to be self-sufficient with respect to such services; however, there will occasionally be situations in which a patient is sufficiently ill to require transportation to a hospital in Barrow or Fairbanks. Furthermore, there may be occasional problems which will require police action, but the extent of requirements for these services cannot be predicted with accuracy.

3A.2.5.5.3 Employment Changes

By the beginning of 1978, the level of employment in the Arctic Study Area is projected at about 2,200 persons. About one-half of the employed persons will be associated with oil and gas development activities at Prudhoe Bay and elsewhere on the North Slope. The other one-half will consist primarily of Eskimos and other natives living at Barrow, Anaktuvuk, Kaktovik, and other Arctic communities.4/ The long-term trend of employment expansion, taking the effects of the Alyeska oil pipeline into account, is one of relatively low, but potentially accelerating, growth. The combined impacts of petroleum development and intensifying regional economic and social development fostered by ANCSA probably will stimulate population and employment expansion in native communities. The Alaskan Project will accelerate the process. Projected trends in baseline and gas pipeline employment in the Arctic Study Area are presented in Table 3A.2-10.

4/See subsections 2A.7.3.2.3 and 2A.7.3.2.4. It should be noted that employment opportunities for natives to work on the gas pipeline project will parallel those generated by the Alyeska oil pipeline project. The Applicant is prepared to subscribe to a hiring and training agreement with the state and federal authorities similar to that undertaken by Alyeska Pipeline Service Co.

TABLE 3A.2-10

PROJECTED EMPLOYMENT, ARCTIC STUDY AREA, 1977-1982
(mid-year)

	1977	1978	1979	1980	1981	1982
Baseline Employment	2,200	2,050	2,100	2,150	2,200	2,250
Petroleum	1,200	1,000	1,000	1,000	1,000	1,000
Non-petroleum	1,000	1,050	1,100	1,150	1,200	1,250
Alaskan Project[1/]	250	600	650	350	70	70
Total	2,450	2,650	2,750	2,500	2,270	2,320

[1/]Average annual number of Arctic Study Area proportionate share of total pipeline construction and operating personnel.

Between 1977 and 1979, the year of peak pipeline employment, the level of oil and gas industry-related employment in the Arctic will approximately double, mainly because of the gas pipeline construction. By 1979, upwards of 1,000 workers are projected to be occupied north of the Brooks Range in gas pipeline construction. All will be lodged in work camps and will remain in the area of the right-of-way except for periodic "R & R" leaves to Fairbanks and Anchorage.

Construction on the pipeline is scheduled to be completed by the end of 1981, with the final efforts to be directed at expansion of compression capacity. Total area employment should then have declined, although to a level higher than that extant prior to 1977. It cannot be predicted whether petroleum employment on the North Slope will expand, contract or remain stable in the 1980's. National and international developments in oil and gas exploitation will certainly influence exploration efforts on the Slope. Increasing native resources and growing public interest and tourism into the Arctic will probably lead to a strengthening of non-petroleum sources of employment.

3A.2.5.5.4 Income Changes

During the period of construction on the Alaskan Gas Pipeline, Project workers on the North Slope will receive over $75 million in total wages (1973 dollars).[5/] Only a small portion of this payroll will accrue to residents of the Arctic Study Area, because; (1) relatively few residents will be employed on the Project, and (2) there will be little opportunity for workers to spend their wages in the area. Much

[5/]See description of project activities in the Arctic Area, subsection 3A.2.5.2.

of the wage income will be spent in Anchorage and Fairbanks in the form of R & R expenditures and, in the case of residents, for family support. Some income will be remitted to families in the Lower 48 States (perhaps one-half of the total construction payroll, net of taxes). On the other hand, virtually all of the salaries for the operating personnel will be spend in the state.

The residents of the North Slope will receive income generated by the Project primarily in the form of property taxes and shared state oil and gas tax and royalty revenues. Estimates of these funds are made in subsection 3A.2.5.4.6 below.

Project income accruing to the state (apart from taxes) will come partly from payrolls and partly from local procurements of construction materials. In the case of the Arctic Study Area, however, there would be no local procurements apart from possible purchases of motor fuels from the ARCO topping plant at Prudhoe Bay. Such purchases would have little effect on the Alaskan economy however, because the purchase funds would be remitted to out-of-state interests.

Assuming a gross construction payroll of $77.5 million during the period 1977-1981, of which 20 percent is taken in state and federal income taxes, and 50 percent of the remainder ($31 million) is remitted immediately out-of-state, a balance of $31 million will remain. According to studies by the University of Alaska and other institutions, an income multiplier of 1.5 is appropriate to apply to project-generated increments in state income.[6/] Thus, for every dollar injected into the state economy from outside sources, an additional $0.50 is generated in the process of several rounds of local respendings and savings out of the initial one dollar. The $31 million remaining from the $77.5 million Arctic Area construction payroll would, on this basis, generage an additional $15.5 million of local income, for a total of $46.5 million over the five-year period.

Operating personnel in the Arctic Study Area are projected to receive wages with a gross value (in 1973 dollars) of $1.8 million per year.[7/] After taxes, net payroll income would amount to an estimated $1.4 million. Most of this income would be spent in Alaska, since it is assumed that most of the operating personnel will be permanent residents of the State. Total additional income (net payroll plus induced income from the income multiplier) would amount to $2.2 million per year.

Actual payroll and income levels will undoubtedly be much higher than those indicated above, owing to inflation and escalation

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6/High spending leakages because of the high import requirements of the state prevent the multiplier from reaching higher levels.

7/Subsection 3A.2.5.2.

of wages. Whether real (i.e., uninflated) wages and purchasing power are greater in 1982 than in 1973 is another matter. To the extent that economies in surface transportation and local production of consumption goods and services are achieved and price differentials between Alaska and the Lower 48 states are narrowed, then the "terms of trade," or relative prices of Alaskan versus out-of-state goods will improve, and the traditionally higher wage scales of Alaska will translate into improved purchasing power and higher income values.

3A.2.5.5.5 Changes in Taxes and Public Finances

In the Arctic Study Area, the Alaskan Gas Pipeline follows a route running south from Prudhoe Bay to the crest of the Brooks Range--a distance of about 165 miles (20 percent) of the 809-mile total length of the pipeline. It may be expected that capital investment in the North Slope Borough will thus approximate about 20 percent of the $1.94 billion Alaskan Project, or $388 million (1973 prices). Assuming a uniform assessment value per mile and a uniform tax rate, the Arctic portion of the Project would yield about $6.6 million in property taxes each year. It is not known whether all of the Arctic Study Area property taxes would be rebated to the North Slope Borough, in which the pipeline is located. If the full amount of $6.6 million were rebated, it would amount to more than $1100 per capita for the 5,700 persons projected to be living in the area in 1982.[8] These revenues would be in addition to the potentially larger funds from oil and gas royalties and production taxes which would be allocated to the same area under terms of revenue sharing agreements between the state and the various boroughs and native regional corporation.

3A.2.5.6 Summary of Socioeconomic Impacts, Arctic Study Area

Construction and operation of the Alaskan Project will produce a number of short- and long-term impacts in the Arctic Study Area. In general, they will be of much less significance than those resulting from the Alyeska oil pipeline project, because the gas pipeline will be laid in the same corridor of land and will use many of the same roads and other facilities constructed for the oil pipeline. Land use impacts, therefore, will be minimal in both the near- and long-terms.

Population impacts will not be significant in the near-term. During construction, a maximum of 1,000 workers will be working out of construction camps along the North Slope right-of-way, but they will have virtually no impacts on native communities, because none will be settling families in the area. More significant will be the stimulus to local population growth stemming from developmental spending of tax revenues by state, borough and local municipal governments, and by the

[8] Section 3A.2.5.4.1, Population Changes - Arctic.

North Slope Regional Corporation. It must be recognized, however, that population and economic development on the North Slope will bring permanent and sometimes adverse changes in the life styles of many Eskimos and natives. The impact of the Alaskan Project will be incremental in this respect, since it will be adding to social and economic developments set in motion by the Alyeska oil pipeline.

Impacts of the gas pipeline on Arctic Study Area employment, income levels, taxes, and economic output will mainly be indirect and long-term. Except for a temporary increase in area construction employment during the period from 1977 to 1981, the general trend of employment is projected to rise slowly. Incomes will rise primarily in response to inflows to tax revenues expended on social and economic development programs. Output of natural resource-based goods (apart from petroleum) is not a significant commercial activity (although very important locally for subsistence), and the Alaskan Project will have little effect on expanding area production and trade.

3A.2.6 Aesthetic Features

The proposed winter construction schedule in pipeline Sections 1 and 2 inherently prevents any aesthetic impact during the construction phase, since very few persons visit the North Slope in winter.

Once the gas pipeline is buried, proper revegetation should restore the tundra along the right-of-way to its original scenic landscape, precluding any long-term aesthetic impacts during operation. Summer visitors will notice permanent, aboveground facilities, such as compressor stations, maintenance camps, pipeline route markers and corrosion-control equipment.

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SECTION 3A.3 - INTERIOR BASIN DIVISION

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3A.3 INTERIOR BASIN DIVISION

3A.3.1 Land Features

Impact on land features in the Interior Basin Division is expected to be essentially identical to impacts in the Arctic Division discussed previously. A few minor differences will exist, however.

Permafrost varies from continuous to discontinuous. In areas where it is absent there will be no significant thaw subsidence after the vegetative cover is removed.

Since the southern half of the route through the Interior crosses inhabited areas, it may be possible to use existing sanitary landfills for refuse disposal, thereby minimizing such impact.

3A.3.2 Climate and Air Quality

The general impact of construction of compressor stations and the pipeline on the air quality of the Interior Division is expected to be minimal. Winds in Interior valleys are lower than in the Arctic; however, the small quantities of contaminants released during construction will result in air pollution levels well below applicable regulatory standards.

3A.3.3 Water Resources

The impact of construction, operation and maintenance, and accidents upon water resources in Interior Alaska will be similar to those discussed for the Arctic. This section presents only those impacts particular to the Interior.

3A.3.3.1 Surface Water

Adverse effects of trenching, pipelaying and backfilling operations at river crossings will be more pronounced in the nonglacial, clear water streams north of the Alaska Range; however, the effects will be somewhat minimized owing to winter construction when stream flow is at a minimum. The effects of the previous winter's construction may be greatest following the spring breakup if stream banks and beds have not stabilized. The effects of scour and sedimentation will be somewhat minimized because of normally high erosion ocurring during breakup.

It is possible that summer construction will be required on several larger rivers, such as the Tanana River. In these cases, construction effects will be minimized if construction periods coincide with the post-breakup periods of low flows or in the late fall or early winter prior to the river freeze-up.

Operation and maintenance of the pipeline and support facilities are expected to have minimal or localized effects on surface water hydrology. The support facilities will be located out of river flood plains whenever possible.

At meandering and braided streams where lateral erosion and channel shifting are expected to be problems, minor alterations of channel geometry may be required. In some cases, bank protection structures may be required. At major stream crossings, the pipeline will be buried at depths ranging from 5 to 14 feet to alleviate the possibility of rupture from extreme scour and related problems. Aerial crossings are proposed for the Yukon and Tazlina Rivers to obviate erosional problems. The protective measures planned will insure the integrity of the pipeline and reduce scouring and sedimentation problems in streams during the operational phases of the Project.

Most major streams in the Interior Division maintain some flow throughout winter. Consequently, any constriction or blockage of the channel may result in river icings. Operation of a cold pipe under a river channel may result in formation of anchor or bottom ice, which in turn would constrict winter flows, and possibly result in increased river icings. The extent of resulting effects of the cold pipe at stream crossings will be assessed on an individual basis because of the complexity, uncertainty, and variability of the thermal regime under Interior Alaskan streams.

3A.3.3.2 Groundwater

The effects of construction, operation, and maintenance on the groundwater system in the Interior Division are likely to be more pronounced than in the Arctic Division. In general, the active layer in the Interior is deeper, and permafrost occurs in thinner layers and in some areas is nonexistent. Consequently, the probability of groundwater is greater than in the Arctic Division. Physical disruption of the active layer by access roads and a chilled pipe may cause alterations in the thermal regime and promote ground icings.

3A.3.3.3 Water Quality and Uses

Four construction camps will be located in the Interior Division. Table 3A.3-1 presents the waste load and water usage for construction camps in the Interior Basin Division. Because the locations of construction camps have not been determined, the effects of water use and wastewater disposal cannot currently be assessed. It should be noted, however, that these uses of water will be short-term and will not degrade water quality on a long-term basis.

TABLE 3A.3-1

CONSTRUCTION CAMP CONSIDERATIONS IN INTERIOR ALASKA

Pipeline Milepost Location	162.5-755
Construction Season	Winter1/
Peak Manpower	3,066
Waste Load, lbs. BOD per day	156.5
Water Use, gallons per day	306,600

1/Summer construction along three miles in Atigun Pass, and between Mileposts 560 and 600

Nine compressor stations and two maintenance bases will be located in the Interior Division. Manpower to operate these facilities will consist of two men at each compressor station and 30 men at each maintenance base. Waste loads and water use at these facilities will not be substantial enough to create problems with water quality or water supply.

3A.3.4 Species and Ecosystems

3A.3.4.1 Terrestrial Environment

The Interior Division will contain 592 miles, or 73 percent, of the proposed 809 mile pipeline.

Major qualitative differences between the Interior and Arctic Divisions arise first in the abiotic characteristics. Soil permafrost relationships are less predictable south of the Brooks Range drainage divide. The distribution of permafrost ranges from nearly continuous to isolated patches by the time the gas pipeline traverses Thompson Pass. It is reasonable to anticipate that ditching, pipe-laying, and backfilling will involve a number of on-the-spot design changes to counter structural problems arising from the predictable distribution and ice content of permafrost. Such changes in construction procedures will inevitably change the area of biological effects.

A second qualitative difference will occur in the winter snow cover of much of the Interior Division. Except at higher elevations (above treeline), the snow is typically very light and uncompacted until late winter. The absence of strong winds and of heavy snowfall in low-lying timbered areas may cause the need for supplemental snow gathering activities, in addition to the planned use of snow fences to accumulate a snow work pad. Snow gathering over a wide area with heavy equipment may therefore be necessary to secure enough low-density snow to form a pad two feet thick, especially in years of normal or below-normal snow accumulation. These qualitative differences in permafrost and snow cover combine to require a substantially expanded zone of direct disturbance to the above- and below ground vegetative mats.

Construction of the pipeline and support facilities will be, to a large extent, carried out in forested areas. The clearing of right-of-way in such areas will be carried out by hand, in order to minimize disturbance to the ecosystems involved.

Following clearing, slash must be disposed of in order to decrease fire hazard and to minimize the potential for outbreaks of forest pests such as bark beetles. Applicant has chosen to mulch slash, which method of slash disposal has two advantages: (a) it reduces the possibility of wildfire, and (b) it rapidly restores nutrients to the forest floor.

In the Interior Division, a winter construction schedule will generally be followed. However, when summer construction is necessary, severe permafrost degradation may occur. The result of such perturbation has been discussed in the Arctic Division narrative (subsection 3A.2.4.1.1).

Contamination of forest ecosystems by hydrocarbons may be expected to result in death of primary producers as was described for the Arctic Division. In forested areas, however, higher summer temperatures and a longer frost-free season imply that microbial decomposition of hydrocarbon compounds will be more rapid than is the case for tundra systems. Thus, disturbances may be shorter-term than on the North Slope.

In many cases, forested areas of the Interior are not underlain by permafrost. Under this condition, spills of petroleum products will vertically (rather than laterally) penetrate the soil profile to low areas such as drainage channels and other bodies of water. Thus, contamination of water bodies following a terrestrial spill of such compounds is less likely in this region.

Problems associated with revegetation are generally similar to those outlined for the Arctic Division. In an effort to obviate problems associated with the spread of potentially noxious cultigens, Applicant plans to revegetate utilizing appropriate native species. Where these native grass species are unadaptable, Applicant, upon the recommendation of qualified specialists, will use introduced species.

Wildfire is a bigger ecological factor in the Interior than in either the Arctic or South Coast Divisions. The importance and natural frequency of wildfire puts a special onus of decision-making and responsibility on industry and governmental agencies. Briefly stated, the problem is that prevention or arrest of wildfires creates environmental alteration, as does accidental setting of wildfires. More ignitions will undoubtedly occur as a result of increased human pressure during the construction phase of the proposed pipeline. More firefighting will also probably occur, with attendant physical and chemical environmental reverberations.

3A.3.4.2 Aquatic Environment

Conceptually, the pattern of effects on aquatic ecosystems resulting from the construction process in the Interior Division will be identical to that occurring in the Arctic Division. The discussion of impact in that division should be referred to for details.

The Interior Division differs from the Arctic Drainage Division in two particular respects; the first is that most of the area along the gas pipeline route is already accessible by road or has nearby population centers. Construction of the pipeline will therefore not play the same role it will in the Arctic. Economically, however, the aquatic resources of the Interior are more susceptible to degradation than in the Arctic because of the higher monetary yield provided by fish in the Interior. Recreational use in the Interior is considerable. Twenty-five thousand angler-hours are spent annually on the Chena River near Fairbanks. Sporting goods stores, guiding establishments, and taxidermists realize direct profits from the activity. Salmon spawning in the Interior is extensive and supports (with that of certain other species) a commercial industry that is part of the State's leading economic resource, as well as important subsistence usage. Therefore, any substantial damage to fish populations resulting from construction activities could represent a direct economic loss to people of the State. Certain populations could be seriously affected if, for example, siltation in spawning areas continued for an extended period.

The second difference found in the Interior Division is the presence of surface features requiring special modes of construction, as described in Section 1. These include the Yukon River, Moose Creek, the Whistler Creek to Trims Creek area, the Tazlina River, and the Tsina River. Where appropriate, special methods will be used to prevent erosion (particularly at the pipeline crossings of the road in the Tsina River flood plain) and insure security of pipeline installation. With these measures, no exceptional impact is expected.

Conceptually, operation and maintenance of Applicant's pipeline in the Interior Division will produce the same effects outlined for the Arctic Division. Accessability to most of the Interior region will not be substantially increased, which fact will mean a lesser incremental impact than will occur in the Arctic. Petroleum-related development is, however, expected to effect a permanent population increase in the Interior, and the gas pipeline will contribute to the increase. However, the resulting contribution to pressure on aquatic natural resources should be minor.

Areas requiring special construction modes mentioned under construction (above), may require more than average maintenance during the life of the pipeline.

3A.3.5 Socioeconomic Considerations

3A.3.5.1 Project Activity Affecting the Interior Study Area

Project activities in the Interior Study Area will include the construction and operation of a 592-mile long stretch of pipeline, with nine compressor stations, two maintenance bases, 11 communications stations sites and other support facilities. The gas pipeline section in the Interior Area extends from the crest of the Brooks Range across the Yukon River, past Fairbanks and across the Tanana River and the Alaska Range, across the Copper River Valley and through the Chugach Mountains to Thompson Pass. The Interior section amounts to 73.2 percent of the total 809.2-mile length of the pipeline, and construction work will extend over a four and one-half year period, 1977-1981.

On the basis of proportionate costs, the Interior Study Area facilities will require about $1.4 billion in capital outlays (1973 costs), of which about $273 million would represent labor costs. Much of the construction payroll (after deduction of withholding taxes and employee-paid benefits) would enter the Fairbanks and Anchorage area economies in the forms of rest and recreation spending and dependent support.

During the 1978-79 period of peak construction, more than 3,000 workers will be employed along the section of the pipeline in the Interior. Many of the work camps will be located near existing communities, and changes in the level and pattern of commercial and public service activities initiated by the Alyeska oil pipeline project will be reinforced.

Of the 268 total operating personnel to be employed over the entire pipeline, an estimated 200 will be assigned to Interior Study Area facilities[3/]. For those employed at compressor stations and maintenance bases near communities, many will probably take up residence in town. For example, Compressor Stations Nos. 7 and 8 and Maintenance Base C are within 20 miles (by good highway) of Fairbanks, and most of the personnel assigned to these facilities will likely reside in the Fairbanks area.

[3/] Not all will be on station at any one time, however, due to leaves, control station duty, etc.

The Interior Study Area segment of the Project would, on a proportionate basis, incur about $52 million per year of operating and maintenance expenses (73.2 percent of $71.1 million per year; see subsection 3A.2.5.2). Labor costs would amount to $6.6 million per year and ad valorem taxes paid to state and local governments would amount to an additional $24 million (again, assuming direct proportionality and uniform tax rates). For convenience, the foregoing Project characteristics have been summarized in Table 3A.3-2.

TABLE 3A.3-2

PRINCIPAL PROJECT CONSTRUCTION AND OPERATION CHARACTERISTICS, INTERIOR STUDY AREA

Length of pipeline	592 Miles
Number of compressor stations -	9
Number of maintenance bases -	2
Estimated capital costs ($ 1973) -	$1,400.0 Million
Estimated direct construction labor costs ($ 1973) -	$273.0 Million
Estimated maximum construction labor force (1978-79) -	3,000+
Estimated annual operating costs ($ 1973) -	$52.0 Million
Estimated annual operating payroll (200 men) -	$6.6 Million
Estimated annual ad valorem taxes -	$24.1 Million

No information is presently available to indicate the nature or magnitude of abandonment effects. Applicant intends to restore the environment as closely as possible to its original state.

3A.3.5.2 Land Use Impacts

3A.3.5.2.1 Land Ownership Changes

The Interior Study Area contains 592 miles of the Alaskan Gas Pipeline right-of-way. Land which must be acquired or leased for the gas pipeline right-of-way is primarily in the federally-withdrawn Utility Corridor. In the vicinity of Fairbanks, considerable lengths of state land will be crossed, as will several plots of privately owned land.

In the area north of the Yukon River where the majority of land ownership is Federal, the Project is not expected to have any direct land use impacts. While there will likely be increased pressure from the private sector for sales of state lands in this area (for second homes and recreation usage, especially in the Brooks Range), such increased demand would be primarily due to the improved accessibility of the region afforded by the State-Alyeska Highway.

In the Fairbanks area, land ownership is more equally distributed among federal, state, and private holdings. Fairbanks will be an important center of supply for the Project, and the value of private lands, which are already high, will continue to increase. This is an impact upon ownership in the extended (up to 40 miles wide) impact zone.

Land values adjacent to the gas pipeline in the Fairbanks area will likely not increase in value over those more distant. The proposed pipeline may indeed depress the value of some adjacent lands for residential purposes because of the disturbed appearance, in some places, of the cleared right-of-way; however, the value of adjacent lands for industrial purposes might be enhanced.

Increased interest in the acquisition of state lands near Fairbanks by private interest will undoubtedly result from the influx of construction workers and their families, and the subsequent expansion of the area's permanent population.

Roadside acreage along the Richardson Highway should also increase considerably in value as a result of the increased population in nearby Fairbanks, Delta Junction, and Glennallen, and because of planned construction activities. Again, there will be increased pressure for sales of roadside and other state property.

3A.3.5.2.2 Land Use Pattern Changes

The most obvious changes to the present patterns of land use in the Interior Study Area will occur in the immediate effect zone (i.e., within the 150-foot right-of-way). Contained within the Interior Study Area will be 592 miles of cleared right-of-way, 9 compressor stations occupying about 162 acres, 2 maintenance bases, 11 communications sites, and a number of miles of access roads to material sites, storage yards, and compressor stations. Material source sites have not yet been designated. Sufficient gravel may exist in some areas for the construction and maintenance of the Alyeska haul road, but in other places, stone may have to be quarried and crushed. It is likely that use of many of the Alyeska barrow sites will be permitted.

The proposed pipeline construction would have its principal impact on the larger communities (especially Fairbanks) which would be the staging areas for the greater portion of the pipeline route. In view of the large population increases projected for the Interior Study Area (see subsection 3A.3.5.3.1), it is likely that a housing shortage will persist in Fairbanks and its environs for the duration of the Project. It is also likely that an appreciable number of new homes will be constructed for Project workers and their families. Much of the growth will likely be outside the incorporated area of the City of Fairbanks, where local building codes do not presently apply. Zoning and land use problems will probably intensify.

There is no indication that the pattern of land use in the roadside communities south of Fairbanks would significantly change. The communities of Delta Junction, Glennallen, and Copper Center are likely to increase in size, but they will retain the same basic pattern of land use which has prevailed in the past, namely, strip settlement along the highway.

The traditional pattern of land use by native groups may be somewhat altered by their increased incomes. It is possible that they would spend less time at subsistence activities than in the past, and that village and regional settlement corporations will turn increasingly to commercial development of their forest, river and mineral resources. Thus, within the native settlement land withdrawals, an increasing degree of corporate-style use of land resources is likely.

3A.3.5.2.3 Community Changes

The impact of the Alaskan Project on communities north of the Yukon will consist primarily of stimulating an expansion of various services to meet the increasing cash-based demands of local residents, tourists and sportsmen. The increased earning potential of natives in Rampart, Stevens Village, Allakaket, and other native villages may influence changes in the style and quality of the housing in those areas. Only a small amount of permanent growth is forecast for the communities north of the Yukon as a result of the proposed gas pipeline; most population growth in the area outside of Fairbanks is projected in the southern part (see subsection 3A.3.5.3.1).

Fairbanks and its environs will feel the greatest effects of the pipeline impact on the Interior Study Area. As a result of the large influx of workers and money into the area, an acceleration in the expansion of residential and utility service areas can be expected. This increase will come at a time when the influence from the Alyeska oil pipeline is declining. The net effect will be a continuation of the community impacts established by Alyeska, with a moderate increase.

The communities of the Interior Study Area which are south of Fairbanks are, by tradition, closely tied to the road system and the servicing of tourists and other travel. The influx of pipeline construction workers and other pipeline-related personnel will swell the number of establishments that entertain and service transient workers. There will likely be an increase in population, especially in the service-related communities of Delta Junction, Glennallen, and Copper Center. The peak years for the increase should be around 1979-80.

3A.3.5.2.4 Land Use Planning Changes

The principal organizations involved in land use planning in the Interior Study Area are the Fairbanks-North Star Borough and two native regional corporations, Doyon, Inc. (extending roughly from the Brooks Range south to Fairbanks) and Ahtna, Inc. (occupying roughly the Copper River Valley)(see Figure 2A.7-4). There is also a Joint State-Federal Land Use Planning Commission nominally responsible for recommending uses of federal and state lands along the pipeline corridor as well as elsewhere in Alaska, but its planning activities had not had any significant impacts on the area as of mid-1974.

Doyon, Inc., the native regional corporation for Interior Alaska, is negotiating the preparation of a 5-year plan which will address long-term problems relating to resource and other economic development (River Times, 1974). This 5-year plan can be one of the principal tools for Interior land use planning, and may assist the native group in dealing with land use and other problems, some of which will be pipeline oriented.

Ahtna, Inc., the native regional corporation for the Copper River area, may prove to be a significant factor in decisions regarding land use for some of the native communities (Ahtna, Inc., 1973). Ahtna has developed a background publication for regional and community planning which should be a valuable guide in solving land use problems. The native leaders of Ahtna have expressed considerable interest in their land use problems and seem to be aware of possible difficulties which may result from the pipelines which will cross their region. Fairbanks-North Star Borough's Land Use Department has recently developed a new comprehensive general plan (summer, 1974). That agency has been hampered in the past by rapid borough area growth, compounded by an outdated zoning ordinance and general comprehensive plan. It may require additional personnel by 1980, the year that area's population is expected to peak.

Significant, but temporary growth will occur in the roadside communities of Delta Junction, Gulkana, Gakona, Copper Center and Glennallen, all of which are in unorganized territory (designated as an unorganized borough), and which, with the exception of Delta Junction, are unincorporated. None collect local taxes. Town expansion problems could be eased through proper planning and zoning, although there is a strong local opposition to zoning because of the potential limitations this would have on landowners' freedom to develop their holdings. State support will be available for planning activities, but the communities will have to incorporate first in order to gain control over local land uses. Although Delta Junction is incorporated, as of mid-1974, it had not voted whether to impose local taxes and land use regulations.

3A.3.5.3 Population and Economic Impacts

3A.3.5.3.1 Population Changes

Although the Alaskan Gas Pipeline will traverse the entire length of the Interior Study Area, the major impacts from Project construction and operating activities will be concentrated in Fairbanks, which supplies most of the health and educational services to the Interior.

The Upper Yukon and Copper River areas will experience impacts from the Alaskan Gas Pipeline, but, as in the Arctic, many of the effects will be extensions of the construction-related impacts created by the Alyeska project. Major long-term changes will center in and around Fairbanks, although the Alyeska haul road will stimulate recreational travel to the Upper Yukon. Permanent population growth in the Upper Yukon will likely result from this accessibility.

Growth Dynamics

Projected changes in the Interior Study Area population with and without the Alaskan Project are provided in Tables 3A.3-3 and 3A.3-4. Referring to Table 3A.3-4, it may be noted that in 1977 the Interior population will be about 16 percent of the total state population, rising to about 17 percent of the total population by 1981. Thereafter, the growth rate will be slower.

Table 3A.3-5 shows population growth in the Fairbanks-North Star Borough due to the Alaskan Project. It reflects direct changes in the labor force, and not permanent settlement.

TABLE 3A.3.3

BASELINE POPULATION PROJECTIONS FOR STUDY REGIONS, 1977-1983
WITHOUT ALASKAN PROJECT
(Thousands of Persons)

Study Area	Year 1977	1978	1979	1980	1981	1982	1983
Arctic	5.4	5.5	5.5	5.4	5.4	5.5	5.5
Interior	66.2	67.0	68.1	69.6	70.5	71.1	71.7
South Coastal	209.0	210.8	212.6	215.6	223.0	230.2	238.0
Other	145.4	148.7	157.8	157.4	162.3	167.7	172.8
Total Alaska	426.0	432.0	444.0	448.0	461.2	474.4	488.0

Source: Department of Labor Research and Analysis Section (March, 1974).

Note: Totals may not add due to rounding

TABLE 3A.3-4

IMPACT POPULATION PROJECTIONS FOR STUDY REGIONS, 1977-1983
WITH ALASKAN PROJECT
(Thousands of Persons)

Study Area	Year 1977	1978	1979	1980	1981	1982	1983
Arctic	5.4	5.5	6.1	6.0	5.7	5.7	5.6
Interior	66.2	69.9	83.8	90.0	89.9	89.7	89.5
South Coastal	209.0	214.3	257.6	261.8	266.3	273.3	279.2
Other	145.4	146.3	152.5	157.2	158.1	166.3	172.8
Total Alaska	426.0	436.0	550.0	515.0	520.0	535.0	547.1

TABLE 3A.3-5

CHANGE IN POPULATION DUE TO ALASKAN PROJECT
CONSTRUCTION 1977-1982 INTERIOR STUDY AREA

	1977	1978	1979	1980	1981	1982
Interior Area	0	2,900	13,700	20,400	19,400	18,600
Fairbanks	0	1,400	9,100	13,600	12,900	12,400
Difference	0	1,500	4,600	6,800	6,500	6,200

The difference between the level of population in the Interior Area and that in the Fairbanks-North Star Borough is the number of persons who will be located near the pipeline outside the borough boundaries. An estimate of the number of persons who will be attracted to points along the pipeline is provided in Table 3A.3-6 below.

TABLE 3A.3-6

TYPE OF POPULATION IN INTERIOR BUT OUTSIDE OF FAIRBANKS, 1977-1982

	1977	1978	1979	1980	1981	1982
Total Projected Increase outside Fairbanks	0	1,500	4,600	6,800	6,500	6,200
Less Project Construction Workers[1]	0	1,400	1,800	850	800	100[2]
Induced Population	0	100	2,800	5,950	5,700	6,100

[1] In camps outside of Fairbanks; estimated at approximately 75% of Interior Study Area portion of pipeline construction personnel.

[2] Operating personnel.

No large induced population growth is anticipated in the Upper Yukon, although Bettles and Wiseman may receive some new settlers. More of an influx is expected along the Richardson Highway, especially in such communities as Delta Junction, Glennallen and Copper Center.

Project operating personnel in the Interior Study Area will number about 200, of whom perhaps 100 will be located outside Fairbanks. The presence of the latter probably will not have much of a direct impact on surrounding villages since, while on duty, they will be quartered at the compressor stations and maintenance camps.

Age Distribution

Changes in age distribution occurring in the Interior Study Area will be greater during pipeline construction than during operation. During construction, the number of males aged 16 to 60 migrating into the Interior will increase markedly. This movement would result in a decrease in the Demographic Dependency Ratio, and a decrease in the percentages of the total population of young and old people. After operations commence, the distribution will probably return to about the 1970 situation.

Sex Ratio

Influx of young male construction workers will also inflate the sex ratio for the Interior, but induced population growth may modify the change somewhat. Persons filling jobs induced by the Alaskan Project may not be discouraged from bringing their dependents. During the operating phase, the sex ratio will likely return to 1970 levels.

Vital Statistics

Alaskan Project-related activities should decrease the overall birth rate but have little direct influence upon fertility rates. Other societal factors not related to the Project will be more influential with respect to changes in birth and death rates.

Education

The influx of new population for the Alaskan Project-related activities will probably have little net impact upon the overall educational profile of the study area. The education level of Fairbanks is already above average for Alaska, and the construction personnel will probably be neither better nor less well-educated.

3A.3.5.3.2 Quality of Living Changes

In general, the direct effects of the oil and gas pipelines on the native villages of the Upper Yukon and the Copper River Basins will not be great. As in the Arctic Study Area, the most important impacts are not likely to be the indirect, long-term impacts which result from the economic activity prompted by pipeline construction (both oil and gas) together with the social, economic and political activity prompted by ANCSA. There will doubtless be an improvement in the regional and village economies, and there will be less dependence upon subsistence resources, because of both greater availability of wage employment and a possible decrease in availability of game caused by ever greater hunting pressure. As in the case of the Arctic Eskimos, it cannot be determined whether this upturn in economic activity itself will translate into an improvement of living conditions and quality of life for the native population.

Economic development in Interior Alaska stimulated by the oil and gas industry will also herald major changes for the urban center of Fairbanks and its predominantly non-native population. Fairbanks will become larger and richer, and it will acquire those social appurtenances that size and wealth command: larger shopping centers, more theaters, more restaurants, expanded jet service to other cities, and the like. There is general agreement that the short-term social dislocations which will result from the oil pipeline and the proposed gas pipeline will have undesirable aspects. Fairbanks will be a major "rest and recreation" center for construction workers, and few people anticipate much in the way of lasting contributions to city growth from this source of business.

Tables 3A.3-7 and 3A.3-8 present projected population figures for the major census divisions along the pipeline route. By 1982, Fairbanks will have grown by nearly 15,000 people--a 25 percent increase over the 1977 baseline level of 56,200.

TABLE 3A.3-7

BASELINE POPULATION PROJECTIONS FOR SELECTED CENSUS DIVISIONS ALONG PIPELINE CORRIDOR, WITHOUT ALASKAN PROJECT, 1977-1983
(Thousands of Persons)

Place	Year 1977	1978	1979	1980	1981	1982	1983
Anchorage	199.5	204.2	207.9	209.8	215.1	222.1	229.4
Fairbanks	56.2	56.4	56.6	57.1	57.7	58.2	58.8
Cordova-McCarthy	2.5	2.5	2.5	2.6	2.7	2.8	2.9
Other	167.8	168.9	177.0	178.5	185.7	191.3	196.9
Total Baseline Population	426.0	432.0	444.0	448.0	461.2	474.4	488.0

Note: Totals may not add due to rounding.

TABLE 3A.3-8

POPULATION PROJECTIONS FOR SELECTED CENSUS DIVISIONS ALONG UTILITY CORRIDOR, WITH ALASKAN PROJECT, 1977-1983
(Thousands of Persons)

Place	1977	1978	1979	1980	1981	1982	1983
	Year						
Anchorage	199.5	198.1	234.9	253.8	260.8	268.9	274.1
Fairbanks	56.2	58.0	67.4	70.5	70.8	70.6	70.6
Cordova-McCarthy	2.5	2.5	8.0	10.0	7.9	5.3	5.4
Other Alaska	167.8	173.4	176.2	181.3	185.9	191.6	197.0
Total Impact Population	426.0	437.0	500.0	515.0	520.0	535.0	547.1
Baseline Population[1]	426.0	432.0	444.0	448.0	461.2	474.4	488.0
Change due to Alaskan Project	0	5.0	56.0	67.0	58.8	60.6	59.1

[1]From Table 3A.3-3

The borough zoning authority may take aggressive action to stem helter-skelter development, and it may adopt a uniform building code, something it has not done in the past. Also, the borough may adopt a uniform building code, which it did not have as of mid-1974.

Housing

Tables 3A.3-7 and 3A.3-8 indicated the increase in population that will have to be housed in the borough[4]. By assuming the same ratio of persons per occupied housing unit (3.4) that was reported in 1970, an estimate can be made of the number of housing units needed as a result of the Alaskan Project. Table 3A.3-9 shows projected requirements with and without the Alaskan Project for the period 1977-1982.

The peak construction year of 1980 shows the largest increases (21.8%) in housing requirements; in that year and in 1981, 3,700 new units will be required each year as a result of Project-induced growth. A

[4]Fairbanks Census Division is the only part of the Interior analyzed. The only difference between the Census Division and the borough is that the Census Division includes Eielson Air Force Base, and the Fairbanks-North Star Borough does not.

total of 800 units would have been necessary to meet the natural (i.e., non-pipeline-caused growth) increase in housing need over the 1977 level (17,300 units in 1982 minus 16,500 units in 1977). This is a total of 4,300 new units, or an increase of 26 percent over the 1977 housing level. Therefore, 4300 new permanent units will be needed between 1978 and 1982 to handle the increase in permanent population, and another 700 units will be required for construction-related personnel.

TABLE 3A.3-9

PROJECTED HOUSING UNITS REQUIREMENTS FOR FAIRBANKS WITH AND WITHOUT THE ALASKAN PROJECT, 1977-1982
(Thousands of Units)

	Year					
	1977	1978	1979	1980	1981	1982
Without Alaskan Project	16.5	16.6	16.8	17.0	17.1	17.3
With Alaskan Project	16.5	17.1	19.8	20.7	20.8	20.8
Increases	0	0.5	3.0	3.7	3.7	3.5
% Increases	0.0	3.0	17.9	21.8	21.6	20.2

Public Safety

Existing crime problems of Fairbanks may worsen with the influx of transients and new residents. The crime rate will probably continue to rise faster than the rate of population growth.

Increased staffing needs are difficult to establish. Assuming one policeman for every 400 persons (see subsection 2A.7.2.3.2.2), the need for new policemen could range from 27 to 34 in 1980, to 33 in 1981. In the peak construction year of 1980, police staffing requirements would consist of 21 permanent additional police due to the Project, 2 more permanent police due to normal growth and 4 temporary police due to transient population growth. If the crime rate does indeed increase more rapidly than population, increased requirements for police will be related to the crime rate.

Education

Table 3A.3-10 shows the projected school-aged population for Fairbanks during the construction period and for the first year of Project operation (1982). Such projection is based on the assumption that the age distribution for this time period is the same as that in 1970 (U. S. Census of Population, 1970). This is a conservative assumption (i.e., it yields a high estimate of school-age children). The peak demand for educational services should occur in 1980, but the long-term growth is still substantial. If a ratio of 21 students to one staff member is assumed, 165 new staff personnel would be needed in 1980 (Table 3A.3-11). Unless the student-to-staff ratio is increased it appears that there will have to be at least a 25% permanent increase in Fairbank's educational staff between 1977 and 1982, with personnel increasing from about 650 in 1977, to 840 in 1982.

TABLE 3A.3-10

PROJECTED SCHOOL POPULATION, FAIRBANKS, 1977-1982
(Thousands)

	Year					
	1977	1978	1979	1980	1981	1982
Without Alaskan Project	13.7	13.8	14.1	14.2	14.3	14.5
With Alaskan Project	13.7	14.2	16.7	17.6	17.6	17.6
Impact	0	0.4	2.6	3.4	3.3	3.1

TABLE 3A.3-11

STAFF INCREASES FOR FAIRBANKS EDUCATION SYSTEM DUE TO ALASKAN PROJECT, 1977-1982

	1977	1978	1979	1980	1981	1982
Without Alaskan Project	650	655	670	675	680	690
With Alaskan Project	650	675	795	840	840	840
Net Increases	0	20	125	165	160	150

Health

The maximum increase in hospital bed capacity in the Fairbanks Census Division due to the Alaskan Gas Pipeline, assuming 190 persons per bed, will be approximately 75 beds. This level would be reached in 1980, the year of peak construction (Mathematical Sciences Northwest, Inc., 1972, Vol. II, p. 155).

3A.3.5.3.3 Employment Changes

On the basis of estimates of total population and employment in the state, it is projected that a total of 28,000 persons will be employed in the Interior Study Area at the beginning of 1977[5]. More than 75% of the total will be located in the Fairbanks area. Many of the workers will be persons who relocated to Fairbanks from other states in response to employment opportunities generated by the Alyeska project. Comparing the projected 1977 level of 28,000 workers with the 1970 level of 15,500 indicates an increase of more than 80 percent; a projected increase of similar magnitude in the Anchorage area implies that many of the new jobs will be filled by immigrants

The Indian working-age population will probably be participating in the urban-industrial labor force to a greater extent than in the beginning of the decade, although by 1977, when the Alyeska work is tapering off, unemployment among natives probably will temporarily increase[6]. State, borough and regional corporation unemployment and welfare assistance budgets will have to be expanded as a result. Total employment is projected not to decline after completion of the Alyeska oil pipeline because of the strength of the general economic expansion generated by the project.

The basic long-term trend of employment between 1977 and 1982, when the Alaskan Gas Pipeline goes into commercial operation, is projected at about 3 percent a year (on the basis of long-term trends during the 1960s and early 1970s). The Alaskan Project will generate a permanent shift in area total employment similar to that caused by the Alyeska oil pipeline project. Because the Fairbanks area will be headquarters for all project construction north of the Yukon and south at least as far as the Alaska Range, a large amount of activity will be generated -- more than proportional to the number of workers directly engaged in pipeline construction in the Interior. As a result, a large amount of secondary, or induced employment is projected to develop in the Fairbanks area. Increased traffic along the Richardson Highway will also generate significant increases in services employment in the various corridor communities (Delta Junction, Glennallen, etc.).

The projected trends in baseline, Project, and Project-induced employment in the Interior are presented in Table 3A.3-12 for the years 1977-1982 (mid-year levels). The levels of direct Project employment indicated for 1978, 1979, and 1980 in the Table are lower than peak employment in those years. Peak employment will come during the fall and winter months of those years, when frozen ground will permit intensive levels of work activity on the tundra. During other seasons, the surface is too fragile for full-scale construction operations.

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[5]See subsections 3A.2.5.1.1 and 3A.3.5.3.1 for bases for area population and employment projections.

[6]As noted earlier, Applicant stands ready to enter into native manpower development agreements similar to those undertaken by Alyeska. Thus, gas pipeline employment would reduce native unemployment.

TABLE 3A.3-12

PROJECTED EMPLOYMENT, INTERIOR STUDY AREA, 1977-1982

Basis	Middle of Year 1977	1978	1979	1980	1981	1982
Baseline Employment1/	28,000	28,000	29,000	30,000	31,000	32,000
Alaskan Project Impact	800	3,500	6,100	8,900	7,600	7,300
Direct2/	800	2,200	2,400	1,100	1,000	2004/
Induced3/	0	1,300	3,700	7,800	6,600	7,100
Total	28,800	31,500	37,500	40,000	39,600	39,500

1/Based on estimated study area share of projected total state labor force in 1977, assuming 3 percent annual growth rate after 1978.

2/Average annual level. During the fall and winter of 1978-79, peak study area construction employment of 3000 is projected.

3/Estimate based on difference between baseline employment trend plus direct pipeline employment subtracted from projected study area total employed labor force. Total employment estimated on basis of approximately 45-50% labor force participation rate with unemployment averaging 11%. Thus, induced component includes exogenous growth factors after peak of direct project employment is reached.

4/Operating personnel.

Total employment (including Project-related) is projected to rise from about 28,800 in mid-1977, to a maximum of 40,000 in 1980. Subsequently, there will probably be a slight decline as Project activity tapers off, with a period of no overall growth during 1981-82. Thereafter, the baseline trend of at least a 3 percent annual growth rate is projected.

It should be noted that these employment projections reflect only the estimated impact of the Alaskan Project superimposed on the long-term trend of employment. Other factors could profoundly alter the estimates. Most importantly, the military establishments at Fort Wainwright and Eielson AFB probably will continue to account for the major inflows of income in the area upon which much of the employment in Fairbanks is based. Closure of either of these facilities conceivably could more than offset the growth stimuli of both the oil and gas pipeline projects.

The Interior Study Area, and the Fairbanks area in particular, are neither sufficiently populated or economically developed to generate their growth internally, that is, on the basis of the breadth and depth of the region's market. Nor are the region's exports of any great importance as a growth factor. Income and employment are generated and supported primarily by inflows of public and private spending and investment from outside interests. The Interior Study Area economy will continue to depend on the military establishments and the State and local governments. Oil and gas tax and royalty revenues will serve to raise the level of income over the long-term, and thus support a higher level of employment than was possible before the pipeline projects. Once the maximum throughput capacities of the pipelines are reached, however, only increases of wellhead prices and assessed values of pipeline properties along the right-of-way will permit increased expenditures by state and local agencies from oil and gas revenues. Inflationary price increases will eliminate any real increases in purchasing power. Therefore, unless new sources of income are developed, the growth of employment will probably reach a peak in the late 1980's and stabilize thereafter. This would, in turn, impose a limit on areal population expansion. Equally likely is the possibility that the native regional corporations and outside interests will expand the output of forest and mineral resources, with attendant impacts on employment levels.

3A.3.5.3.4 Income Changes

The direct impact of the Alaskan Project on the income characteristics of the Interior Study Area will be manifested in increased personal income levels, increased local spending, and increased purchases of construction material and supplies. In addition, oil- and gas-related taxes will accrue to the area.

Data are not available to measure the extent of local procurements of construction materials. However, as an indication of the potential magnitudes of such procurements, 10 percent of the projected total capital outlay for construction in the Interior would amount to more than $190 million (in 1973 prices). Inclusion of a similar proportion for the Arctic section capital spending would add nearly $38 million.

Personal income and spending levels would rise substantially. It is not possible to make a precise estimate of the extent of such increases because there are no data upon which to base a breakdown of the location of spending by Project workers. While some workers will be permanent residents of the area (Fairbanks), many will be Anchorage and out-of-state residents. In addition, some proportion of the workers on the Arctic area will spend parts of their income in the Fairbanks vicinity. If it is assumed that one-half of the after-tax wage income of Project construction workers in the Study Area is spent in the state, and that, in turn, one-half of the in-state portion is spent in Fairbanks, Delta Junction, Glennallen, and other corridor communities in the Interior (including earnings of natives spent in local villages) then the total increment to Interior Study Area income from payrolls would amount to an estimated $50-60 million over the five-year construction period[7]. On the basis of the foregoing assumptions, another $50-60 million would be spent on R & R for and by dependents in the Anchorage area. Following the same reasoning, if one-half of the in-state R & R and dependent support spending of construction workers in the Arctic Study Area (subsection 3A.2.5.4.4) were spent in the Interior (mainly Fairbanks), then the area would receive an additional $15 million, for a total of $65-75 million in construction payroll spending. Recalling the brief discussion of the income multiplier effect in Alaska, which is estimated at 1.5, the combined portions of Interior and Arctic construction payroll income and spending would result in an aggregate increase in Interior Study Area income of more than $100 million.

Pipeline operating personnel are projected to receive a total of $9.3 million per year (1973 wage scales). Assuming that virtually all income is spent locally (i.e., that all personnel will maintain residence in the Interior), then total after-tax income accruing to the Interior area will amount to about $7.4 million[8]. With a 1.5 income multiplier, total personal income in the area will increase by about $11.2 million per year over levels without the pipeline.

The above calculations are based on very general assumptions as to the division and allocation of Project and worker spending; actual values (apart from changes in prices) may vary by several tens of millions of dollars. Nonetheless, the additional income will constitute a very substantial increment and stimulus to the local economy.

The impact of tax revenues from the Project on the local economy will be significant, particularly with respect to the finances of the native regional corporations and the local boroughs and municipalities. These are discussed in some detail in the following subsection.

3A.3.5.3.5 Changes in Taxes and Public Finances

Along the estimated 592 miles of pipeline right-of-way within the Interior Study Area will be 9 compressor stations and two maintenance bases. The principal communities that will experience growth impacts from the Project, and importantly, the ones closest to the compressor and maintenance stations after the pipeline goes into operation are the following (listed from north to south, and including major military installations): Wiseman[9], Livengood[9], Fairbanks, Eielson Air Force Base, Delta Junction Fort Greely, Paxson, Gulkana, Gelnnallen, Cooper Center, and Tonsina[9].

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[7]Total construction payroll is projected at $237.0 million - subsection 3A.3.5.1.

[8]Assuming 20 percent is taken in state and federal income taxes.

[9]These communities were very small in 1974, but it is expected that by the 1980's improved road access and the proximity of compressor station crews (added to those with the Alyeska oil pumping stations in the vicinity) will have stimulated their growth considerably.

With the exception of the military establishments at Eielson Air Force Base and Fort Greely, most public services are supplied by the State, including public health, education[10], social welfare, law enforcement, courts, environmental protection and public works. The private sector supplies housing and some sewage service and water supply[11]. The small communities have volunteer fire departments.

As was noted in the general discussion of impacts of the Alaskan Project (subsection 3A.2.5.2.1), the construction of the gas pipeline is not expected to have as severe impacts, relatively, as the Alyeska oil pipeline. Communities will have expanded as a result of the Alyeska stimulus and will be better prepared physically and organizationally to deal with the added burdens of the gas pipeline construction.

As has been discussed earlier, the Fairbanks City and North Star Borough governments have projected impact fund requirements for the years 1974-1976, amounting to $30.5 million, in anticipation of the Alyeska project. By 1980, the expanded local tax base and increased revenue-sharing income from the State (via oil royalties and production taxes and the state assessed property tax) will have greatly eased pressures on operating and capital budgets. Accordingly, the impact funding requirements deriving from the gas pipeline project should be substantially less. No data have been developed to quantify the potential reduction in the Interior Study Area's impact funding requirements, but a judgmental assessment of relative Project-induced requirements vis-a-vis the expanded public sector resource base leads to the conclusion that the gas pipeline impacts will be lighter than those of the oil pipeline.

During the peak of construction-induced population expansion (1979-1980), the total population of the Interior is projected to rise by more than 20,000 persons, or 30 percent over the permanent baseline trend (subsection 3A.3.5.3.1). Two-thirds of the growth is projected to take place in the Fairbanks North Star Borough, where local property and sales taxes will provide the major funding for impact expenses. In the unorganized parts of the Interior Study Area (which is most of its territory), maximum Project-induced population growth is estimated at about 6,000 in 1980 (Table 3A.3-5). Most of the additional population outside Fairbanks will settle in the various towns and villages listed in the beginning of this section--communities which at present rely primarily on state-supplied services. By the early 1980's, many of these towns, or the unorganized boroughs in which they are located, probably will have incorporated themselves in order to gain greater control over their development and administration. With property and sales taxes of their own, plus revenue

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[10] In the Fairbanks-North Star Borough, the Borough School District provides public education through high school. The District is 90 percent state-funded. Fairbanks City children also attend these schools.

[11] Public utilities (including telephone) are supplied by a municipal utilities system in Fairbanks; elsewhere, including the non-city parts of Fairbanks-North Star Borough, the services generally are privately supplied (including electric power cooperatives).

sharing from the State, it is expected that these small communities' financial problems will be relatively small in coping with the growth stimulated by the Alaskan Gas Pipeline.

Recalling the estimates of property taxes on the Alaskan Project, (subsection 3A.2.5.2.1), it was projected that the Interior Study Area would collect (both locally and by the state) about $24.1 million per year after 1981 (on the basis of 1973 construction costs). Comparing this to the approximately 15,000-20,000-person increase in the permanent population of the Interior as a result of the Project, the additional taxes represent a return to study area governments of more than $1,100 per each new person per year. This is in addition to other state and federal revenue sharing, general grant-in-aid, and the like. Typically, the per capita costs per resident of public services expansion are substantially less than $1,100.

3A.3.5.3.6 Impacts on Other Sectors

The Alaskan Project is not expected to have major direct long-term effects on the various economic sectors of the Interior Study Area. An assessment of the impacts of the Project on the other economic sectors was prepared in subsection 3A.2.5.2, "General Impacts on Public Finances and Economic Output." The specific sector assessments are presented with the following headings:

Subsection	Title
3A.2.5.2.2	Petroleum Development
3A.2.5.2.3	Mining
3A.2.5.2.4	Fisheries
3A.2.5.2.5	Agriculture
3A.2.5.2.6	Forestry
3A.2.5.2.7	Electric Power
3A.2.5.2.8	Transportation

3A.3.5.4 Summary of Socioeconomic Impacts, Interior Study Area

The Alaskan Project will have significant short-term and long-term impacts on the people and other resources of the Interior Study Area. A major factor will be the concentration of construction management operations at Fairbanks for the North Slope as well as for the central section of the pipeline. Also, the Fairbanks area economy will be stimulated by the spending activities of construction workers on leave from construction work camps up and down the pipeline.

Between 1977 and the peak construction year of 1980, area population is projected to increase from 66,200 to more than 90,000 persons. Total civilian employment is projected to rise from 28,800 to 40,000 workers. After completion of the gas pipeline, population and employment are projected to remain at approximately these levels for one or two years before reducing growth at the long-term rate of about three percent per year. Income and tax revenues will be substantially expanded by the

Project, with income impacts being more pronounced during construction, and tax impacts (direct and indirect) of considerably greater long-term significance.

The pipeline will not have any major direct land use impacts, since it will be installed within the designated Utility Corridor to the maximum extent feasible, and will use many of the lands and material sites used by the Alyeska project. Of greater significance are the indirect impacts resulting from pressure on land prices of new residents seeking homesites near Fairbanks, greater use of recreational assets by tourists, and resource development by native regional corporations utilizing federal and state funds. Particularly noticeable will be expansion of strip commercial developments in small communities like Delta Junction, Glennallen and Copper Center, along the pipeline route.

During construction, public facilities' requirements will increase and social problems will likely worsen in Fairbanks and other communities along the pipeline route. Increased public services staffing and budgets will have to be provided. Lags in property tax assessment and collection will necessitate state supplementary budget support.

The Alaskan Project is not expected to directly stimulate increased production of minerals, agriculture and forest resources. Transportation service and electric power requirements will increase markedly during construction and then level off to slower long-term growth trends after completion of the gas pipeline.

While the Alaskan Project will have an important bearing on the long-term development of the Interior Study Area, other factors will remain of substantially greater importance. Such factors include the U.S. military establishments in the region -- Fort Wainwright, Eielson Air Force Base, and Fort Greely -- which, together with the state government, are and will remain the principal sources of employment in the area.

3A.3.6 Aesthetic Features

A winter construction schedule (for the most part) through the Interior Study Area again precludes significant aesthetic impact during construction phase of the Project. Exceptions to the winter schedule are the Atigun Pass area, and along 40 miles from Darling Creek to Summit Lake. Because of deep snows and high potential for snow slides, these segments require a summer schedule. Some inconvenience will be imposed upon travelers and vacationers using the Richardson Highway while construction is underway, although actual working areas will, in most cases, be out of sight of the highway.

Once the pipeline is operational, little aesthetic impact will occur. Stream crossings will not mar the streams for boaters or canoeists. Elevated stream crossings (e.g., the Yukon River) should no more clash with the normal environment than would a highway bridge. Revegetating the ditch will preclude an unsightly brown strip across the landscape.

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Section 3A.4
South Coastal Division

3A.4 SOUTH COASTAL DIVISION

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3A.4.1 Land Features

Impacts on land features in the South Coastal Division are expected to be generally similar in character to impacts in the Arctic and Interior Divisions with the exception that permafrost-related factors will be absent.

Furthermore, the rugged topography, thin soils and moist climate may present less slope stability than that found to the north. The rugged terrain of Keystone Canyon necessitates construction of two 9-ft diameter tunnels, one 2330 feet long, and the other 1860 feet long. Aside from their visible presence, the tunnels are expected to have no impact on land features.

3A.4.2 Air Quality

3A.4.2.1 General

Oxides of nitrogen will be released to the atmosphere during the operation of the liquefaction facility. Oxides of nitrogen and sulfur dioxide will be released to the atmosphere from LNG carriers burning Bunker "C" fuel oil. Ground level concentrations resulting from these emissions will be so small that the effects on air quality will be insignificant. Emissions of all other contaminants will be insignificant.

NO_x emissions at the LNG Plant will result from four different operations, as follows:

1. Gas turbines for propane compressors,
2. Supplemental fired waste heat boilers,
3. Gas turbines for electric power generators, and
4. Regeneration gas heaters.

The effluent from operation 1, above, will be discharged directly into operation 2, resulting finally in a discharge from a single stack. Operations 3 and 4 each release effluents from separate stacks. The conservative assumption that two tankers will be present as continuous emission sources at the loading platform was used, although rarely will more than one be in berth at a time.

A summary of stack and operating parameters for the four operations is given in Table 3A.4-1. Stack data are tentative because

TABLE 3A.4-1

EMISSION PARAMETERS FOR AVERAGE 8-TRAIN OPERATION

Operation	Total Units Operating	Stack Height (m)	Exit Temp. (°K)	Exit Veloc. (m/sec)	Exit Radius (m)	Contaminant	Total Source Strength (g/sec)
(1) Gas turbines for propane compressors	8	*	*	*	*	*	*
(2) Supplemental fired waste heat boilers	8	45.7	478	12.2	2.77	NO_2	248.2
(3) Gas turbines for electric power generators	6	30.5	644	24.4	1.37	NO_2	113.4
(4) Regeneration gas heaters	8	30.5	422	2.0	.56	NO_2	2.82
(5) LNG Tanker	2	30.5	394	12.2	1.07	NO_2	18.48
(6) LNG Tanker	2	30.5	394	12.2	1.07	SO_2	72.56

Propane compressor turbine exhaust gases are discharged to the supplemental fired waste heat boilers.

detailed design of the plant has not yet been completed. The results of dispersion calculations, therefore, must be regarded as approximate. As detailed engineering proceeds, the calculations will be repeated to improve the accuracy of the ground level concentration estimates, and to provide assurance that ambient air quality standards are not violated.

The estimated ground level concentrations due to the NO_x emissions must be compared with the national air quality standards, which for NO_x are also the Alaska standards. The only standard to be addressed is the arithmetic annual average concentration (not to be exceeded) of 100 $\mu g/m^3$.

Estimated SO_2 concentrations must be compared to the national air quality standards, which are also the Alaska standards for SO_2. They are as follows:

1. 3-hour average - 1300 $\mu g/m^3$.
2. 24-hour average - 365 $\mu g/m^3$.
3. annual arithmetic average - 80 $\mu g/m^3$.

3A.4.2.2 Methodology for Nitrogen Dioxide Concentrations

The source parameters presented in Table 3A.4-1 were used as input to the Air Quality Display Model (*AQDM*). Such model uses stability wind roses as the meteorological input. The version of the program used for these estimates incorporates the Briggs formulation for plume rise (Briggs, 1970). This program gives annual average concentrations in the area around the sources.

Several conservative assumptions were employed in the application of the computerized model:

1. All sources were treated as though located at the same point, although there may be substantial physical separations;
2. Continuous 100% loading was assumed;
3. No augmentation of plume rise due to the additive effects of multiple sources was assumed.

Because precise on-site meteorological data are not available, data from the two closest weather stations (i.e., Cordova and Middleton Island) were used as input to the program. Although differences in terrain at those stations and at Gravina Point may lead to significant differences in directional frequency distribution of stability conditions and wind speeds, stability classes and wind speeds at the site probably fall between those of the two stations. Therefore, although the locations (directional) of the maximum concentrations obtained from the computer runs is probably not representative of the site conditions, both the distance and magnitude thereof most probably are. A summary of the two sets of wind roses is presented in Tables 3A.4-2 and 3A.4-3.

TABLE 3A.4-2

SUMMARY OF ANNUAL STABILITY WIND ROSES:
CORDOVA, ALASKA; HOURLY OBSERVATIONS, 1959-1962

Stability Class	Mean Wind Speed (knots)	Frequency of Occurrence	Percent Occurrence	Percent Calms
A	(calm)	43	0.01	0.1
B	2.5	1000	2.80	1.3
C	3.6	3272	9.30	3.6
D	6.1	21914	62.50	10.5
E	5.4	1463	4.20	-0-
F	1.4	4001	11.40	7.2
G	0.5	3347	9.60	7.8
All	4.6	335040	100.00	30.6

TABLE 3A.4-3

SUMMARY OF ANNUAL STABILITY WIND ROSES:
MIDDLETON ISLAND, ALASKA; HOURLY OBSERVATIONS, 1959-1962

Stability Class	Mean Wind Speed (Knots)	Frequency of Occurrence	Percent Occurrence	Percent Calms
A	(calm)	49	.01	0.1
B	4.1	689	2.00	0.4
C	5.3	2074	6.00	1.2
D	13.0	26702	77.00	3.5
E	6.7	2590	7.50	-0-
F	3.2	1976	5.70	1.8
G	0.5	3347	9.60	1.4
All	11.1	34699	100.00	8.6

3A.4.2.3 Methodology for Sulfur Dioxide Concentrations

In order to obtain the annual average SO_2 ooncentrations from the tanker emissions, the same methodology described for NO_x was used, with both meteorological data sets as input. Source parameters are given in Table 3A.4-1.

To address short-term concentrations, the EPA program *PTMAX* was used. The program cycles over a full range of hypothetical meteorological conditions, including wind speeds in the range of 0.5 m/sec to 20 m/sec, and stability conditions A through F. Thus, the hypothetically worst conditions were included, and maximum expected concentration and distance of occurrence were computed. The dispersion equation was the Pasquill-Gifford equation, and the Briggs plume rise formulations were used. The ten-minute maximum obtained from the program was converted to a three hour average by application of the peak-to-mean factor 1.79 (Turner, 1970).

3A.4.2.4 Modeling Results - NO_x

The calculated annual average maximum ground level concentration of NO_x (as NO_2) was 3 $\mu g/m^3$, or 3 percent of the standard.

3A.4.2.5 Modeling Results - SO_2

The maximum short-term SO_2 concentration occurs under stability class A with a wind speed of 3 m/sec at a distance of 0.51 km. The ten-minute concentration of 292 $\mu g/m^3$ can be converted to the three-hour average of 164 $\mu g/m^3$ as described above. This value not only is less than the 3-hour standard (1300 $\mu g/m^3$), but is also less than the 24-hour standard (365 $\mu g/m^3$).

The estimated maximum annual average ground level concentration of SO_2 is 8 $\mu g/m^3$, or 10 percent of the standard.

3A.4.3 Water Resources

This section discusses features in the South Coast segment of the pipeline and at the LNG Plant and Alaskan Marine Terminal.

Because of the inadequacy of water resources data along portions of the pipeline corridor in this segment, the baseline description was inferred from available data. Prediction of the Project's effects on water resources, therefore, is limited to the project description super-imposed upon an inferred baseline.

3A.4.3.1 Surface Water

Impacts associated with trenching, pipelaying and backfilling operations will produce short-termed effects including the physical disruption of stream banks and channels. Since construction is scheduled for the summer months when stream flow is generally highest, the likelihood of increased scour and sedimentation will be correspondingly higher. Adverse impacts will be somewhat lessened, however, since most large streams in the region, such as the Lowe and Gravina Rivers, are glacier-fed and normally carry high suspended sediment loads during the summer months.

Impacts from the operation and maintenance phase are expected to be minimal. At major stream crossings, including Sheep Creek, Lowe River, Dead Creek, and Gravina River, the pipeline will be buried below anticipated depths of scour. These crossings will likewise be buried at right angles to stream channels to minimize possible rechannelization along the pipeline. It is possible that certain streams could develop icings, as discussed under 3A.2.3. The gas pipeline will be constructed for the most part in remote areas and have little or no effect on existing man-made structures.

Because of the nature of the terrain in the South Coast (steep slopes and swift rivers), the likelihood of accidental disruption of stream channels and banks is perhaps slightly higher than in other segments. During the operation and maintenance phases, it is possible that flooding (including glacier outburst floods) may occur and result in physical disruption of the pipeline. The pipeline will, however, be buried at depths up to seven feet below the stream channel to minimize the possibility of pipeline disruption.

Construction of the LNG Plant and marine terminal facilities will require leveling and grading of approximately 395 acres. Care will be taken to insure that erosion problems do not develop below the construction site from channeling of waters into new areas or into stream channels.

An impoundment may be required on Harris Creek to provide water for various processes during construction. If such a structure is required, the resulting impacts to the surface water hydrology might include increased scour and sedimentation in Harris Creek below the impoundment site. Some fresh water may be withdrawn from Harris Creek, and stored for firefighting during the operation phase. It is not known whether off- or on-channel storage will be used.

It may be necessary to withdraw aggregate for the construction of the LNG Plant from Simpson Creek or the Rude River. This action may result in channel modification and increased scour and sedimentation. The size of borrow material areas will be controlled, and restoration of these areas will be part of construction. A quarry may also be required to supply stone for construction of the access road to the construction dock. This action would result in some minor alteration of local drainage patterns.

All temporary construction facilities at the LNG Plant, such as haul roads, work areas and structures, stockpiles of excess or waste materials, and other such evidence of construction that could affect surface drainage will be removed following construction.

Adverse impacts on surface water hydrology will be minimal during the operation phase. Some permanent diversion of surface drainage patterns will be required at the LNG Plant site. Storm drains will be provided to protect the LNG Plant against flooding. Flow in Harris Creek will be regulated if an impoundment is required.

3A.4.3.2 Groundwater

Proposed construction of the LNG Plant and Alaskan Marine Terminal should have little impact on the groundwater hydrology at the site. Some lowering of the groundwater table may occur if the groundwater is shallow or if it is perched, owing to construction of drainage facilities. This would have an impact only in the immediate area and would not affect groundwater hydrology in other areas.

Possible seepage of treated effluents into groundwater may occur from the holding pond which will serve as a mixing chamber for the various effluent streams prior to their discharge to Orca Bay.

3A.4.3.3 Water Quality and Uses

Pipeline construction manpower in the South Coastal Division will peak at 294, indicating a maximum water load of approximately 15 pounds of BOD per day, and water usage of 29,400 gallons per day. These levels of waste and water usage should pose no problems to the quality or quantity of water in this region.

Construction activities at the LNG Plant potentially affecting the water quality of Harris Creek include:

(1) Impounding basins for collection and treatment of water,
(2) Excavating and grading for buildings, roads, and quarry, and
(3) Disposal of cleared surface vegetation, trees and peat.

Construction of the impounding basins will cause stream bed and bank disturbances resulting in direct impact on Harris Creek by increasing suspended solids and turbidity levels, and possibly decreasing dissolved oxygen concentration downstream from the basins. These impacts will be short-term and probably inconsequential, and the quality of impounded water is not expected to be degraded.

Excavating, grading, and quarry operations will cause erosion, which will create a short-term increase in suspended solids and turbidity in Harris Creek. Erosion control techniques will be employed, however, keeping erosion and its subsequent impact on the quality of Harris Creek to a minimum.

Leaching of disposed surface vegetation, trees, and peat could cause an impact on Harris Creek. These materials are to be disposed of by spreading and grading to match existing land contours, thereby minimizing run-off to Harris Creek.

Sanitary wastes, chemicals, and other liquid wastes will not affect the quality of Harris Creek since they will be discharged, after appropriate treatment, to Orca Bay. Disposal of waste materials will be in accordance with the provisions of permit requirements. Oil and other petroleum products will be disposed by incineration, thereby keeping them out of Harris Creek.

Water required for personnel, fire protection, and construction use will be obtained from wells, or from impoundments on Harris Creek. The quantity withdrawn will vary with the size of the labor force, which will vary seasonally, but is expected to peak at 5600 personnel for the LNG Plant and 120 for the marine terminal. Assuming total water use will approximate 100 gpcpd indicates that about 572,000 gallons per day (0.89 cfs) of water will be required. Construction use will inflate this figure, but the amount is unknown. The estimated mean monthly discharge of Harris Creek from July through November (the period of maximum labor force) ranges from 30 to 70 cfs, which is roughly two orders of magnitude larger than the amount of water required. Utilization of this amount of water should create no adverse impacts to Harris Creek. Additionally, this will be a short-term use.

A significant impact to the groundwater resource of the area is expected if wells are used as the sole water source. Groundwater systems in the Prince William Sound region generally produce from 10 to 100 gpm (Feulner, et al., 1971) which amounts to 0.02 to 0.20 cfs. This amount would not be sufficient during peak demand periods.

Sanitary and liquid wastes, after appropriate treatment, will be discharged to a retention area and then to Orca Bay. No impacts from waste disposal will accrue to Harris Creek since the Creek's assimilative capacity will not be approached.

Operation and maintenance of the pipeline in the South Coastal Division should have little effect on the quality or quantity of water resources. One maintenance base, having facilities for 30 personnel, will be the source of about 1.5 pounds of BOD daily and will require about 3000 gallons per day (0.005 cfs) of water. These levels of water use for supply and waste disposal should not create adverse conditions along this section of the pipeline.

Operation and maintenance of the LNG Plant and Alaskan Marine Terminal will have little, if any, effect on the quality of Harris Creek. Fresh water requirements, including potable water, are provided by sea water desalination units, thereby eliminating the need for withdrawals from Harris Creek. All liquid effluent streams are routed to a holding pond prior to their discharge to Sheep Bay.

The quality of Harris Creek could be affected by: (a) run-off from sludge and solid waste disposal areas, and (b) accidental spills. Sludge from the diglycolamine and activated sludge units will be disposed of by biological land cultivation within the plant boundary, and other solid wastes will be disposed of in a land fill. The locations of these disposal areas have not been finalized; therefore, their effects on Harris Creek cannot be predicted at this time. Accidental spills of LNG will be contained by dikes around the storage area. Accidental release of petroleum products or chemicals would degrade surface water quality. The probabilities of run-off and accidents affecting the quality of Harris Creek are small.

No impact will accrue to the quality or quantity of the fresh water resource in the vicinity of the LNG Plant during operation since total plant freshwater requirements, including potable water, are provided by desalination of sea water.

3A.4.4 Oceanography

This section presents a discussion of the effects on physical and chemical oceanography from construction and operation and maintenance of the proposed Alaskan Gas Pipeline, LNG Plant, and Alaskan Marine Terminal and the fleet support vessels. Effects may occur in several areas, including the pipeline crossing at Comfort Cove, in the vicinity of the LNG Plant and marine terminal, and along the tanker route within Prince William Sound. Also discussed are the effects which might result from accidents owing to adverse oceanographic conditions.

Existing physical and chemical oceanographic conditions in Comfort Cove will be affected by the trenching, pipe-laying, and backfilling operations, resulting in a short-term degradation of water quality. Turbidity and sedimentation and their associated effects on water quality and biota will increase. Neither the magnitude of this increase nor the areal extent of influence can be assessed, since current velocities and circulation patterns are not known for the Cove.

Operation and maintenance of the pipeline in Comfort Cove is expected to cause little, if any, effects on the physical and chemical oceanographic conditions of the Cove.

Construction activities at the LNG Plant and marine terminal will cause short-term degradation of water quality in Orca Bay. Onshore disturbances such as excavation, grading, and the disposal of surface vegetation, trees, and peat not used as foundation materials will cause erosion and potential leaching problems. Erosion control techniques will be employed, however, to keep erosion and its subsequent impact on Orca Bay to a minimum. Leaching should cause little impact on the Bay, since soils are to be spread and graded to match existing land contours, thereby minimizing run-off.

Sanitary and other liquid construction wastes will be treated to meet regulatory requirements prior to discharge to Orca Bay. Although the strength and nature of liquid construction wastes are not known, an estimate of the BOD from sanitary wastes can be derived using the criteria presented in section 3A.2.3.3 and assuming 5,720 workers (estimated peak manpower during construction). BOD from domestic waste will amount to approximately 292 lbs/day. Liquid effluent streams will be routed to a retention basin, made compatible with bay waters, and released.

Offshore construction activities involving placement of piles for access trestles, loading platforms, and dolphins for the marine terminal will cause disturbance of marine sediments and result in some increased turbidity. More significant effects are likely to occur, however, with the construction of the 600-ft-long rubble mound structure to be used as an access road for the construction dock as well as a breakwater for the small boat harbor. Construction of this structure will result in temporary increased turbidity and disruption of the normal near shore circulation patterns in the area. Lack of sufficient baseline information on the nature of near shore circulation precludes a detailed assessment of possible environmental impact at this time.

Adverse effects on the water of Orca Bay from operation and maintenance of the LNG Plant and Alaskan Marine Terminal will be related to discharges of process waters, uncontrolled run-off from sludge and solid waste disposal areas, and accidents.

Process waters to be routed to a holding pond prior to discharge to Orca Bay include boiler blowdown, process area and tank farm storm sewer effluent water, fresh cooling water losses, demineralizer backwash and rinse effluent water, and the chlorinated effluent from the sanitary treatment unit. Effluents containing oil and oil by-products will be treated, and the demineralizer backwash and rinse effluent water will be pH-adjusted prior to discharge to the holding pond. Characteristics of the holding pond effluent discharged to Orca Bay are presented in Table 3A.4-4. None of the components in this table exhibit concentrations that would cause adverse effects to the waters of Orca Bay unless circulation and mixing are such that this effluent concentrates in a local area.

Possibly the most significant effluent to Orca Bay during operation will be the discharged cooling water and brine. This combined effluent will have an average flow of 2550 cfs (1650 mgd), approximate to the mean annual flow of a 300 square mile drainage basin. The cooling water and desalination unit combined effluent will be approximately 16^{o}F warmer than the intake water. This effluent will undoubtedly alter the thermal regime and density stratification in Orca Bay in the vicinity of the LNG Plant, and affect circulation. The areal extent and magnitude of influence of the thermal discharge cannot be accurately assessed because of the lack of necessary baseline oceanographic data for the region.

Run-off from sludge and solid waste disposal areas should not appreciably affect the quality of Sheep Bay. These wastes will be disposed of by biological land cultivation or in land fills, in accordance with applicable standards.

TABLE 3A.4-4

WASTE DISCHARGE FROM HOLDING POND TO ORCA BAY DURING OPERATION OF LNG PLANT

Flow	GPM	MGD
Average 1/	1170	1.68
Normal 1/	738	1.06
Design 1/	8867	12.77

Component	PPMW 2/	LBS/DAY 2/
BOD_5	0.4	5.62
Phosphate ($PO_4^{\equiv}$)	1.5	21.08
Chloride (Cl^-)	12	168.60
Oil	<1	<14.05
Suspended Solids	5	70.25
Total Dissolved Solids	52	730.60

Temperature of discharge will be 61°F and pH will be 7.0

1/ Major portion of flow in storm water run-off from process units and LNG tank farm areas.

2/ Values given are for average conditions.

The placement and periodic maintenance of navigational aids, such as buoys and their anchors, may cause local, short-term increases in turbidity along the tanker route within Prince William Sound. The effects are expected to be minimal.

The mixing and diffusion characteristics of discharges into the bay near the LNG Plant are presently unknown. These factors will be vital in the assessment of the ultimate effects and extent of waste discharges on the marine environment.

Accidental spillage of oil or oil by-products could result in some degradation of water quality. The adverse effects will depend on spill size, spill location, existing meteorologic and oceanographic conditions, and the type of products involved.

Accidents will probably be associated with, or possibly caused by, adverse oceanographic conditions such as severe waves or tsunamis. Tsunamis are not uncommon to Prince William Sound, as shown in records of the events following the 1964 Alaskan earthquake. Although no bathymetric features offshore of the LNG Plant site appear likely to amplify these tsunamis, significant wave run-up could occur. Locating the LNG Plant above the 100-ft. elevation minimizes the risk of tusunami damage; however, some damage could occur to the marine facilities. Little warning would be available for locally generated tsunamis (within Prince William Sound), but the U. S. Department of Commerce operates a tsunami warning system which would provide some warning for waves generated outside the Sound. In the event of such a warning, the LNG products handling facilities will be shut down.

3A.4.5 Species and Ecosystems

Although this is the shortest Alaskan section of the Project in linear extent (less than 10 percent), the environmental considerations of the proposed gas pipeline and LNG Plant and terminal merit substantial biological concern. The biota south of the Lowe River differs in quantity, quality, and, no doubt, in functional ecological relationships. Valdez Arm -- the only area of Prince William Sound studied in detail -- is atypical of more southerly parts of Prince William Sound. Moreover, the substantial reliance of inhabitants of Cordova and Tatitlek upon regional biological production signifies both their local integration into the ecosystem and their anticipated attentiveness to any developments that potentially affect livelihood and lifestyle patterns.

3A.4.5.1 Terrestrial Environment

Section 2A.6.3 identified sensitive biological processes particularly among consumers in the South Coastal Division. The incompleteness of available biological data for this region makes the following predictions of ecological effects less specific than those presented for the Arctic and Interior Divisions.

3A.4.5.1.1 Construction

This phase of the proposed Project will involve four types of ecological effects:

(1) Direct destruction of habitat will occur within the right-of-way and at LNG Plant site (approximately 450 acres). The species that will be affected include the Sitka black-tailed deer primarily, since they will be excluded from the Gravina Site, an area identified as relatively heavily used in comparison to other mainland localities.

(2) Disturbance will occur to large consumers, such as mountain goats, bald eagles, and trumpeter swans from equipment and aircraft operations and blasting. In cases where construction is scheduled for summer, this may lead to failure to breed. In the case of goats, their normal seasonal movements may be altered temporarily; however, goats can probably withstand moderate temporary displacements.

(3) Applicant may be required to control curious brown/grizzly bears which may infiltrate the construction area; however, proper solid waste disposal to be exercised by Applicant should discourage this situation.

(4) Through the influx of construction workers and support personnel, the harvest pressure on regional terrestrial consumers is likely to increase. Deer, goat, bear, and waterfowl hunting will be recreational outlets for increased numbers of people. As it becomes necessary, the hunting seasons on mammal species may be shortened, as has already happened with both species of bears in Game Management Unit 6.

(5) Increased waterfowl harvest will chiefly center on the Copper River Delta. The effect of the proposed Project on hunting pressures may be contributory rather than primary, when and if the Copper River Highway is extended to connect Cordova to outside road networks in interior Alaska.

As with other regions and other phases of the proposed Project in Alaska, the increased numbers of people brought into the Prince William Sound region will be the single most pervasive and significant ecological event or aspect of the Project. Virtually all of the biota in the South Coastal Division is known or suspected of being lower in productivity (slower growing, slower reproducing) than its counterparts in more southerly locations. Increased harvest of standing crops of, for example, timber, may therefore be successful only temporarily, if such harvest outruns the productivity of the resource and a steady, sustained yield cannot be maintained.

3A.4.5.1.2 Operations and Maintenance

Several actions during the operations and maintenance phase may have ecological effects:

(1) The most significant waste from the LNG Plant will be large quantities of heat. Whether this heat is dissipated directly to the atmosphere, to fresh water, or to sea water, some of it will impinge on the terrestrial environment and its biota. It may do so in the form of higher air and soil temperatures, leading to enhanced metabolic rates of primary producers and decomposers locally. But it may appear only in the form of an increased volume of nutrients deposited on land from warmed (and therefore more productive) fresh or sea water.

(2) Traffic to and from the LNG Plant and other points along the pipeline in the South Coast Division, whether for patrol and maintenance or crew changes or other activity, and depending on whether it is aerial, marine, or surface, may have some effects on large consumers, such as goats and nesting birds.

(3) Right-of-way maintenance may involve measures to discourage the regrowth of alders and larger trees which might otherwise obscure visibility during patrol. Experience with southeastern Sitka black-tailed deer (Section 2A.6.3) indicates that the inhibitory effects to deer movement of deeper snowfall on open ground constitutes a barrier to their normal movements between uplands and tidewater. The problem is expected to be less acute in Prince William Sound, however, because there are fewer deer on the mainland, snowcover builds up more gradually in the fall, and the width of such a potential barrier over the cleared right-of-way is small in comparison to tracts of clearcut timber lands. To the extent that mountain goats may normally move through timber during the winter, this anticipated permanent clearing of a continuous line might pose a similar problem to goat mobility.

(4) Solid waste disposal will have to be carefully regulated to prevent attraction of nuisance bears. A less obvious benefit to continually (winter as well as summer) burning and burying garbage properly is that of not attracting and sustaining gulls through the winter period of normally minimal food supply for gulls. In the Atlantic Ocean, open waste dumps have sustained the overwintering populations of herring gulls (Larus argentatus) in increasing numbers during past decades. The increased initial breeding populations of this species have made serious inroads on the breeding success of the common puffin (Fratercula arctica), since gulls tend to pirate food being brought to puffin chicks by the adults, and often prey directly on chicks themselves. Major breeding colonies of puffins are now gone, as at Lundy Island off Wales (D. Nettleship, personal communication). The two common gull species in Prince William Sound - Glaucous-winged gull, Larus glancescens, and the herring gull - (Isleib, 1973) might be similarly thrust into the roles of pirates and predators upon local breeding populations of horned puffins (Fratercula corniculata) tufted puffins (Lunda cirrhata) or other alcids in Prince William Sound by careless waste disposal.

3A.4.5.1.3 Accidents

Fuel oil spills, line failure, wildfire, and vandalism pose the same threats in the South Coastal Division as discussed for preceding regions of Alaska, with the following differences:

(1) Spills of petroleum products are expected to disperse into aquatic and marine environments relatively quickly because of the close interactions of the three environments, and because of the rapid run-off process. Because of the lack of permafrost, spilled petroleum will in summer, tend to percolate to deeper soil layers where granular substrate occurs, facilitating entrance to below ground and watery environments.

(2) Line failures or ruptures might have a higher probability of occurrence in this region without special construction modes or provisions to avoid dangers from the common snow and rock slides in the Chugach Mountains. The severity of the impact of natural gas is judged to be minimal in the terrestrial environment, but its biological effects (i.e., toxicity) in water are unknown.

(3) The danger of setting wildfires, and the danger to proposed facilities from active wildfires, will be lower in this region of high rainfall and slow-drying fuels than in interior Alaska. Wildfire occurrence is not a natural part of ecosystem functioning in coastal Alaska as far as is now known (Noste, 1969). Prevention and suppression of wildfires are therefore desirable aims that do not raise as serious ecological dilemmas as in the Interior Division.

(4) Vandalism or accidental damage to part of the LNG Plant would seem to be a far more serious event and to pose greater ecological problems than vandalism or accident to the pipeline. This is because of the vastly greater concentration (and its aboveground presence) of fuel at the Plant. Fencing and other types of security to prevent discharge of firearms within at least a mile of the LNG Plant and terminal facility are planned. A buffer zone in what is presently an area available for deer and bear hunting may actually result in protection, or a de facto refuge zone for these species near the plant.

3A.4.5.2 Aquatic Environment

3A.4.5.2.1 Construction

Conceptually, the pattern of effects on aquatic ecosystems resulting from construction in the South Coastal Division will be identical to that occurring in the Arctic Division, although the magnitude and extent of impact will be substantially different.

The South Coastal Division differs from the Arctic Division in certain respects, however, particularly in the siting of the proposed LNG Plant on Gravina. Construction activities at the LNG Plant site are planned to cover a period of five years. A single stream (Harris Creek) occurs near the site, and an impoundment may be created on it. Salmon spawned in the stream before the 1964 Alaskan earthquake, and spawning may still take place there, although the earthquake apparently restricted access to the stream. Aquatic biota will be greatly modified within impoundments. Other areas of the stream should be only temporarily affected by impoundment construction. If spawning by salmon does take place in Harris Creek, special scheduling of work may be required to avoid interference. The northwest boundary of the LNG Plant site parallels the stream for a distance of one mile, and lies approximately 1000 feet from it. There is potential for the introduction of silt by run-off, nutrients, and waste products resulting from construction activities. The biology of the stream would be changed if even low-level input continued for an extended period.

The entire South Coastal Division lacks permafrost soils. Therefore, the introduction of nutrients and solid material through permafrost degradation, as may be expected in the Arctic Division, will not occur here. The heavy rainfall in the area will, however, increase erosion at construction sites and introduce increased silt loads, nutrients, and chemicals into lakes and rivers. All material introduced into streams and rivers will eventually be transported to the ocean. The marine ecosystem in Prince William Sound is characterized by highly productive seaweed and marine grass communities along the extensive shorelines. These communities are extremely important ecologically, and may fuel much of the deep-water biological productivity as well as that near shore. A reduction in this productivity resulting from increased toxins, silt, or other material could therefore have important and far-reaching effects upon marine biota.

The South Coastal Division differs from the rest of the route, in that summer construction is scheduled for most of the pipeline, because of heavy winter snowfalls in the area. River crossings, and construction in low-lands adjacent to rivers, however, will take place in winter to avoid disturbance of fish migrations.

The biology of the area from the Lowe River to the LNG Plant site has not been extensively studied. The terrain is very rugged, and the steepness of the land may increase the potential for erosion and landslides. The Gravina River is an important spawning stream for salmon, and may require special attention during construction. An unnamed lake that drains into the Gravina River near its mouth also supports spawning. The pipeline will pass very close to the lake, and winter construction or other special attention is desirable.

The area is not currently accessible by road, and the rugged terrain discourages human usage of natural resources, except along the coastal fringe. The large labor force expected (5720 at peak) may place considerable pressure on fish populations in the area.

Productivity of aquatic ecosystems in the South Coastal Division may be higher than along the rest of the pipeline route, because of longer summers, warmer temperatures, and the absence of permafrost. If productivity is higher, it may imply a quicker recovery time for disturbed biotic communities.

3A.4.5.2.2 Operation and Maintenance

Conceptually, operation and maintenance of the proposed pipeline in the South Coastal Division will produce the same effects outlined for the Arctic Division. Little change in access will occur north of where the pipeline route diverges from the Lowe River. From that point to the Gravina Site, there are currently no public roads. Considerable pressure on aquatic resources may be expected during the operation and maintenance phase of the Project if public access is achieved through opening of roads built during the construction phase. Discussion of the significance of human presence in a wilderness area may be found in the Arctic Division (Section 3A.2.4.2).

Operation and maintenance of the LNG Plant should have a negligible effect upon aquatic (freshwater) ecosystems. All fresh water used in plant operation, including personnel requirements, will be provided by desalination of sea water. Treated sewage effluent from the holding pond will be disposed of directly into Orca Bay. Thus, Harris Creek should not be affected. Some foreign material may be introduced by run-off from the plant site, though the quantity should be negligible after construction is completed.

The size of the resident labor force at the LNG Plant is 378. Some pressure on aquatic resources will presumably result from personnel during recreational hours. The nearby Gravina River is a productive fishing area and may experience considerable usage.

The increased potential for erosion and landslides resulting from the steepness of the terrain between the Lowe River and the LNG Plant may require more than average maintenance during the life of the pipeline.

3A.4.5.2.3 Accidents

A discussion of accidents affecting the aquatic environment is presented in subsection 3A.2.4.2.

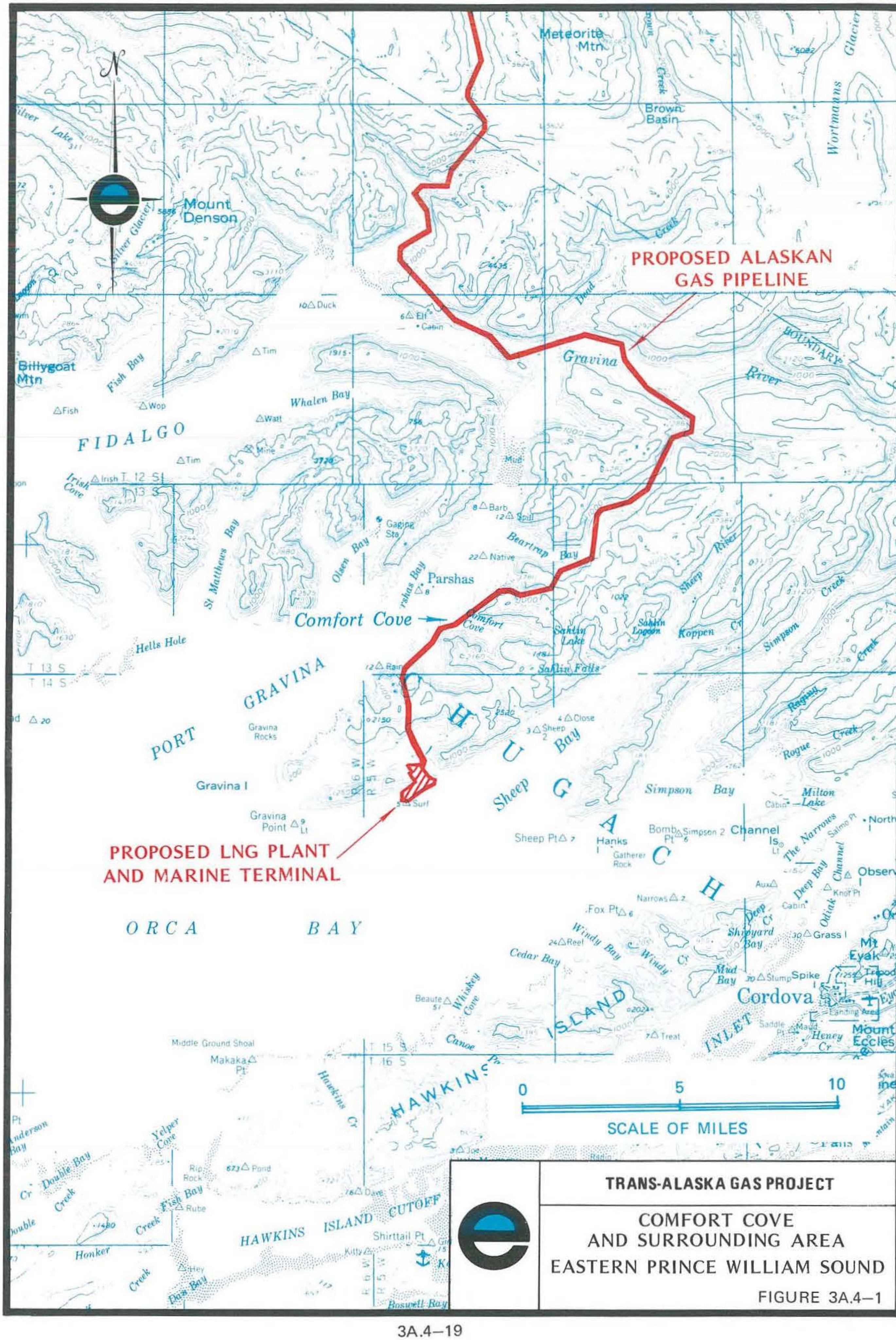
3A.4.5.3 Marine Environment

A proposed gas pipeline is to traverse Comfort Cover, a marine habitat on the northeast side of Gravina peninsula (Figure 3A.4-1). The planned crossing method is a buried concrete coated and anchored pipeline at a depth six feet beneath the sea floor. In the vicinity of the pipeline route, the cove reaches a maximum depth of approximately 20 meters; the bottom sediments are composed of fine silts and empty clam shells. Since the flushing characteristics of Comfort Cove are unknown, magnitude of impact is impossible to assess. Burial of a 42-inch pipeline in a marine system must involve dredging, filling, or both. Dredge spoils contribute to silt loading and build up bottom sediments that either bury or scour existing benthic assemblages.

3A.4.5.3.1 Construction

The environmental impact of trenching on aquatic ecosystems have been discussed by O'Neal and Sceva (1971), and the Environmental Protection Agency (1972; 1973). Generally, this type of activity has an immediate effect on both water quality and the biota in the system. However, it is difficult to predict what effect dredging and filling will have on the underlying benthic community in Comfort Cove. Additional silt could lead to increased water turbidity in the receiving waters, with a resultant reduction in submarine light penetration. The importance of light and its effect on primary production, has been discussed in Section 2A.6.3.5.1. Many of the animals that obtain food by filtration would experience difficulties with silt-ladened waters. There is some indication that larval recruitment in the subarctic is patchy, and that marine organisms living in this region for the most part are long-lived. Therefore, recovery processes may take longer than if the disturbance took place in a temperate or tropical marine ecosystem.

Primary considerations during construction of the LNG Plant are the effects on the shoreline and intertidal beaches. A narrow, rocky beach exists in the vicinity of the proposed terminal site, and construction is expected to temporarily alter nearshore water quality and disturb the marine organisms living on or within the substratum. The biota of the



TRANS-ALASKA GAS PROJECT

COMFORT COVE
AND SURROUNDING AREA
EASTERN PRINCE WILLIAM SOUND

FIGURE 3A.4–1

seashore is generally associated with either the soft, unstable sediments (mud and sands), or the consolidated rocks. Much of the interstitial and infaunal life is confined to less than 30 cm below the surface of the substratum. Most are sedentary and unable to move away from the construction zone. Onshore human activity such as trenching, road building, and equipment movement will probably affect the ecology of the shoreline. The softer sediment is the habitat of clams, worms, and crustaceans; the harder substratum supports a mussel-barnacle-rockweed association. Lack of sufficient background information on the benthic community off Gravina peninsula precludes any assessment of this impact; however, based upon marine fouling and settling studies (Cole and Allen, 1942; Ray, 1959; Pearce, 1968), some ecological change seems inevitable.

Road excavation, blasting and other construction activities near the shoreline are expected to have an indirect effect on the nearshore system because of disturbances to the soil and terrestrial vegetation. Rainfall is excessive in this region and disturbance to the topsoil during the rainy season could result in excessive run-off and siltation in the nearshore zone.

In order to reach the 50-ft depth contour, the terminal structure is expected to extend approximately 1200 feet offshore. Pile emplacement and filling should produce ecological change. Cluster piles, or dolphins, will be driven into the soft substratum. Because physical disturbance is involved in the installation of the pilings, a number of motile animals will probably move out of the area. Sedentary organisms will be crushed or buried, especially if they live within an area targeted for pile installation. Most invertebrates are not random in their distribution pattern, but are typically found in patches or clusters. For example, if a subtidal clam bed or crab mating and spawning area were located in the proposed terminal area, it could be damaged during the construction phase.

Construction and installation of the terminal structure will probably indirectly affect the benthic community because solid substratum will be placed on a relatively soft bottom. There have been a number of studies documenting the changes that take place following the emplacement of artificial structures in the marine environment (Carlisle, et al., 1964; Randall, 1963). Car bodies, piers, tires, drilling platforms, and artificial islands have been placed on sandy and mud bottoms along the east and west coasts of North America. Essentially, the placement of the docking structure is analogous to creating an artificial reef. Changes will occur in the soft bottom community in the vicinity of the terminal. The pilings will provide attachment sites for sessile plants and animals; they also could attract transient fishes and motile invertebrates seeking refuge and foraging areas. Conversely, other invertebrates such as clams and polychaete worms, which typically inhabit soft bottoms, may be excluded by the new recruits.

Construction of the small boat harbor will add to the overall nearshore disturbance. Plans call for a 600-ft-long filled structure and the nearshore area beneath the structure will probably be covered by the rubble, fill, and pilings. During construction, nearshore water turbidity is expected to increase, with a resulting reduction of solar light penetration into the subtidal zone. Plant growth could be temporarily reduced, especially if construction occurs during the spring and summer months. Siltation and sediment deposition in shallow subtidal and intertidal regions along the Gravina Peninsula could possibly affect the spawning habits of salmon and herring, which are known to use these zones in other parts of Prince William Sound (Helle, et al., 1964). The boat harbor should produce impacts similar to the terminal structure. Existing populations of invertebrates could be buried during the construction stage. The "artificial reef" analogy also applies to these structures. Solid substratum will become available for colonization and occupancy; some species will benefit by the boat harbor, others will probably be outcompeted or excluded.

Installation of the seawater intake and outfall systems will probably affect the nearshore sediments and produce similar kinds of changes. A part of the sea floor will be buried under the pipe, but new, solid substratum will become available with the addition of these structures.

Overall construction noise and presence of man in the terminal site will temporarily disturb marine birds and mammals that either move along the sea surface or feed upon surface-dwelling prey.

3A.4.5.3.2 Operation and Maintenance

During plant operation it is expected that at least 1.1 million gallons per minute of sea water will be drawn into the LNG Plant for once-through cooling. Phytoplankton, zooplankton and small fishes coming in contact with the intake pipe will probably be carried into the system. Larger fishes and marine mammals will probably not be vulnerable to entrainment unless they become trapped against the intake screens. Based upon the thermal and chemical characteristics of the LNG Plant and desalinization units, a 100 percent mortality of the organisms entrained into the plant can be expected. The larvae and juvenile stages of commercially important species such as salmon, herring, clams, shrimps, and crabs are all potential candidates for entrainment into the LNG Plant. Coastal power plants in California have experienced similar entrainment problems. During seasonal spring and summer phytoplankton blooms, mortality is expected to be much higher than during winter months. The frequency of encounter with tanner, king, and dungeness crab larvae will also increase during the summer because the larvae are drifting in the water column. Planktonic organisms tend to be both patchy and stratified in their patterns of distribution, so the location of the intake will probably determine the amount and kinds of plankters encountered.

A projected one million gallons per minute of heated effluent will be discharged into Orca Bay daily. Current specifications call for the effluent to be approximately 16°F above the ambient sea water temperature. Effluent from the LNG Plant will consist of heated brine and chlorine. The presence of heavy metals or chemical discharges during descaling operations may be toxic to organisms living in the discharge area. These properties were found to be important at a desalting plant in Key West, Florida (Clarke, et al., 1970).

The effects of heated effluent on marine organisms in subarctic waters are unknown. Temperature tolerance studies have not been conducted on the marine life inhabiting Prince William Sound. Studies by Newell and Northcroft (1967) have shown a significant difference exists between aquatic animals that are acclimated to changes in temperature and those that are shocked with a new extreme. Seasonality is an important consideration to understanding physiological changes incurred through thermal stress. The seaweeds and seagrasses, two important groups in Prince William Sound, appear to be quite sensitive to changes in sea water temperature (Newell & Pye, 1968; North, 1971; Thorhaug, 1973). Some marine plants are not killed outright by an elevation in temperature; however, increases in temperature can reduce resistance to disease or alter physiology (e.g., respiration), or both to a point where the plants are indirectly eliminated. With respect to thermal tolerance, temperate organisms appear to be more adaptable to extremes in water temperatures than are tropical forms. Based upon observations made in the vicinity of power plant outfalls off the California Coast, a biotic change should be expected in the vicinity of the LNG Plant. However, since so little is known about community structure in this region, it is difficult to predict what the course of events will be following discharge of heated effluent.

3A.4.6 Socioeconomic Considerations

3A.4.6.1 Project Activities Affecting the South Coastal Study Area

Project activities in the South Coastal Study Area will consist of construction and operation of a 55-mile stretch of pipeline extending south from Thompson Pass in the Chugach Mountains, past the inland tip of the Valdez Arm (where Maintenance Base D will be located) to its terminus at Gravina Point on Prince William Sound, plus construction and operation of the LNG Plant and the Alaskan Marine Terminal. Construction activities will be conducted over a 4-1/2 year period beginning in the spring of 1977, and, during the period of peak employment in spring and summer of 1979, will occupy more than 6,000 construction workers.

Because of its complexity and size, the LNG Plant will require the majority of the resources and time in construction--over $1.6 billion in total capital costs and more than 32 million man-hours of construction labor costing over $300 million. Site acquisition cost is projected at $5.4 million. The 55-mile long pipeline segment and the maintenance base near Valdez are projected to cost about $130 million (assuming proportionality of total capitol costs to length of pipeline segment) with $25.2 million represented in construction payroll costs. The marine terminal and related ship service facilities are estimated to require a total of $57.7 million in capital expenditures.

Temporary housing for the LNG Plant and marine terminal construction labor force will be built at Gravina Point near the 450-acre plant site. Permanent housing will be provided for 65 key operating personnel and their families on Gravina Point, with access to schools and other amenities to be provided. Other plant and terminal personnel will reside in Cordova, and will commute to work in company launces. Pipeline maintenance personnel who will staff the maintenance base near Valdez will reside in that city.

Table 3A.4-5 summarizes capital and operating cost and personnel data for the Project facilities in the South Coastal Area. After commencement of full commercial operations, total operating costs of area facilities are projected to total more than $134.0 million per year, most of which is accounted for by LNG Plant maintenance expenses and fuel gas for power generation and compression. Ad Valorem taxes paid to the state and (potentially) local governments will total an additional $32.2 million. Total operating payroll for the South Coastal Study Area pipeline segment, LNG Plant and marine terminal is projected at $7.8 million per year (1973 Alaskan wage rates).

The economic life of the proposed facilities is projected to be 25 years, after which they will be abandoned. Restoration of the LNG Plant site to its original, pre-Project condition probably would not be completely achievable owing to the necessity for extensive initial site preparation work. Thus, development of the facility will have a long-term irreversible impact in the form of permanently altering land contours in the Gravina Point area. Restoration of the pipeline right-of-way probably will be less difficult.

3A.4.6.2 Land Use Impacts

3A.4.6.2.1 Land Ownership Changes

Land ownership in the South Coastal Study Area is heavily federal and state, with private parcels being mostly in the Valdez, Cordova, and Anchorage areas and in scattered mining and homesteading claims.

Changes in land ownership for the immediate effect zone (the right-of-way) in the South Coastal Area principally include the acquisition of the 55-mile pipeline right-of-way from Thompson Pass to Gravina Point, necessary lands for road systems, 100 acres for material storage (tunnel construction at Keystone Canyon), and the site for the LNG Plant and marine terminal facilities. The plant and terminal site is 450 acres with an additional 750 acres planned as a surrounding greenbelt. It is estimated that 20 percent of the construction work force for the LNG Plant and marine terminal facilities will be housed there.

The principal form of land ownership change in the extended and diffused effect zones which might result from the Alaskan Gas Pipeline is the sale of state lands to the public. State lands surround the corridor east of Valdez, and also comprise the areas to the north and south of that city. As a result of the increase in local jobs resulting from the Alyeska oil pipeline, and the limited amount of privately held land in the area, land speculation and rising real estate prices are common. The building of the proposed terminal facilities and pipeline in the proximity of Valdez may not

TABLE 3A.4-5

PRINCIPAL PROJECT CONSTRUCTION AND OPERATION CHARACTERISTICS SOUTH COASTAL STUDY AREA (Millions of 1973 Dollars)

Pipeline[1]	
Length of pipeline	54.7 Miles
Number of compressor stations	0
Number of maintenance bases	1
Estimated capital costs	$130.0
Estimated construction labor costs	$25.2
Estimated maximum construction labor force (1978-79)	300
Estimated annual operating costs[2]	$4.7
Estimated annual operating payroll (22 men)	$0.7
Estimated annual ad valorem taxes	$2.2
LNG Plant	
Estimated capital costs	$1,600.0
Estimated construction labor costs	$307.9
Estimated maximum construction labor force (1980)	5,600
Estimated annual operating costs[2]	$127.8
Estimated annual operating payroll (309 men)	$5.4
Estimated annual ad valorem taxes	$29.0
Marine Terminal	
Estimated capital costs[3]	$57.7
Estimated construction labor costs	$5.6
Estimated maximum construction labor force (1978-79)	120
Estimated annual operating costs[2], [3]	$1.5
Estimated annual fleet support payroll (47 men)[3]	$1.7
Estimated annual ad valorem taxes	$1.0
Summary	
Total estimated capital cost	$1,787.7
Total estimated construction labor cost	$338.7
Total estimated annual operating cost[2]	$134.0
Total estimated annual operating payroll (378 men)	$7.8
Total estimated annual ad valorem taxes	$32.2

[1] Assume direct proportionality of costs to length of pipeline in study area and 25-year operating life.

[2] Operating costs exclude estimated ad valorem taxes.

[3] Includes capital and operating costs of shore-based equipment serving the LNG Carrier Fleet.

only support the presently high land values, but may escalate them even higher.

Native Select

3A.4.6.2.2 Land Use Pattern Changes

The South Coastal Study Area will contain the southern-most 55 miles of the pipeline right-of-way and the 450-acre site for the LNG Plant and marine terminal facilities. Land will be required for a maintenance station, helicopter pads and communications areas. Changes in the zone of immediate effect also include 132 acres devoted to camp construction and 100 acres (total) for two tunnel spoil disposal sites.

At a point southeast of Valdez, the proposed gas pipeline will be routed south through coastal mountains to Gravina Point, a peninsula on the eastern portion of Prince William Sound. From the point where the pipeline leaves the Utility Corridor east of Valdez to the LNG Plant at Prince William Sound, it will be routed through several heavily forested, remote areas. The numbers and locations of the borrow sites for the 55-mile right-of-way have not yet been determined; however, such sites will be restored as required by landowners and permitting agencies.

Changes in land use patterns as a result of the Project are not anticipated in the areas adjacent to the right-of-way. They are expected to remain in the conservation land uses of national forest and wildlife habitat. There will be pressure from the public for the sale of state lands near Valdez, especially as the peak year of construction activity and employment (1979) nears.

Some of the Project operating employees, and most of the construction workers and their families probably will settle in Anchorage, expanding the need for additional services, residences, schools, sewerage, etc. The majority of the operating personnel are expected to settle in Cordova, however, which fact will greatly accelerate the expansion of that community.

3A.4.6.2.3 Community Changes

There are no communities in the right-of-way of the Alaskan Gas Pipeline in the South Coastal Study Area. However, the communities of Valdez and Cordova are in the extended effect zone of the pipeline. The changes in land use in these communities could be extensive. At present (mid-1974), the housing situation at Valdez is critical as a result of the construction of the Alyeska pipeline. Housing also is tight in Cordova. By the time construction of the Alaskan Gas Pipeline begins, the scarcity of residences probably will not have eased, and will most likely have escalated to critical proportions when the height of construction employment in the area is reached (1977-79). Most of the construction workers will live in a work camp near the site, but many are expected to bring dependents to Cordova, which at present is unprepared to accommodate a sharp and sustained increase in residents. In both Cordova and Valdez there is the risk of uncontrolled urban growth.

The principal impact of the pipeline upon the communities of Valdez and Cordova will be that resulting from an increase in construction labor forces. An increase in the need for residences and the resultant need for services will essentially prolong the impacts alrady created by the Alyeska pipeline. The boundaries of Valdez, Cordova, and to a lesser extent Anchorage, will be extended to accommodate the people transferred or attracted to these cities. New land areas must be devoted to expanding residential areas and utilities. After 1980, the critical situation should ease somewhat with the gradual decline of construction crew staffing, and by 1982, equilibrium between housing, services and residents should be achieved.

3A.4.6.2.4 Land Use Planning Changes

There may be some changes in land use planning in the South Coastal Study Area on the federal level as a result of the gas pipeline construction. If changes are created at this level they may be initiated by the Bureau of Land Management, the Forest Service (Chugach National Forest) or the State-Federal Land Use Planning Commission. Changes in land use policy would most likely come from the latter organization, which considers the problems and needs on both the state and federal levels. Land use planning by individual federal agencies may not be as extensive in the future as it has been in the past.

There are already a great many land use problems facing the cities in the South Coastal Study Area. The impact of the Alaskan Gas Pipeline will be to increase the pressure upon the meager land use planning capabilities present in the area today (1974). An increased interest in planning in the area by the State-Federal Land Use Commission, coordinated with local municipal interests, can reduce the severity of the problem until an area borough is organized. Impact funding assistance from the State will be essential to develop zoning and development plans and controls.

The Greater Anchorage Area will need to expand its land use planning resources to deal with the projected large influx of Project and non-Project workers and their families in the late 1970's. This increase is expected to peak in 1979 or 1980, with a net inflow of nearly 50,000 persons over the 1977 pre-construction level (subsection 3A.4.6.3.1).

3A.4.6.3 Population and Economic Impacts

3A.4.6.3.1 Population Changes

Anchorage will experience the largest population increase in the South Coastal Study Area as a result of the Alaskan Project. However, the area around Cordova may experience higher relative impacts. Indeed, this is the only area along the Alaskan Gas Pipeline which will have had few impacts associated with the Alyeska oil pipeline. Furthermore, the LNG Plant and marine terminal are isolated from Cordova, and the only access to the site from Cordova is by boat, float plane, or helicopter.

Since Anchorage is the center of commerce and the major port of entry for Alaska, most Project administrative offices, support organizations and subcontractors will be located there. Furthermore, since the pipeline maintenance camps, compressor stations, and the LNG Plant and marine facilities will be staffed by persons on a rotational schedule (e.g., operating crews will work 10 days and then have 5 days off), many dependents will probably locate in Anchorage. It is expected, however, that the communities of Valdez and Cordova will receive many families of supervisory personnel assigned to the southern leg of the pipeline and to the LNG Plant during both the construction and operating phases.

Growth Dynamics

The South Coastal Study Area should grow more rapidly than the other study regions. Absolute changes should also be greater, as is indicated in Table 3A.4-6. In fact, two-thirds of the projected increase in overall state growth from 1978 to 1979 is projected to occur in the Anchorage area. Moreover, after 1980 Anchorage is not expected to lose population from one year to the next, as Fairbanks may.

The peak of population change directly accountable to the Alaskan Project in the South Coastal Area will occur in 1977. Thereafter, increases will occur at a decreasing rate, reflecting a decline in direct project employment but a steady rise in overall population induced by the oil and gas industry and other factors.

The Cordova-McCarthy Census Division will grow an estimated 86 percent over its projected level without the Project. This is a substantial increase, and it will occur mainly in and around the City of Cordova.

Air and water are the only existing modes of access to Cordova, and the Chugach Mountains effectively isolate the town; therefore, much of the LNG Plant construction force will be housed in a self-sustaining camp at Gravina Point. Dependents of the construction work force will not live at the construction camp, except in the case of some supervisors who will be provided housing for their families. Most dependents of plant personnel probably will live in Anchorage or Cordova. Valdez may house many of the families of supervisory personnel working on the southerly portions of the pipeline.

Age Distribution

Initially, the Cordova-McCarthy Census Division will have a decreasing Demographic Dependency Ratio (DDR) because of the influx of males (ages 18 to 60) for construction of the LNG Plant. On completion of the pipeline, the ratio should return to about normal.

Anchorage, on the other hand, may experience an increase in its DDR, since many of the dependents of the Alaskan Gas Pipeline construction and operating work force may live there.

TABLE 3A.4-6

PROJECTED POPULATION IMPACTS OF THE ALASKAN PROJECT IN SOUTH COASTAL STUDY AREA CENSUS DIVISIONS, 1977-1983
(Thousands of Persons)

Place	1977	1978	1979	1980	1981	1982	1983
South Coastal Study Area							
Without Project	209.0	210.8	212.6	215.6	223.0	230.2	238.0
With Project	209.0	215.3	257.6	261.8	266.3	273.3	279.2
Impact	0.0	4.5	45.0	46.2	43.3	43.1	41.2
Anchorage Census Division							
Without Project	199.5	204.1	205.2	208.1	215.1	222.1	229.4
With Project	199.5	207.5	242.5	246.9	253.5	262.7	268.1
Impact	0.0	3.4	37.3	38.8	38.4	40.6	38.7
Cordova-McCarthy Census Division							
Without Project	2.5	2.5	2.5	2.6	2.7	2.8	2.9
With Project	2.5	3.5	8.0	10.0	7.9	5.4	5.4
Impact	0.0	1.0	5.5	7.4	5.2	2.6	2.5

Source: Baseline (without project) projections derived from Alaska Dept. of Labor, (1974) on basis of 1970 Census Division populations and boundaries. "With-Project" projections derived from analysis in subsection 3A.2.5.1.1.

Sex Ratio

The Sex Ratio in Anchorage may drop and stay below 100 for the civilian population during the construction phase of the gas pipeline. With husbands working on the pipeline, there is likely to be an increase in the number of dependent women living in Anchorage without husbands.

Cordova may experience the opposite trend. It already has a high Sex Ratio, and the ratio may increase during Project construction. Afterwards it should return to about its pre-1978 level.

Vital Statistics

The expected influx of single, male workers during construction on the Project facilities in the South Coastal Study Area will depress the area's overall Birth Rate, but the average number of births and fertility rates probably will not change significantly. Nor should death rates change appreciably. As is projected for the Interior Study Area (subsection 3A.3.5.3.1) other societal factors unrelated to the Alaskan Project will probably have a greater influence over that study area's vital statistics.

Educational Distribution

There will probably be no significant change in either Cordova's or Anchorage's educational profile. The education level of the construction workers and their dependents will probably be about the same as that which is already characteristic of these communities.

3A.4.6.3.2 Quality of Living Changes

Anchorage is now a modern cosmopolitan, urban center with most of the amenities, and an increasing number of the social problems, of cities in the Lower 48. Unlike Fairbanks, where there is still a frontier-rugged individualist flavor, Anchorage is a city of urban and suburban dwellers. Consequently, accelerated economic development in Anchorage as both direct and indrect results of the oil and gas industry, does not threaten to destroy a distinctive life-style. Whether the quality of life actually improves or declines with further growth for Anchorage residents depends in part upon the "carrying capacity" of the area--both in a physical environmental and socio-political sense. That is, the quality of life will suffer if growth means more offensive air and water pollution, overburdened sewer systems, crowded residential areas, and the like. Similarly, the quality of life will not improve with future growth if effective solutions to social problems are not timely.

In contrast to Anchorage, Cordova is a city confronted with the prospect of destruction of its traditional, distinctive life style as a direct result of the Alaskan Gas Pipeline and the LNG Plant at Gravina Point. Valdez is currently undergoing the transformation from a rural, predominantly sea-oriented community to a high income service center. Although the LNG Plant will not be built as close to Cordova as the Alyeska oil tanker terminal is to Valdez, Cordova will nonetheless be directly affected

and not

by the facility. Support services (e.g., air and water taxis) will congregate in Cordova, and fishermen will abandon their former livelihood for wage employment at the plant. If fishing and crabbing operations can coexist in Prince William Sound with the tanker traffic to both Valdez and Cordova, the local fishing industry will persist. However, the life style in Cordova will inevitably be changed.

Housing

Table 3A.4-7 presents projected changes in housing as a result of the Alaskan Gas Pipeline.[1/] It is assumed that the ratio of persons per occupied unit in 1970 for Anchorage (3.1) and Cordova (3.0) will hold.

The negative net change for Anchorage in 1978 can be ignored because it reflects the hiring in Anchorage in that year of residents as construction workers for the Project. Over a five-year period (1977-82), Anchorage must provide more than 20,000 new housing units--more than a 30 percent increase. Mobile homes probably will be utilized in large numbers, and rents will increase greatly because of the new demand.

Cordova may require 1,000 housing units by 1982 to meet the growth of housing needs from 1977, an increase of 125 percent. At peak construction, (1980) the demand may be for 2,500 more units than would normally be needed on the basis of population projections. Again, mobile homes probably will have to be utilized to meet this need.

Education

Anchorage and Cordova will both experience large demands for increased educational services. Tables 3A.4-8 and 3A.4-9 show projected increases in school-age population and related educational staff requirements (assuming a student to staff ratio of 21 to 1) in the South Coastal Study Area.

By 1980 Cordova schools must add approximately 70 new teachers; an increase of 200 percent as a result of gas pipeline Project induced population increases.

Population projections for Anchorage also indicate new demand for educational services. The peak need is projected to occur in 1980 and to continue rising somewhat thereafter. By 1982, there will be 15,200 more students than there were in 1977. This is a long-term increase which will require an increase of nearly 1,000 teachers and other staff over 1977 levels, and which is nearly 20 percent higher than would be required if normal growth were to occur.

Public Safety

It is projected that metropolitan Anchorage will require about 800 police in 1982. This is about 120 more men than would have been needed

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1/Projections derived from population growth estimated developed in subsection 3A.4.6.3.1.

TABLE 3A.4-7

PROJECTED HOUSING NEEDS ASSOCIATED WITH THE ALASKAN PROJECT, 1977-1982
(Thousands of Units)

Place (Census Division)	1977	1978	1979	1980	1981	1982
Anchorage						
Without Project	64.4	65.8	66.2	67.1	69.4	71.6
With Project	64.4	66.9	78.2	79.6	81.8	84.7
Impact	0.0	1.1	12.0	12.5	12.4	13.1
Cordova-McCarthy						
Without Project	0.8	0.8	0.8	0.9	0.9	0.9
With Project	0.8	1.2	2.7	3.3	2.6	1.8
Impact	0.0	0.4	1.8	2.5	1.7	0.9

Source: Derived from Table 3A.4-2

TABLE 3A.4-8

INCREASED SCHOOL-AGE POPULATION DUE TO ALASKAN PROJECT, 1977-1982
(Thousands)

Place	1977	1978	1979	1980	1981	1982
Anchorage						
Without Project	56.2	57.5	57.8	58.6	60.6	62.5
With Project	56.2	58.4	68.3	69.5	71.4	74.0
Impact	0.0	1.1	10.5	10.9	10.8	11.4
Cordova-McCarthy						
Without Project	0.7	0.7	0.7	0.7	0.8	0.8
With Project	0.7	1.0	2.3	2.8	2.2	1.5
Impact	0.0	0.3	1.5	2.1	1.5	0.7

Source: Derived from Table 3A.4-2

TABLE 3A.4-9

INCREASED EDUCATIONAL STAFFING REQUIREMENTS DUE TO ALASKAN PROJECT[1], 1977-1982

Place	1977	1978	1979	1980	1981	1982
Anchorage						
Without Project	2,675	2,725	2,750	2,800	2,875	2,975
With Project	2,675	2,775	3,250	3,300	3,400	3,525
Impact	0	50	500	500	525	550
Cordova-McCarthy						
Without Project	35	35	35	35	35	40
With Project	35	45	105	135	105	75
Impact	0	10	70	100	70	35

1/Assumes 21 students per staff member.

Source: Derived from Table 3A.4-4.

if the Alaskan Project were not built.[2] The maximum requirement for additional peace officers will occur in 1980.

Cordova will not face the same kind of public safety problems that Anchorage will face, because of its small size and isolation. Estimates are that by 1980, 20 to 25 new officers will be needed, but by 1982, the city will probably need only around 15 officers to maintain current levels of service.

Public Health

The civilian public health sector of the South Coastal Study Area is centered in Anchorage. Anticipated growth of Anchorage by 1982 would require more than 300 extra hospital beds even without the Alaskan Project. With the Project, there will be a need for a total of 650 to 700 more beds, or a net demand for 350-400 more hospital beds attributable to the Project. There will also be a need for 100 or more civilian physicians by 1982, of which 50 would be attributed to the presence of the Alaskan Gas Pipeline.

Cordova does not have adquate medical facilities for its potential population growth. By 1982, at least four more doctors will be needed, together with 75 more hospital beds. At the peak of construction employment (1979) 5 more doctors are necessary and 100 more beds needed, according to population projections for the city.

3A.4.6.3.3 Employment Changes

Employment trends in the South Coastal Study Area during 1977-1982 will repeat the pattern projected for the period 1974-1977. Treating the area as a whole, the Alaskan Project will generate a large bulge in total area employment, with the peak occurring in 1979 followed by a tapering-off that will end in 1982, with the level of employment shifted permanently to a higher level than before the Project. Projected changes in baseline and direct and indirect Project-related employment for the South Coastal Study Area (including the Anchorage metropolitan area) are presented in Table 3A.4-10.

Referring to the table, the baseline trend of employment, exclusive of Project impacts, is projected at an average annual rate of growth of 3 percent. This rate may in fact be conservative because of the tendency towards higher rates of participation in the labor force by women, and a tendency for the Anchorage area to supply more and more of its consumption requirements as a result of achieving a sufficiently large population. A similar baseline rate is projected for Valdez and Cordova. By 1977, with the completion of the Alyeska oil pipeline and Valdez Marine Terminal, permanent baseline employment growth in the Valdez area is expected to stabilize near the statewide trend.

[2]This assumes a 330 person-to-police staff ratio.

TABLE 3A.4-10

PROJECTED EMPLOYMENT, SOUTH COASTAL STUDY AREA,[1] 1977-1982
(Mid-Year, in Thousands of Workers)

Place	Year 1977	1978	1979	1980	1981	1982
Baseline Employment[2]	92.1	92.9	93.7	95.0	98.3	101.4
Cordova-Valdez	5.4	4.2	4.5	4.6	4.8	4.9
Anchorage	86.7	87.5	88.2	89.4	92.5	95.5
Gas Pipeline, LNG						
Plant and Terminal	1.1	6.7	21.2	21.7	20.5	20.5
Direct	0.2	3.3	4.7	2.9	0.7	0.4[4]
Induced[3]	0.9	3.4	16.5	18.8	19.8	20.1
Total	93.2	99.6	114.9	116.7	118.8	121.9

1/Including portions of Study Area outside indicated cities.

2/Based on estimated study area share of projected total state employed labor force, assuming 3 percent annual growth rate after 1980.

3/Estimate based on difference between baseline employment trend plus direct pipeline employment subtracted from projected study area employed labor force. Total employment estimated on basis of approximately 45-50% labor force participation rate with unemployment averaging 11%. Thus, induced component includes exogenous growth factors after peak of direct project employment is reached.

4/Operating personnel.

The largest concentration of Project construction workers will occur in the South Coastal Area, mainly because of manpower requirements for the LNG Plant. Most of the related population growth, however, will be in the Anchorage area. In part, this will occur because the hiring for the southern area construction work will be done in Anchorage and the initial work force is expected to be primarily Alaskan residents. Also, many, if not most of the in-migrating workers from the Lower 48, despite encouragement to the contrary, will bring their families to Alaska and settle them in Anchorage (rather than in Cordova or Valdez) because housing will be easier to obtain. Even so, the population pressure on Cordova is expected to be very acute because of the small size of the town and the scarcity of developable housing sites.

Induced, or secondary employment will take place in Cordova, Valdez and Anchorage. Wherever additional households for Project workers are established, additional goods and service must be provided, thus generating new jobs. Most of the Project-induced expansion of employment will be in the Anchorage area, since most of the Project-induced population growth will occur there. The expansion of service employment in Cordova and Valdez will be governed partly by community planning efforts and controls on residential development. If temporary housing is allowed to proliferate, for example, then the chances are enhanced for less permanent or less socially desirable forms of commercial activity to develop. Also, an excessive stimulus is given to the development of public utilities and other municipal and public services. Employment patterns would reflect such developments. Ideally, the communities of Cordova and Valdez will strive to maintain control over the expansion process so that the communities' economic bases and employment structures will remain viable and stable.

3A.4.6.3.4 Income Changes

The largest increases in income to be generated by the Alaskan Project will occur in the South Coastal Study Area, mainly because of the LNG Plant at Gravina Point and because the majority of the personnel and population to be associated with the Project will be residing in the area. Many workers will have households and families in Anchorage. Cordova and Valdez will also house several hundred new families. Most of the construction workers will probably take their R & R visits in Anchorage.

A total of almost $340 million in direct construction wages (1973 wage scales) is projected to be paid out over the five years from 1977 to 1981 for work in the South Coastal Study Area. Thereafter, operating salaries are projected to aggregate $7.8 million per year. Assuming that one-half of the after-tax construction payroll is spent locally, and that the other half is remitted to other states for family support, savings, investments, insurance, etc., then the total construction wage income entering the local economy would amount to about $136 million during the years 1977-1981. With a 1.5 income multiplier, the aggregate impact would amount to slightly more than $200 million, or an average of $40 million per year additional to the local economy.

The gross operating payroll of 7.8 million per year would, after estimated taxes, amount to about $6.2 million. Assuming it were all spent locally, it would generate an additional $3.2 million, for a total increase to local income of $9.4 million per year.

Local procurement of construction materials will contribute to area economic activity. Most local procurements probably will be made in the Anchorage area. If ten percent of total study area capital costs will be expended on local Project procurements, then the LNG Plant, marine terminal and Thompson Pass-Gravina Point pipeline segment will require about $179 million.

3A.4.6.3.5 Changes in Taxes and Public Finances

The City of Anchorage and the Greater Anchorage Area Borough are not on the pipeline route, but as the major trade center and principal metropolitan area in the state, there will be more Project impacts here in aggregate terms than in any other part of the state. Local governmental expenditures are expected to rise. Table 3A.4-11 lists projected expenditures for selected functional areas for the Greater Anchorage Area Borough. The projections reflect the impact of both the Alyeska oil pipeline and the Alaskan Project as part of the growing economy of the State of Alaska. Estimates of incremental costs attributable to the Alaskan Project alone are projected in Table 3A.4-12 for the mid-project year 1980 and the first post-project year, 1982. These estimates are based on projected incremental costs to the Borough from the Alyeska project at similar points of time, the assumption being that, in the aggregate, the impacts of the two projects on the Anchorage area will be similar.

The impacts at Cordova in the late 1970's and early 1980's from the LNG Plant will have some similarities with the impacts of the Alyeska pipeline on Valdez in the mid-1970's. Both port cities will have extensive impacts during not only the construction period, but also during subsequent operation of the respective pipelines and terminals.

The principal difference beteen the two cities' experiences will be in the magnitude of the Alaskan Project's effects on the city of Cordova, compared to those of the Alyeska project on Valdez. It is expected that Cordova will have a larger project-related population to accommodate (short-term transients as well as long-term residents) than will Valdez with the Alyeska project, owing to structural and equipment complexities. The LNG Plant and marine terminal to be constructed at Gravina Point will concentrate a very large number of construction workers in the Cordova area compared to the Alyeska pipeline and oil-loading terminal construction crews to be lodged near Valdez. Moreover, construction work on the LNG Plant will span nearly five years, while the Valdez oil terminal and oil pipeline probably will require only two to three years. As a result, Cordova will need financial support for a longer period. On the other hand, the prolongation of the construction period and the larger resident operating staff 1/ for the LNG Plant and terminal at Cordova, vis-a-vis the Alyeska terminal at Valdez, will permit Cordova to build more durable public service facilities than might be undertaken for a shorter-lived project, and to have a larger residential property tax base to support the city's bonded debt. There is a great opportunity to

TABLE 3A.4-11

GREATER ANCHORAGE AREA BOROUGH
PROJECTED EXPENDITURES FOR MAJOR SERVICES, 1978, 1980 and 1983
(Thousands of Dollars)

Service	Fiscal Years 1978	1980	1983
Health	$ 1,900	$ 2,500	$ 2,700
Public Safety	3,200	4,200	4,500
Education	60,400	79,600	85,500
Other	22,000	29,000	31,300
Total	$87,500	$115,300	$124,000

TABLE 3A.4-12

GREATER ANCHORAGE AREA BOROUGH
PROJECTED INCREMENTAL COSTS FOR MAJOR SERVICES
AS RESULT OF ALASKAN PROJECT, 1980 & 1982

Alaskan Project	1980	1982
Health	$1,900,000	$2,000,000
Public Safety	1,800,000	1,000,000
Other	1,200,000	800,000
Total	$4,900,000	$3,800,000

utilize large state, and even federal resources in land use and urban development planning that would assure the preservation of the town's fishing character, while at the same time securing relief from chronic scarcities of water, power and housing. Coordinated community development activities will probably culminate in organization of a borough that includes the LNG Plant properties on Gravina Point as well as the Valdez oil facilities.

The experiences of Valdez with respect to the Alyeska pipeline resulted in the Alaska State Legislative Special Petroleum Impact Committee recommending (in its Report on Impact of Trans-Alaska Pipeline Construction on Governmental Services and Facilities, February 12, 1974) that Valdez receive $3,061,000 in operating funds and $4,245,000 for capital improvements over the three-year period from 1974 to 1976, inclusive. In addition, the committee recommended that Valdez schools receive $1,638,000 for operations and $600,000 for capital improvements. The three-year total for the city and the schools was $9,544,000. Valdez, with a 1970 population of 1005, was not much smaller than Cordova (with a population of 1164). Gas pipeline impacts would probably merit the same $10,000,000 level of assistance for Cordova.

3A.4.6.3.6 Impacts on Other Sectors

With the exception of LNG tanker operations affecting fishing activities in Prince William Sound and the possibility that petrochemical processing operations could be established near Valdez or Cordova, the Alaskan Project will have little direct long-term effect on economic activities in the South Coastal Study Area. The impacts of the Project on the various goods and service-producing sectors of the state economy are discussed in subsection 3A.2.5.2, "General Impacts on Public Finances and Economic Output," under the following headings:

Subsection	Title
3A.2.5.4.6	Petroleum Development
3A.2.5.4.7	Mining
3A.2.5.4.8	Fisheries
3A.2.5.4.9	Agriculture
3A.2.5.4.10	Forestry
3A.2.5.4.11	Electric Power
3A.2.5.4.12	Transportation

3A.4.6.4 Summary of Socioeconomic Impacts

The most significant land use, population and economic impacts of the Alaskan Project will occur in the South Coastal Study Area. The largest complement of construction workers on the gas pipeline system will be concentrated at the LNG Plant site. Estimates of peak direct employment range to 6,000 workers in mid-1979. Many will have residences in Anchorage, where project hiring will be conducted. The communities of Valdez and Cordova will also experience a sharp influx of transients and permanent residents, and it can be expected that many workers will wish to relocate their households to the site vicinity. More than 300 operating personnel will be located in Cordova after the LNG Plant commences regular operation,[3] and commercial development stimulated by the increase in the local population will augment business activity in the town.

Anchorage will experience significant increases in population and, consequently, will need to expand housing, schools and public services. As administrative and hiring headquarters and the major R & R destination for the entire project, the city will attract many other people seeking work. In absolute terms, Anchorage will experience larger increases in population, employment, social problems and other effects of economic development than any other part of the state. The city's relatively large size will temper the magnitude of Project-induced impacts, however. Also contributing to the attenuation of Project impacts is the prior expansions of facilities and services that will have been made in response to the Alyeska oil pipeline project.

The concentration of system facilities at Gravina Point and Valdez will be a major source of property taxes. Neither the LNG Plant site, nor Valdez and Cordova are in an organized borough, and it is likely that local interests will take steps to organize a borough in order to acquire the power to tax the plant and pipeline properties. Until this is done, the two communities will have to rely primarily on state revenue-sharing to fund expansion of needed public services and facilities.

Fishing is the principal resource-based activity in Cordova and Valdez. Oil tanker traffic in and out of Valdez will have already affected fishing activities in Prince William Sound before LNG carriers begin to call at Gravina Point. The commencement of LNG operations will add to ship traffic proplems in the Sound, and it is possible that fishing activities will be somewhat curtailed.

3A.4.7 Aesthetic Features

The proposed gas pipeline will traverse Keystone Canyon via two tunnels. The mouths of the tunnels will be constructed to reduce any scenic impact that might be otherwise generated.

The remainder of the route south to the LNG Plant site passes through the Chugach National Forest, an area generally inaccessible to the public, owing to the absence of roads.

The presence of the LNG Plant, the Alaskan Marine Terminal and the LNG Carrier Fleet must be considered an impact to the scenic surroundings of Orca Bay.

3/Exclusive of 65 supervisory personnel permanently residing at the LNG Plant site.

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Section 3F
Environmental Impact — N. Pacific

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3F LNG CARRIER FLEET IMPACT

3F.1 SOCIOECONOMIC CONSIDERATIONS

On a national basis, the resurgence of the American maritime industry, to which the Alaskan Project will make a marked contribution, signals an increase in the demand for maritime-related products and services.

On a regional basis, Prince William Sound and Santa Barbara Channel have long traditions of water-borne commerce, and the labor, goods and services needed for support of the proposed LNG Carrier Fleet are, or will be generally available in each of these regions.

The American yards which will construct the LNG tankers will be selected on the basis of factors such as delivery schedules, the availability of reasonable and prudent contractual terms, yard space availability, and the Alaskan Project time requirements. At least seven American shipbuilding yards have the capability to construct LNG carriers of the size planned for the Alaskan Project. They are: Avondale Shipyards, Bethlehem Steel, General Dynamics, Ingalls Shipbuilding, Newport News Shipbuilding and Dry Dock Co., Sun Shipbuilding and Dry Dock Co., and Todd Shipbuilding. At present, Avondale, General Dynamics, Newport News and Sun Ship, either have in hand, or are known to be actively pursuing, LNG shipbuilding contracts.

It is estimated that the yard cost for each carrier will be approximately \$139 million. Assuming the Keynesian Gross National Product multiplier is not less than 2.5, the total impact upon the U.S. economy from each LNG tanker will be about \$348 million. Since it is planned that all 11 carriers will be built in U.S. yards, the total effect on the U.S. shipbuilding industry will be \$1.5[1/] billion, and the extrapolated impact on the total U.S. economy will be nearly \$4 billion.

Even though the 1970 Merchant Marine Act imposed an initial maximum construction differential subsidy (CDS) of 50%, the LNG Carrier Fleet will not be eligible for such subsidies. Under the terms of the Jones Act and the 1970 Merchant Marine Act, U.S.-built ships plying a trade route between U.S. ports will not be built under the CDS program.

Each LNG tanker will require an estimated annual operations support cost (including maintenance, provisions and fuel oil) of \$1.9 million. For the fleet of 11 ships, the total economic impact will be approximately \$21 million. Because the operations support function has an undetermined complementary multiplier, the full positive impact of

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[1/]Exclusive of other loadings, such as AFC, Int. Plant and Working Capital. Total estimated capital cost of the LNG Carrier Fleet is \$2.045 billion.

fleet operations on the total economy cannot be accurately determined.

Operations support for the LNG tankers may have an important effect on the stabilization of American shipbuilding employment. Dry dock facilities used for annual maintenance of the LNG tankers will have positive impact on local employment.

Each LNG tanker will have a 35-man U.S. crew, with an annual payroll of approximately $1.2 million per ship-year, or about $13 million annually for the entire fleet. The employment potential in the port areas will be affected by the presence of the ships' payroll, which will in turn create a small beneficial need for supportive services such as lodging, transportation, and recreation.

3F.2 IMPACT OF SHIPS IN TRANSIT

The implications of 308 tanker round trip transits annually along the 1902 nautical-mile trade route are discussed in the following subsections in terms of possible traffic, air quality, water quality, aquatic biota, and noise impacts.

3F.2.1 Traffic Impact

The ship traffic represented by the proposed 308 round trip transits annually will have impacts upon existing traffic in the forms of interference with cargo shipping and commercial and recreational activities. Current waterway use and traffic are discussed in Section 2F.5 of this Report.

3F.2.1.1 Open Ocean Sector

The open ocean sector (Hinchinbrook Entrance to Point Conception) comprises about 98 percent of the 1902 nautical-mile trade route, and includes waters of the Gulf of Alaska and the northeast Pacific Ocean from 60°N, 146°W to 34°N, 120°W.

After reaching open sea, the LNG carriers will follow a great circle route to a point off the California Coast near Point Arguello, where they will generally parallel the coast and enter the northern reaches of the Santa Barbara Channel. The carriers will navigate a sufficient distance west of the Farallon Islands to avoid coastal traffic south of San Francisco.

Most vessel traffic along the northern part of the open ocean sector of the trade route consists of fishing vessels, cargo carriers, and some tankers; the tonnage transported is not large. The sector north of San Francisco is little travelled in comparison with the main ocean trade routes of the world.

The addition of 308 LNG ship round trip transits along the open ocean sector of the route annually should not cause adverse traffic impacts along the route, nor should these transits adversely impact commercial and recreational fishing activities.

3F.2.1.2 Point Conception Area

An LNG carrier approaching Point Conception will prudently follow the coastline from Point Arguello past Point Conception and

Government Point, and then sail directly to the terminal site (see Figure 1.2-5 in Section 1). This route should result in only minor interferences with commercial and recreational fisheries and boating in the Santa Barbara Channel.

3F.2.1.3 Prince William Sound

According to Coast Guard records (USDI, 1972), Valdez is visited by an average of three vessels per week (over 300 gross tons) plus one ferry per day during summer and two ferries per week in winter. Hence, there has been no need for establishing shipping lanes. Large vessel traffic consists mostly of cargo and fuel supply vessels. About 30 commercial fishing vessels 30 to 50 feet in length and 150 to 200 recreation boats of all sizes are based in Valdez.

Alyeska plans to use the Port of Valdez as the southern terminus of its trans-Alaska oil pipeline. During the early phases of pipeline operation (possibly as early as 1977), three tanker movements per day are anticipated at Valdez. Tanker movements would reach a total of 5 to 6 per day during maximum production. The tankers involved would vary in size from 30,000 DWT to 250,000 DWT.

According to USDI (1972, V 4, p 471 and Table 21),

> The Alyeska-related traffic would amount to about 6 percent of the projected 1980 traffic at the entrance to Prince William Sound, and a smaller percentage of the projected total ship traffic in Alaskan waters. However, because most of the present traffic in Alaskan waters consists of fishing and general cargo vessels, the additional tanker traffic of about 104,000,000 tons per year at maximum proposed throughput would amount to about 491 percent of the total freight handled in Alaska ports in 1969.

The proposed 308 LNG vessel round trips per year associated with the Alaskan Project equates to an average of 1.68 ship movements per day in Prince William Sound. This is an incremental daily addition of about 32.6 percent to the 5.14 Alyeska tanker movements projected for 1980. Although this amounts to only a 2 percent increase in the 1980 projected total number of vessels at the entrance to Prince William Sound, their traffic impact will be significant because of their large tonnage (122,000 gross tons).

In view of the anticipated tanker traffic, the U.S. Coast Guard has proposed (USDOT, 1973) a Prince William Sound Vessel Traffic System to and from Valdez. The system is designed to enhance the safety of navigation in the Sound by traffic separation thereby reducing the potential for vessel collisions and groundings. Traffic separation would commence approximately 30 miles seaward from Hinchinbrook Entrance and continue through Prince William Sound to Valdez.

As discussed in Section 2F.7, commercial fishing is of primary importance to hundreds of residents of the Prince William Sound area. Fish packing and processing is the primary industry in Valdez and Cordova. A comprehensive summary of the fisheries resources of Prince William Sound is provided in USDI, 1972 (V 3, pp 370-376 and 380-385).

The construction phase of the Alyeska oil pipeline project and subsequent crude oil tanker operations will have a significant impact on fishing in Prince William Sound, and particularly near Port Valdez (USDI, 1972). Fishing vessel movements will be restricted by the necessity of keeping clear of the tanker's tracks.

After departing from the terminal waters at Gravina Point, an outbound LNG carrier will traverse the western extremity of Orca Bay and sail along the northern shore of Hawkins and Hinchinbrook Islands for the 10-mile journey to Prince William Sound proper. The carrier will utilize the Coast Guard's proposed outbound lane, as shown on Figure 1.2-4 in Section 1. In order to enter the outbound traffic lane, the LNG carrier will cross the inbound lane.

The movement of LNG tankers in Orca Bay could alter established patterns of commercial fishing. Local inquiries indicate that for some years Sheep Bay and Orca Bay have been the scene of intense crabbing activities but that recently crab production has diminished somewhat and that boats are shifting to other areas of the Sound. During the 1973 fishing season, an estimated 1000 tanner crab pots reportedly were placed in the vicinity of Sheep Bay. King and Dungeness crabs are also fished in this region, and all three current fishing techniques require the use of floating buoys and lines. Large ships in Orca Bay would preclude placement of some crab traps to avoid entanglement and loss. In addition, Gravina Point is used as a "hook point," or place of attachment, by commercial net fishermen. Fishermen rely on these areas for successful salmon harvest, and shipping could preclude using these areas at certain times of the year.

3F.2.2 Air Quality and Noise Impact

Emissions from the in-transit LNG tankers that were examined for possible impact on air quality are the products of fuel combustion (Bunker "C" fuel oil and natural gas) in the ships' boilers, and the remote possibility of emergency venting of cargo boil-off.

3F.2.2.1 Cargo Boil-off

The air quality effects of possible emergency venting of cargo boil-off would be virtually identical for the open ocean, Point Conception area, and Prince William Sound sectors of the trade route.

Heat influx through the cargo tank insulation causes preferential vaporization (boil-off) of the components of the LNG cargo with the lowest boiling point, i.e., nitrogen and methane. Boil-off vapors are not vented during normal operations; they are used for fuel in the ships' propulsion plant. If LNG boil-off is greater than the ships' fuel requirements, the vapor is burned in the boilers and the excess steam that is generated is condensed. Cargo vapors are therefore consumed, and are not released to the atmosphere.

Emergency venting of cargo boil-off in U.S. waters is unlikely. It would occur only if gas-burning equipment fails, or if the steam condensing equipment fails when the ships' fuel requirement is low. Should emergency venting be necessary, the boil-off vapor would be primarily methane, which is a non-toxic, photochemically non-reactive hydrocarbon. The boil-off vapors would, if vented, be heated to 50°F so as to ensure that they would be lighter than air and, hence, rise harmlessly into the atmosphere.

3F.2.2.2 Combustion Emissions

While underway at sea, the LNG carriers will use LNG boil-off vapors and Bunker "C" for boiler fuel. Under maximum consumption conditions and at the 18.5 knot service speed, approximately 175,000 cfh of natural gas and 1500 gallons per hour of Bunker "C" will be consumed. The estimated emissions from the combustion of this fuel mix are shown in Table 3F.2-1. Such emissions easily meet opacity requirements and applicable emission regulations. Thus, the air quality impacts of the LNG Carrier Fleet operating in the open ocean sector of the trade route should be negligible.

TABLE 3F.2-1

POLLUTANT EMISSION RATE (gm/sec) FOR THE COMBUSTION OF NATURAL GAS AND BUNKER "C"

Pollutant	Natural Gas 1/	Bunker "C" 2/	Total
Particulate	0.04	4.34	4.74
Sulfur Dioxide	0.01	59.31	59.32
Carbon Monoxide	0.37	0.78	1.15
Hydrocarbons	0.06	0.61	0.67
Nitrogen Oxides (NO_2)	2.65	15.09	17.74
Sulfur Trioxide	0	0.69	0.69
Aldehydes (HCHO)	0	0.17	0.17

Consumption rates at 18.5 knot service speed

1/ For combustion of 175,000 ft^3/hr of natural gas
2/ For 1500 gal/hr or Bunker "C" fuel oil with 2% sulfur content

3F.2.2.3 Noise

Noise from vessel operation should not present any appreciable impacts on noise levels along the trade route. The estimation of noise generated by the proposed LNG tanker is limited to experience based on similar sized ships.

The Noise Control Act of 1972 directs responsibility to the Administrator of the EPA to set noise emission standards. The Maritime Administration Standard Specification for Merchant Ship Construction provides for shipboard noise attenuation. The proposed LNG tankers will comply with these standards and regulations.

3F.2.3 Water Quality Impact

Overboard discharges from the proposed LNG tankers which may have impact on water quality include ballast water, bilge water, sanitary wastes, cooling water and solid waste.

3F.2.3.1 Ballast Water

Approximately 66,000 tons of ballast water will be taken on board each carrier in segregated ballast tanks while unloading LNG at Point Conception and will be discharged without shipboard contamination at the Alaskan Marine Terminal as LNG is loaded. Normally, ballast water will neither be taken on nor discharged while the ship is underway.

3F.2.3.2 Bilge Water

Minor bilge water accumulations occur during normal engine room operation. Minor quantities of lubricants from the ship's machinery may also accumulate with the bilge water during normal operation.

The LNG tankers will be equipped with an oil/water separator and holding tank. During operation in U.S. waters, all bilge accumulations will be transferred to the holding tank. This operational procedure assures that oily discharges are not made in U.S. waters.

In international waters, bilge water accumulations are processed by the oil/water separator before discharge to reduce the oil content to an acceptable level. The separator outlet will be equipped with an oily water detector which will automatically stop the discharge of any effluent exceeding the appropriate standards. Effluents not meeting the discharge standards will be transferred to the holding tank for subsequent treatment.

3F.2.3.3 Sanitary Wastes

No sanitary wastes will be discharged in U.S. waters. The sanitary system for the LNG vessels will incorporate the most advanced type of sewage treatment systems available.

During normal operation in international waters, all wastes will be treated by the sewage treatment system prior to discharge.

3F.2.3.4 Cooling Water

Seawater will be used to cool the ships' condensers. When the ships' energy needs are less than that provided by cargo boil-off, the excess boil-off will be burned in the boilers, and the surplus steam will be condensed along with exhaust steam from turbines and auxiliaries.

Underway, an LNG carrier will discharge 60,000 gpm of condenser cooling water at 6F° above intake temperature. This represents a heat rate of about 3 million Btu per minute. The heated discharge will be rapidly mixed with the receiving waters. It is estimated that the temperature elevation of the receiving water, in the prism displaced by the ship underway, will be less than 0.01F°.

3F.2.4 Impact of Solid Wastes

There will be no dumping of solid wastes into U.S. waters; thus, there will be no associated impacts. Generally, the 35-man crew of each LNG carrier will generate 1.85 pounds per capita per day of solid wastes similar in type and quantity to residential waste accumulation. Solid wastes will be compacted and properly baled (or ground) and weighted before overboard disposal in international waters. These methods are acceptable on the open sea.

3F.2.5 Marine Biological Impact

Under normal operations, the only source of environmental impact of an LNG tanker underway upon marine organisms and fisheries is the cooling water discharge. There will be no discharge of sanitary wastes and bilge water in U.S. waters and only treated wastes will be discharged in international waters. The ballast water (which is seawater carried in segregated ballast tanks) will be discharged only at the Alaskan Marine Terminal.

3F.2.5.1 Cooling Water

Planktonic organisms in the cooling water will be exposed to the 6F° temperature increase as well as mechanical abrasion in the pumps and condenser. Based on available information, such temperature differential will not cause significant mortalities, since the organisms are able to tolerate some fluctuation in temperatures. For example, *Acartia tonsa* and *Eurytemora affinis* have been shown to survive temperature increases of 9F° (acclimated to 77°F, temperature raised to 86°F) for 24 and 4 hours respectively (Mihursky, 1969). Oyster eggs fertilized at 80.6°F showed no significant mortalities when exposed to 89.6°F temperatures for 8 hours. Striped bass eggs can survive constant fluctuations in water temperatures ranging 55 to 75°F (Mackenthum, 1967).

Mechanical abrasion will probably result in mortality of a large portion of the planktonic organisms passed through the ship's cooling system. Carpenter, et al., (1974) reports 70 percent mortality of copepods passing through a power plant heat exchange system, most of which is attributed to mechanical damage. The volume of water (and plankton) pumped through the system, in comparison with the surrounding volume of water through which the ship is moving, is so small as to render this impact insignificant.

In short, the impact of normal discharges from the proposed LNG tankers transiting the trade route will be insignificant in terms of marine biological populations. Mortalities of a limited number of phytoplankton, zooplankton, eggs and larvae will occur due to mechanical abrasion in the ship's cooling system and due to thermal stress in the cooling system and at the discharge point. However, because of the very limited volume of water affected by the ship, the impact of a moving LNG tanker on the aquatic biota will be inconsequential.

3F.2.5.2 Sensitive Organisms in Prince William Sound

Potentially sensitive marine organisms in Prince William Sound which may be affected by vessels underway are the water birds and marine mammals, particularly sea otters. Both groups are conspicuous and vulnerable because of their close interaction with the sea surface. In the case of LNG ships, this vulnerability, however, relates to potential abnormal (that is, accidental) discharges, primarily possible oil spills, which are discussed in subsection 3F.2.5.5.

3F.2.5.3 Bottom Scouring

Because of the relatively deep water in the near-shore approaches to Gravina Point, there should be virtually no bottom sediment scouring action caused by passage of the deep draft LNG ship. Hence, there will be no associated impact on the marine benthic assemblage.

3F.2.5.4 LNG Spills

The greatest impact on the marine biota, in the event of an LNG spill (see Section 11 of this Report), would result from the temperature depression of the surface waters. Because LNG is shipped and stored at approximately -260°F, any spillage on the water surface would result in reduction in surface temperature. Currently, it is not known what the intensity of this temperature reduction would be or how deep into the water column this reduction would penetrate. Because of LNG's properties, however, it is likely that the temperature depression would be local and short-lived. Probably, only plants and animals in direct contact with the LNG would be killed or severely damaged from the low temperature.

See subsection 3F.3.5.3 for further discussion of potential biological effects of LNG spills on water.

3F.2.5.5 Oil Spills

The effects of oil spills on marine biota are varied and depend on a number of parameters, e.g., size of spill, type of oil, length of exposure time, oceanographic and meteorological conditions, and the effectiveness of control and cleanup operations. The literature on the biological effects of oil spills is voluminous. A good review of the biological effects of oil spills is given by Moore, et al., (1973). General conclusions by these authors are: most adult marine organisms are sensitive to soluble aromatic derivatives in concentrations of 1 ppm, and lethal toxicity occurs in concentrations of 10-100 ppm. Crustaceans and burrowing animals are generally most sensitive, fish and bivalves moderately sensitive, and gastropods and flora least sensitive. Generally, the more refined hydrocarbon products are more toxic at similar concentrations, than are the crude hydrocarbons.

A substantial quantity of Bunker "C" and diesel oil will be carried by each LNG carrier for use as fuel. Virtually the only way in which a significant volume of either fuel could be discharged at sea would be a result of a collision or grounding. The probability of such an event is very low, as demonstrated by the analysis presented in Section 11 of this Report.

The volume that might be released in a collision or grounding would depend on the nature and severity of the individual situation. The "worst case" spill would involve the release of the total volume of fuel contained in the ship's forward fuel oil tank--about 30,000 barrels. This "total volume" case would exist only as the ship departed the southern California terminal in ballast after unloading LNG. Such a "worst case" event would almost certainly have significant adverse impact upon the marine biological community.

If the 30,000 barrel release occurred within 5 miles of the southern California shoreline, at least part of the resultant oil slick would be expected to drift ashore. Depending on the meteorological conditions (wind speed and direction) and wave and current action, the slick could be expected to coat and otherwise affect the intertidal biota along several tens of miles of shoreline within a maximum of 2 to 3 days.

Coating of intertidal biota with oil would probably result in the death of some organisms, particularly barnacles and algae. Organisms in rocky intertidal areas would probably be more adversely effected than those in sandy beaches. In addition, surface fronds of kelp would likely be coated, but because of the mucous coating on the blades, these plants quickly rid themselves of oil. Recovery of areas exposed to wave action would probably be more rapid due to physical weathering of the oil than in those areas that are protected from the washing action of the surf. The spilled oil could also be expected to affect the avifauna of the region, resulting in the death of a number of birds. Dependent on the time of year and the area affected, oceanic birds would probably suffer the greatest losses.

If the collision and release of oil occurred about midway along the trade route northbound, then the "worst case" total volume of Bunker "C" aboard the ship would be on the order of 15 percent less than the initial 30,000 bbl figure. The "worst case" volume in the Prince William Sound area would be 22,500 bbl.

If the "worst case" spill occurs well out to sea (hundreds of miles) the probable biological impact would be much less adverse, primarily because the slick would very likely not reach a shoreline until the oil had further weathered. Detrimental biological effects of the spill in the open ocean sector would include local mortality of surface plankton and larval fish. Due to the limited area potentially affected and the low density of surface marine biota, there would be little chance of significant damage to pelagic sea birds or marine mammal populations.

A "worst case" spill from an accident in Prince William Sound waters could have effects generally similar to those described above for offshore southern California. In addition, a spill in Prince William Sound could adversely effect salmon and shellfish as well as the marine mammals, which are relatively common in the Sound. Some of these mammals (such as sea otter) are particularly vulnerable to spilled oil.

3F.3 IMPACT OF SHIP IN PORT

The following subsections consider possible air quality, water quality, aquatic biota and noise impacts resulting from the LNG carriers while berthed at the Alaskan Marine Terminal. The impact of possible pierside LNG and fuel oil spills are also evaluated.

3F.3.1 Air Quality Impact

3F.3.1.1 LNG Vapor Release

LNG in the shoreside storage tanks is transferred to the tanker through a closed system. No liquid or vapor escapes to the atmosphere during normal operations.

3F.3.1.2 Combustion Emissions

While in port, the LNG carrier will burn Bunker "C" fuel oil at a rate of about 920 gallons per hour. Emission rates for fuel oil combustion are shown in the following table. A 2 percent (by weight) concentration of sulfur in the Bunker "C" is representative of that used in operation.

TABLE 3F.3-1

POLLUTANT EMISSION RATE[1/] FOR THE COMBUSTION OF BUNKER "C"(gm/sec)[2/]

Pollutant	Emission Rate
Particulate	2.66
Sulfur Dioxide	36.28
Sulfur trioxide	0.43
Carbon monoxide	0.35
Nitrogen oxides	9.24
Aldehydes	0.11

1/Based on 920 gallons per hour
2/Assumes 2% sulfur content

Reference: Lahre, 1973

An analysis of the effect of LNG tanker combustion emissions on air quality while alongside at the Alaskan marine terminal is presented in subsection 3A.4.2. This analysis shows that the vessel emissions easily meet both the 3-hour and 24-hour standards for SO_2 concentrations. Hence, the air quality impact of the LNG tanker in port is negligible.

3F.3.1.3 Pierside LNG Spills

Although the possibility of such a spill is extremely small, the air quality impacts of an LNG spill of 750 barrels were considered. The LNG vapor generated by the pierside spill would be primarily methane which is not considered toxic, is not a photochemically reactive hydrocarbon and is not considered by the EPA to contribute to the formation of a photochemical smog. Further, the vapors would disperse rapidly in the atmosphere. Therefore, the air quality impacts of such a spill would be short-lived and of minor significance. The marine biological impacts of such a spill are discussed in subsection 3F.3.4.3 following.

3F.3.2 Water Quality Impact

Under normal operations no discharges of any kind are expected in U.S. waters except cooling water from the ships' condensers, and ballast water from the segregated ballast tanks.

When in port, the LNG ship will discharge cooling water at a rate of 60,000 gpm and at 2F° above intake temperature. It is probable that the net water quality impacts of this thermal discharge would be negligible, inasmuch as they would be virtually indistinguishable from the effects of the once-through seawater cooling system discharge from the LNG Plant.

Up to 66,000 tons of ballast water will be discharged from the tanker's segregated ballast tanks while alongside the pier at the Alaskan Marine Terminal. Because this ballast water is seawater, its discharge should produce no adverse impacts upon water quality.

Bilge water, sanitary wastes and solid wastes will be treated and retained on board for ultimate discharge in international waters.

3F.3.3 Noise Impact

The estimation of noise generated by the proposed LNG tanker is limited to experience based on similar sized ships. While in port, the power plant is required only to generate electricity and provide the various hotel requirements such as heat, refrigeration and air conditioning. The small amount of engine room noise generated for these needs is significantly attenuated by the ship's hull and water surrounding it. Possible noise associated with cargo loading would be generated by the terminal facilities, and not by the ship. Thus, noise from ship operations will be low level and should have negligible impact.

3F.3.4 Marine Biological Impact

The possible impact of the proposed LNG tankers while in port on the marine biological community of the marine terminal area include those due to: (1) ballast water discharge, (2) cooling water discharge, (3) a minor oil spill, and (4) a pierside LNG spill.

3F.3.4.1 Ballast Water

It is conceivable that the 66,000 tons of ballast water might serve as a transport medium for various warmer water planktonic larvae and juvenile forms present in the water when it is loaded in California. Survival of introduced species is likely due to the predominance of cold-water affinities among southern California marine species. Introduced species could produce significant detrimental impacts on residents through competition, predation, parasitism or disease (see Krebs, 1972).

3F.3.4.2 Cooling Water

Cooling water is discharged from the LNG tanker at approximately 60,000 gpm at 2F° above intake temperature. The benthic and fish communities at Point Gravina will not be affected by the discharge.?

Mechanical abrasion, however, will probably result in mortality of a large portion of the planktonic organisms passed through the ship's cooling system. The volume of water (and plankton) pumped through the system in comparison with the surrounding volume of water, in which the ship and marine terminal are located is so small as to render this impact insignificant.

3F.3.4.3 Pierside LNG Spills

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In the unlikely event of an LNG spill at pierside, the greatest impact on the marine biota would result from temperature reduction in the surface waters. It is not known precisely what the intensity of this temperature reduction would be or how deep into the water column this reduction would penetrate. Observations of the chilling effects of LNG on water substrate indicate that severe chilling will be limited to a thin layer at the water surface. The thickness of this chilled-water layer has been estimated to be on the order of one inch. Because of LNG's speed of vaporization, however, it is likely that the temperature depression would be local and short-lived. Once the pool of LNG vaporizes, convection mixing will cause the water to quickly return to natural temperature levels.

The only organisms likely to be affected by an LNG spill are those found in the first few inches of surface water. Benthic organisms will not be affected. Phytoplankton and zooplankton found in the small restricted water layer directly beneath the LNG pool could experience mortalities. Due to the high reproductive rates of plankton species and water movements bringing in unaffected individuals, the lost organisms will repopulate in a short time. Within a matter of hours, the impact on the plankton should be unnoticeable.

Tests have been conducted to determine the reaction of fish to saturated water solutions of methane, the major component of LNG. Methane does not appear to be toxic or harmful to sunfish, and a saturation solution of approximately 65 milligrams per liter had no effect on minnows after 2 hours of exposure (CSWRCB, 1973).

3F.3.4.4 Pierside Oil Spills

Because the LNG ship will not receive (or discharge) Bunker "C" or diesel oil when in port at the Alaskan Marine Terminal, there will be no opportunity for an oil spill from the ship. Impacts of spills which might occur as a result of a possible collision or grounding of the LNG ship are considered in subsection 3F.2.5.5.

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SECTION 4 - MEASURES TO ENHANCE THE ENVIRONMENT OR TO AVOID OR MITIGATE ADVERSE ENVIRONMENTAL EFFECTS

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4 MEASURES TO ENHANCE THE ENVIRONMENT OR TO AVOID OR MITIGATE ADVERSE ENVIRONMENTAL EFFECTS

Applicant intends to design, construct, operate and ultimately abandon all facilities constituting its proposed Alaskan Project so as to provide the most technically proficient, and most environmentally compatible system feasible for movement of North Slope natural gas to consumers in Alaska and the Lower 48. Applicant anticipates that a vigorous, in-depth appraisal of its proposal will be made by the numerous federal, state and local agencies involved in the project as well as by many interested private concerns--thus assuring the public interest will be served.

To further minimize potential adverse environmental effects, Applicant solicits the assignment of a person or persons to act in the capacity of a "Responsible Officer" in a fashion similar to that in the case of the Alyeska oil pipeline project.

In the following subsections, a number of measures which will avoid, mitigate or compensate for potential adverse impacts resulting from implementation of the proposed Alaskan Project, are presented. It is expected that, as the Project design proceeds to completion, mitigating measures will grow in number and detail.

4.1 ENVIRONMENTAL MONITORING

4.1.1 Pre-Construction and Construction

Applicant will engage qualified consultants to perform periodic species identification, air and water quality sampling, meteorological measurements and review of both the pre-construction and construction phases of the proposed Alaskan Gas pipeline, LNG Plant and marine terminal.

Such monitoring will provide the necessary environmental benchmark from which potential adverse operational impacts can be predicted, thereby providing a base for the design and implementation of preventive or corrective measures.

4.1.2 Operation

Operational data will be compared with pre-construction (baseline) data in order to determine the type and degree of impacts resulting from project implementation, and to support design and execution of post-construction environmental protection measures.

4.1.2.1 Water Quality

Water quality impacts during operation of the proposed gas pipeline are expected to be minor and, in general, localized. Monitoring programs will include periodic sampling of watercourses near road and pipeline crossings and compressor stations, and continuous monitoring of waste treatment facilities.

Monitoring of water quality at the LNG Plant and terminal will quantify the effects of the seawater intake and discharge on existing water quality and marine life in Orca Bay. All treated liquid effluent streams are to be routed to a holding pond and then discharged into Orca Bay. A similar monitoring program will be instituted for Harris Creek in the event that an impoundment is ultimately determined to be necessary.

Water discharges from the LNG carrier fleet include ballast water, bilge water, cooling water and sanitary wastes. Present plans do not call for monitoring of the cooling or ballast water, because neither become contaminated by the ship's cargo or fuel oil supply. Treated bilge and sanitary waste water will be carefully monitored prior to discharge to insure that all applicable standards are met.

4.1.2.2 Meteorology and Air Quality

Meteorological and air quality measurements will be made, both before and during construction, as well as during operation of the proposed natural gas facilities. Since the primary sources of air emissions during operation of the pipeline will be the twelve compressor stations, data collection will be mainly at these locations.

Air emissions from the LNG Plant and the construction and service vessels at the marine terminal are expected to diffuse rather rapidly due to ventilation characteristics of this area. However, sufficient data will be collected during plant operation to quantify specific effects on air quality. Adverse trends can then be identified and appropriate corrective measures taken.

Exhaust stack emissions from the LNG carriers will be monitored as part of the overall program for LNG Plant site.

4.1.2.3 Noise

Sound levels will be measured on a periodic basis at all locations considered to be significant noise sources. Data from these surveys will be compared with baseline levels, to determine if additional insulation and/or noise attenuation equipment is required to meet applicable standards.

4.2 PREVENTATIVE MEASURES

4.2.1 Environmental Training Program

Environmental considerations have been a significant factor in the decisions concerning the routing of the Alaskan Gas Pipeline, the selection of a site for the LNG Plant and marine terminal, facilities design, and determining construction techniques and operational procedures. With respect to construction and operation of the Project, Applicant anticipates that persons will be hired to work in environmentally sensitive areas who may not have a full appreciation for the unique ecological situations of the Project. Therefore, Applicant intends to institute an Environmental Training Program designed to operate through all levels of Applicant's and its contractors' infrastructure. Such program will be implemented by persons professionally trained in environmental disciplines, and will be coordinated with appropriate state and federal agencies. As presently conceived, the program will be developed around the following features:

1. Orienting construction personnel in sensitive biological species in the Project area and in the proper protection of these biota during construction, operation and maintenance;

2. Providing appropriate personnel with a general background in the nature of permafrost, the possible effects of disturbing the tundra mat, and in measures which must be taken to avoid such disturbances;

3. Orienting personnel in the proper use of the proposed construction equipment outside this protective zone, (see 2 above);

4. Orienting personnel in the effects of wildfire, and of the prevention of such fires through the observation of proper safety practices.

5. Providing personnel with a general understanding of archaeology and in the identification of potentially valuable archaeological artifacts, features or sites;

6. Orienting equipment operators and other personnel involved in the construction of river crossings, in the site-specific aquatic resources needing protection, the reasons for this concern, and the measures required to prevent or mitigate such impacts.

7. Orienting personnel in the seasonal biological and physical effects of a liquid petroleum product (fuel oil) spill on water and on land, and in proper prevention and control procedures;

8. Establishing direct and effective channels of communication between responsible authorities, and construction and operating personnel for use in case of:

   (a) an archaeological or palentological find,
   (b) a wildfire,
   (c) biota needing special protection or relocation,
   (d) a fuel oil or LNG spill requiring special containment or clean-up measures,
   (e) a pipeline rupture or leak, or
   (f) any other condition which might be hazardous to the environment.

The Environmental Training Program will be presented at the onset of construction and will be an on-going program to accommodate employee additions or turnover, and to implement improved techniques and practices which will be developed from evolving information.

During the operational phase of the project, rigid inspection and continuous surveillance of all facilities will be maintained to determine the needs for additional input into the program. The program will then result in the employee being able to detect changes in operational patterns which might translate into more severe environmental effects. Periodic patrols of the pipeline right-of-way will provide current information regarding the effectiveness, or lack of it, of procedures intended to prevent erosion of the right-of-way, degradation of stream crossings, and other deleterious environmental changes. Any noticeable lack of proper protection will be recorded and reported, and immediate corrective measures will be implemented. Inherent in such observations will be the assessment of the success of surface restoration and revegetation programs.

Applicant will cooperate fully in providing access and information to state and federal agencies to assure satisfaction of all applicable laws and regulations.

4.2.2 Route/Site Selection

Applicant has conducted an extensive route/site selection study (see Section 8) for the purpose of selecting the most feasible combination of a pipeline route and LNG Plant and marine terminal site from environmental, technical and economic viewpoints.

The proposed pipeline route was chosen within the designated Utility Corridor. It generally parallels the Alyeska oil pipeline, and will have only incremental environmental impacts to those of the oil pipeline. Further, it provides the shortest, most economical route to a suitable marine terminal site which is protected, ice-free, and uncongested, to enhance the operation of the LNG Carrier Fleet.

Certain environmental advantages offered by the proposed gas pipeline alignment include: the use of the Utility Corridor specifically set aside for this purpose; and the use of an area of recently completed pipeline construction, thus facilitating joint or subsequent use of access roads, borrow pits, waste disposal and maintenance facilities and construction equipment. Additionally, because the natural gas pipeline is to be chilled and buried, a shorter, more direct route, with fewer river and stream crossings than required for the Alyeska pipeline will result.

4.2.3 Design

All equipment, facilities, and services will be designed in conformance with all applicable federal, State of Alaska, and local laws, orders and regulations covering sound and air pollution abatement equipment; sewage, solid, and industrial waste disposal facilities; pest control; housing, and domestic water supplies, and esthetics and reclamation programs.

4.2.3.1 Chilled Gas Concept

Special features have been included in the design which not only protect the environment, but provide for the stability of the pipeline system as well. Foremost of such design features is the chilled gas concept. Permafrost occurs over the majority of the length of the pipeline route, ranging from continuous in the north, to discontinuous in the interior, to sporadic or absent in the south. By providing propane refrigeration plants at eleven of the compressor stations, the gas will be chilled to minimize degradation of permafrost, and to assure stable support for the pipeline. The objective is to control the temperature of the gas so that it is at all times lower than the melting point of ice (32°F) and higher than the dew point of the gas. Accordingly, in the design of the Alaskan Gas Pipeline, a maximum gas temperature of 30°F and a minimum gas temperature of -10°F has been provided.

4.2.3.2 Equipment Selection

Final equipment or design selection for the project has not yet been made. However, some equipment and design features considered by Applicant are discussed below in terms of their potential for prevention and/or mitigation of adverse environmental effects during project operation.

Gas turbines will be installed as prime movers at the twelve compressor stations due to their minimal exhaust and noise emissions, economic advantages, low maintenance requirements and ready adaptability to automation.

Pipeline block valves will be installed at appropriate locations to minimize the gas volume released in the event of a pipeline rupture.

These include installations on both sides of selected river crossings, in areas of potential seismic hazards, and in other areas determined to be environmentally sensitive. Automatic actuation of such block valves will ensure rapid closure.

The pipe, valves, and related equipment will be manufactured from steel having special metallurgical properties, and will be subjected to rigorous testing to insure its suitability for use in low temperatures.

The propane refrigeration compressors in the LNG Plant will be driven by gas turbines equipped with waste-heat boilers in order to reduce the need for additional gas-fired boilers. Consequently, noise and atmospheric emissions will be at lower levels, and fuel requirements will be less.

The design of the marine terminal includes quick release hooks on the mooring dolphins and articulated loading arms which will allow substantial movement of the LNG tower at the berth without damaging the ship or the loading equipment.

The LNG tankers will be equipped to burn 100 percent of the cargo boil-off in the ship's boilers while under way. During the loading and operation, the boil-off vapors will be returned to the LNG storage tanks. The use of boil-off as fuel will minimize stack emissions due to the clean-burning characteristics of natural gas.

Design of the tankers will include a clean, totally segregated ballast system. An oil/water separator and holding tank will be included to remove insoluble oily substances in the bilge water prior to discharge.

The tankers will also be equipped with the most advanced sewage treatment systems to treat all waste products from normal shipboard operation. Solid wastes will be incinerated. Effluents will either be evaporated or treated and held in a tank for disposal at sea, as required by the U. S. Coast Guard.

The 1200 foot long off-shore trestle at the LNG terminal will eliminate the need for dredging, thus avoiding potentially adverse effects on marine life.

4.2.3.3 Noise Reduction Measures

Final equipment selection for the proposed gas pipeline will, to some extent, determine the specific sound attenuation measures required. Special enclosures may be necessary for jet-derivative type turbine units, but not for industrial type units. Jet-derivative type turbines may require exhaust silencers, whereas the regenerator on the industrial type turbine provides sufficient sound attenuation. All turbine units will be purchased with inlet and exhaust silencing. Buildings for compressors, refrigeration, and power generation units will be insulated, as will gas piping where gas velocities are such that high levels of piping noise are generated. Blowdown silencers and additional silencing in general will be provided as required to minimize the risk of injury to personnel, public annoyance, and possible noise-induced environmental disruption. If necessary, administrative controls will be imposed to ensure compliance with applicable noise regulations.

When final equipment selection for the LNG Plant is made, necessary provisions to control noise will be incorporated, so as to maintain levels within limits established by OSHA. Typical examples include:

(1) Specification of mufflers on vents, jets, compressor inlets and outlets, and control valves;

(2) Reduction of fan noise by specifying more fan blades and lower operating speeds;

(3) Use of enclosed motors or insulation wraps on motor cases; and

(4) Providing insulated working enclosures for plant operating personnel.

The proposed LNG tanker design provides for shipboard noise attenuation pursuant to both the Noise Control Act of 1972 and the Maritime Administration Standard Specifications for Merchant Ship Construction.

4.2.3.4 Seawater Cooling System

Applicant's preliminary design for the seawater cooling intake/discharge system includes several measures to minimize adverse impacts on marine biota.

The discharge outfall will be placed so as to provide an adequate mixing zone for the heated discharge, thereby minimizing large areal thermal affects. The intake, trash rack and vertical-travelling screen, will all serve to discourage fish passage into the cooling water system. Intake water velocities will be designed such that fishes of the minimal fork length expected can sustain swimming speeds adequate to avoid this area. Regular cleaning of the travelling screen and trash rack with the spray water system will further discourage high water velocities resulting from clogging of these systems by debris. Furthermore, the addition of a velocity cap will prevent the occurrence of vertical vortices at the intake. As fish more readily sense, and can thus better escape dangerous horizontal water movements (than they can vertical movements), the velocity cap should reduce the numbers of fish entrained as well as the potential physical damage resulting from cavitation. Marine life which enter the intake bay will be protected from toxic chlorination, since chlorine will be injected at the pump well, downstream of the vertical-travelling screen.

Impacts from the heated, chlorinated effluent will be minimized by the location of the discharge outfall at a depth of 60 feet below MLLW. This will facilitate rapid mixing of such discharge waters with cooler, deeper, receiving waters in Orca Bay.

Chlorine impacts from the discharge stream will be further minimized by diluting the chlorine in the discharge stream such that the residual concentration at the discharge point before diffusion will be less than or equal to 1 ppm chlorine. Thermal mixing of the discharged water by the diffuser/dilution system will provide substantial additional dilution and additional protection to marine life.

4.2.3.5 Safety Design Considerations

Natural events such as earthquakes, avalanches, landslides, soil subsidence, and erosion pose a potential threat to the pipeline system. Although many of these hazards will be eliminated by burying the pipeline, special consideration will be given to each hazard in final design. For instance, final seismic design will be based on local and regional geologic features, soil response and proximity to zones of historic and potential seismic activity

The pipeline will be designed to withstand stresses imposed by a travelling seismic wave induced by a 8.5 Richter magnitude earthquake. The segment crossing the Denali Fault will be constructed with heavy wall, concrete coated pipe. The ditch will be excavated with gently sloping, "V" shaped sidewalls, and backfilled with select granular material. Such design assures that any lateral shift of the soil along the fault line will tend to displace the pipeline upward rather than create a shearing force. In addition, automatically actuated block valves will be located on either side of the zone to enable its ready isolation.

Avalanches, landslides, and erosion pose threats to the pipeline system. Potential locations of such hazards were avoided to the maximum extent possible in selecting the pipeline route. Additionally, the buried construction mode will protect the pipeline from snowslides and shallow landslides. Extensive erosion control will be employed along the right-of-way by means of proper surface restoration and revegetation techniques.

Stream crossings will be individually designed to minimize the possibility of failure due to external forces. Concrete coated, heavy wall pipe has been specified for all submerged, major river crossings. Depth of burial below the waterway bottoms will vary from five to fourteen feet. Should scour expose a segment of piping, the concrete coating will provide protection from abrasion.

Wildfires are also potential sources of damage to the system. Primary protection of the system from wildfire is provided by the buried mode of pipeline construction. A buffer zone of thinned and controlled vegetation surrounding the compressor facilities will limit possible effects of this hazard.

External corrosion protection will be provided by coating the underground pipe with specially designed butyl rubber and polyethylene materials, by painting aboveground pipe and equipment, and by installing a cathodic protection system along the entire length of the pipeline. Internal coating will be epoxy resin. Internal corrosion protection will be aided by early detection of high concentrations of CO_2 and H_2S in the gas being transported.

Protection against material failure will be obtained by the use of stringent specifications, manufacturing inspection, and rigorous mill tests. The pipe will be manufactured in compliance with American Petroleum Institute Specifications and other applicable quality and safety standards. During the manufacturing of the pipe, Applicant's own representatives will be present at the mills, and a qualified inspection firm representing Applicant will provide added integrity to the manufacturer's quality control program. All pipe will be hydrostatically tested at the mills to 90% of its specified minimum yield strength.

Compressor stations will be equipped with emergency shutdown systems with both manual and automatic actuators appropriately located. The system will isolate and vent all gas piping and equipment, and turn off normal electrical power supplies in the event of an accident. All station building areas will be equipped with hazardous gas detection devices, an OSHA-required fire alarm system, an automatic fire detection system, or portable fire extinguishers. To further curb the possibility of fire propagation, flame arrestors will be placed on combustible product vents at compressor units

Safety will be a major consideration in the final design of the LNG Plant, the marine terminal and the LNG Carrier Fleet. The preliminary designs generally include provisions for equipment to detect fire and/or presence of combustible vapors, high pressure relief and emergency venting, containment and control of LNG spillages and leaks, emergency shutdown systems, seismic factors, noise control, applicable design codes and personnel training. A detailed description of such provisions is presented in Section 1.6, Operation and Maintenance Procedures.

4.2.4 Construction

Primary impacts of construction of the proposal facilities will be increased dust, combustion effluents, noise, and disruption of land features and terrestrial and aquatic environments. Most of these impacts, however, will be short-term and localized, and amenable to prevention and reclamation techniques. In particular, the proposed pipeline will be buried, except for short lengths at the Yukon River and Tazlina River crossings and at the compressor stations. This mode of construction will not only reduce visual effects and eliminate animal crossing problems, but will also provide the most stable pipeline system.

Potential joint use by Applicant and Alyeska of borrow pit sites and the large spatial separation of such sites, will further minimize additional surficial disruption and large scale impacts. Fugitive dust will also be minimized by appropriate stabilization procedures, such as water and oil spraying, winter construction, and gravel implacement on haul and access roads. During site preparation, potential damage to permafrost and tundra underlying the snowpad will be minimized by proper use of construction equipment.

4.2.4.1 Seasonal Considerations

Most construction will be conducted in winter, thereby minimizing disturbances of permafrost and aquatic and terrestrial biota. Winter construction is also economically sound since a lesser degree of terrain disturbance is reflected in less extensive restoration requirements, thereby reducing construction and maintenance costs. Specific advantages of winter construction include:

(1) A reduction in the amount of siltation at stream crossings since most of these will be crossed when frozen;

(2) Minimal impacts from spillage of fuel oil for construction equipment, since gelled petroleum products tend to remain near the top of the snow pack, and thus can be readily removed;

(3) Less disturbance of fish spawning or life-cycle phases, since fish will either be overwintering in or absent from streams crossed.

(4) Reduced siltation due to construction activities through frozen flood plains;

(5) Preservation of surficial vegetation by the use of snow pads during construction; and

(6) Lower levels of construction dust.

Offshore construction of the marine terminal will be scheduled to minimize adverse effects to resident marine populations, particularly during sensitive phases of their life cycles. Scheduling construction of the dolphins, and loading and service platforms during the season of the lowest biological activity (winter) will mitigate disruptive effects on marine organisms.

4.2.4.2 Erosion Control

Erosion prevention procedures to be used by Applicant include the installation of rip-rap, gabions, breakers, cross drains, and sandbagging of slopes. Specific procedures required for specific areas will be determined during the final pre-construction stages of the project.

During construction of the gas pipeline, drainage channels will be maintained across the right-of-way. At stream crossings, erosion will be controlled by dikes, diversions or stream ponding. For each major stream crossing, a detailed survey and design study will be conducted to determine specific measures required to minimize bank erosion and insure pipeline integrity.

Road crossings of riverine systems will be provided with drainage culverts and reinforced as necessary to mitigate erosional processes, thus minimizing downstream siltation loading, and will be designed so as to provide a maximum velocity, especially during fish migration, of 0.6 fps.

At the LNG Plant site, a balanced cut-and-fill design will be made, where feasible. Any excess material will be graded to avoid disruption of drainages in the area adjacent to the site

During construction of the marine terminal, construction activities near the shoreline will be given special attention so as to minimize erosion and associated siltation in Orca Bay. Dredging will not be required.

4.2.4.3 Waste Disposal

Non-combustible wastes resulting from pipeline construction will be disposed of in borrow pits or in other approved areas. Combustible wastes will be incinerated in areas designated by the responsible agency; combustion residues will be disposed of at approved sites.

Slash (organic debris) will be mulched and scattered along the disturbed right-of-way, facilitating the recycling of nutrients, and thereby enhancing revegetation.

Sewage from construction will be treated in approved facilities at construction camps in accordance with applicable standards and procedures. In isolated areas, approved chemical toilets will be provided, to preclude possible waste enrichment in these areas.

Waste disposal during construction of the LNG Plant and marine terminal will follow the scheme described above for the gas pipeline. In all instances, Applicant will comply with applicable local, state and federal guidelines and regulations respecting waste dispsal.

4.2.4.4 Safety

Applicant will design, construct and operate the proposed Alaskan Project Facilities, in a manner which will minimize the potential of accidents. It must be assumed, however, that accidents may occur, and suitable preventative measures will be prescribed before construction is initiated.

Construction camp housing will be designed for safe and comfortable accommodation of crews, and will conform to objectives of the "Alaska Housing Code." Cold region standard practices and precautions with regard to fire hazards, carbon monoxide poisoning, heating, and ventilating will be fully developed. Special considerations will be given to icing, condensation, and wind-snow effects.

All potable water supplied will conform to the 1962 Public Health Service Drinking Water Standards (as revised) with respect to source, protection, bacteriological quality, physical-chemical characteristics, and radioactivity. Water sources and proposals for the foregoing properties will be approved by the Department of Health and Welfare of the State of Alaska, prior to development and use.

The ecological effects of unintentional events associated with the construction of the proposed project are, by and large, not substantial. In general, human reactions to accidents are normally more significant in altering biotic systems than the accidents themselves, as described in Section 3.

Fuel oil or other liquid petroleum product spills may occur. The volume of any one spill will be small, being equal to the total volume of the fuel storage facility. As described previously, fuel oil ground spills during winter will be readily amenable to clean-up.

Spills or leaks of petroleum products reaching an open water course may adversely affect water quality. Due to the scheduled winter construction, however, most waterways will be frozen; thus spills may be cleaned up with little resulting effect on water quality.

Accidental ignition of wildfires may occur during the project construction phase. So long as these are not compounded by spills of petroleum products or by high winds, such ignitions will most probably be containable without the use of heavy equipment. In the Arctic, the probability of setting the tundra afire will be restricted to the summer months when little construction activity is scheduled, and will be further restricted by the lack of combustible materials. Thus, extensive containment measures are not expected to be necessary. In forested regions along the interior and southern portions of the pipeline route, accidental or natural ignitions have a higher probability of occurrence, and will likely require extensive containment measures. All construction personnel will receive training in general safety practices to prevent forest fires.

Where snow is available, construction activities will be conducted on snow pads. Thus, ignition of vegetation at these sites will be limited by little or no direct contact with equipment or weld slag. All powered equipment is designed to minimize the possibility of fire, and flame arrestors will be placed on exhausts and combustible product vents as necessary. In high winds, welding will be performed in portable enclosures to prevent hot weld slag from being carried to areas adjacent to the work pad.

Applicant will employ the same safety measures described heretofore for the Alaskan pipeline during the construction of the proposed LNG plant and marine terminal. Safety measures to be adopted for the LNG carrier fleet will be those of the particular shipyards where the tankers will be constructed.

4.2.5 Operation

4.2.5.1 Safety

Anticipation of potential accidents associated with the operation of the proposed gas pipeline has been an integral part of the design and operational considerations since project conception. As such, the system will be operated in compliance with stringent codes, standards, and guidelines. The primary codes are as follows:

(1) Department of Transportation, Title 49, Part 192 - Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards,

(2) U. S. Occupational Safety and Health Act and Associated Standards, and

(3) ASME Guide for Gas Transportation and Distribution Piping Systems - 1973, and referenced standards.

Applicant has experienced a pipeline failure incidence rate of 0.374 incidents per 1000 miles of pipeline operated per year in its historic market area in the southwestern United States. Forty-eight percent of these were attributed to material failure, construction defects, or corrosion. An additional forty-eight percent were caused by outside forces, both natural and man-induced. Man-induced pipeline failures occur largely through damage from excavating equipment and vehicles, and from wanton destruction.

The pipeline route, for the most part, lies in an uninhabited area. Human activity, other than that of the Applicant, will largely be limited to hunting, fishing and other recreation. None of these activities present a significant hazard to buried pipeline integrity. Near communities and at highway crossings, adequate identification and posting of the right-of-way will virtually eliminate the risk of accidental damage to the pipe and appurtenant facilities.

The completed pipeline system will be rigorously tested before it is placed in operation. Minimum test pressures will be 1.1 times its design pressure, maintained for a period of 24 hours. Compressor station and meter station piping will be tested to 1.5 times design pressures.

The most serious failure that may occur in the gas system is the rupture of pressurized piping or vessels. Any rupture in the system would be detected by flow and pressure monitoring devices, and block valves located on either side of the rupture will be automatically closed, limiting the volume of gas released.

When pipeline leaks are detected, an alarm will be transmitted to the Dispatch and Control Center. The District Superintendent will locate and inspect the trouble spot and immediately initiate corrective action. The dispatchers will also immediately notify the LNG Plant, the producers' field facilities, governmental agencies, and local emergency agencies, as necessary.

Though there is the potential for ignition of a gas leak or pipeline rupture, the ensuing damage to the environment will be mitigated by: the buried mode of the pipeline, the buffer zone around each compressor station and the 150-foot wide cleared area along the entire length of the pipeline right-of-way.

During the operation phase of the project, when activity levels will normally be low, the frequency of fuel oil spills will also be very low. Significant spills will most likely not occur at compression facilities and maintenance bases, inasmuch as liquid petroleum products will be stored in permanent tanks surrounded by diked areas of a size sufficient to contain the maximum stored volume.

An operating and maintenance plan to be established by Applicant will include the following mitigation measures: (1) instructions covering operating procedures during normal operations and repairs, (2) specific repair procedures, (3) patrol schedules, (4) special maintenance programs relating to facilities presenting the greatest hazard to public safety, (5) programs relating to construction, and (6) provisions for periodic inspection.

Applicant will also establish an emergency "contingency" plan, which will include the following measures:

(1) Specific procedures to be followed in emergency situations;

(2) A program to acquaint operating and maintenance employees with such procedures;

(3) Establishment of liaison and line of communication with appropriate public officials, including fire and police officials, and

(4) An education program to enable the general public to recognize and report a gas emergency.

Fire detection systems planned for the LNG Plant and maintained are described in subsection 1.6.2.7. These include automatic ultraviolet flame and combustible vapor, detectors strategically located throughout the liquefaction trains, LNG storage dike, and the harboring and loading facilities. In addition, maintenance crews will make periodic checks for combustible vapors using portable detectors. Fire retardant and extinguishment facilities will include dry chemicals, expansion foam, water spray and inert gas.

The non-LNG related operational safety procedures for the LNG Plant and marine terminal will be established with consideration given to the prevention and control of accidental events. The prevention of accidents at the LNG Plant and marine terminal are a function primarily of three measures: (1) maintenance of the piping and equipment, (2) maintenance of the buffer zone, and (3) adherence to design operating requirements of the system. The specific operating maintenance and emergency plans established by the Applicant will follow those described for the proposed gas pipeline system.

The LNG Carrier Fleet will be designed to provide safe operation on the high seas as well as in port. Design for safe carrier maneuverability in the terminal vicinity and for proper carrier operation are described in subsections 1.3.3.3 and 1.6.3.2 respectively. Included are inert gas operation and extensive fire protection systems, increased maneuverability provided by the 45° rudder angle, twin screw propulsion system powered with 27,500 HP per shaft, a 2500 HP bow thruster, a complete communication and navigation system which includes a collision avoidance course plotter, a double hull design, and an emergency shutdown system with a maximum closure period of 15 seconds.

Planned operational mitigation procedures include tugboat assistance during the berthing operations; Dock Master teams (pilots) on board ship directing the berthing operations; special fleet routing directories recording weather, traffic and obstacles; and continued use of an overall traffic surveillance and control system.

Additional safety considerations for LNG related operations in the LNG Plant, LNG storage and transfer facilities, and the LNG Carrier Fleet are presented in Section 11 of this Report.

4.2.5.2 Maintenance

A routine pipeline inspection program will be designed and conducted to maintain the integrity of the system and to insure a minimum of environmental damage from normal pipeline operations.

Proper maintenance procedures are also important for the protection of LNG Plant and marine terminal operating personnel. Maintenance and inspection will be carried out only by qualified personnel who are adequately trained and fully aware of potential safety hazards. Ignition sources, such as electric welding equipment, and electric motors, will not be operated until the surrounding atmosphere has been checked and found safe. If welding or cutting operations are to be performed on vessels or piping which have contained flammable or toxic gases, they will be purged to a safe condition.

Applicant's employees and contractor personnel will travel only on designated access routes or other approved routes. Applicant intends to apply strict controls on hunting and fishing by all Project personnel.

Proper maintenance will provide for prompt indentification of impacts resulting from erosion, permafrost degradation, pipeline leaks or rupture, icings and frost heaving and immediate corrective measures will be taken to prevent further environmental degradation, and to insure pipeline stability.

The LNG tankers will be subjected to extensive maintenance procedures to assure all shipboard equipment and systems are operational at all times thus reducing the opportunity for malfunctions or failures which could lead to undesirable environmental infringements.

4.2.5.3 Emissions and Waste Disposal

The expected exhaust emissions from the gas-fired turbines in the compressor stations are shown below by component, in lbs/MMBtu:

SO_2	<0.01
NO_X	0.69
CO	0.04
Particulates	Trace

Since these are within the limits of any known standards of the Environmental Protection Agency of the State of Alaska, Applicant has not incorporated any special measures to further mitigate such emissions.

Atmospheric and noise emissions from operating gas turbine-driven compressor units are expected to have a minimal effect on the existing environment, since a buffer zone will be provided, turbine inlets and exhausts will be silenced, gas piping will be insulated as necessary, and turbines will be fired with clean burning natural gas.

Some hydrocarbon wastes will be accumulated at each compressor station, in the form of liquids separated from the pipeline gas in the station scrubbers. The scrubbers will be equipped with automatic level controls to avoid liquid carry-over into the compressors. The liquids from the scrubbers will be dumped into a hydrocarbon holding tank, which will be periodically emptied, with the liquids being disposed of in an approved manner.

All sewage and liquid industrial wastes from compressor stations will be contained and treated in approved facilities. It is anticipated that a processing plant operated on a physical-chemical cycle will be utilized. Sludge will be dewatered and disposed of by incineration or deposition in a holding pit. State of Alaska discharge permits will be obtained where required. Combustible refuse, waste, building materials, and garbage will be burned in an approved incinerator or processed and buried where permitted. Solid wastes that are not biodegradable will be removed from the site and disposed of at approved locations. Combustible solids will be hauled to approved areas, and burned.

Atmospheric emissions expected from the LNG Plant (including non-pollutants) include: (1) NO_X, SO_2 and particulates in flue gases from gas-fired equipment; (2) hydrocarbon vapors (mostly methane) from the LNG tankage area emergency vent stack; (3) waste gases (mostly CO_2) from vent stacks in the DGA units; (4) burned process and pipeline relief gases from the elevated smokeless flare stacks; and (5) oxygen-enriched waste gas from the nitrogen production facilities. Because these emission levels are not expected to cause ground level concentrations close to applicable standards, no measures are contemplated for this mitigation.

Design measures to attenuate noise in the LNG Plant and terminal are detailed in Section 1 and described in subsection 4.3.2.3. Upon completion of detailed engineering design, final sound level contour maps will be prepared to determine compliance with applicable regulations. Wherever additional noise attenuation is required, necessary corrective measures will be taken.

Solid and liquid waste disposal procedures at the LNG Plant and marine terminal will generally follow those previously described for the pipeline. The waste water streams will be collected in a holding pond (60 ft wide x 320 ft long x 10 ft deep), analyzed, and either discharged to Orca Bay if determined to be in compliance, or recirculated for further treatment. Raw sewage will be treated in an activated sludge unit to reduce BOD and suspended solids. An equalization tank will be provided to minimize flow variations. Sewage disinfection will be insured by chlorination prior to its discharge to the holding pond. The BOD, suspended solids and chlorine concentrations in the treated effluent will comply with applicable federal and state regulations. Effluents not meeting appropriate standards will be recycled through the activated sludge or chlorination units for further treatment.

The process area and tank farm storm sewer effluent water will be essentially oil-free since no heavy oils are to be stored in these areas. Compressor building drainage systems will be provided to collect oily drips and drains from normal compressor operation. The drainage system effluent will be routed through a coalescing medium for oil removal, blended with raw sewage, and treated in the sewage facilities prior to its discharge to Orca Bay. A storage sump will hold effluents to allow time for quality testing. Unacceptable effluents will be recycled through the coalescing medium, and oil skimmers will provide additional protection against oil release to Orca Bay.

The holding pond will be designed to provide 2-1/2 hour retention time at a maximum waste water flow rate of 8,867 gpm. Most of this flow will be due to runoff from the process area and tank farm storm sewers. Storm water runoff from outside of the process and storage tank areas will be drained through concrete-lined channels directly to Orca Bay.

The holding pond will serve as an equalization basin to smooth out surges in effluent water flow and composition to allow quiescent settling of suspended solids. An automatic pH recorder-controller will be provided to maintain the pH in the pond effluent water between 6.8 and 7.2. The pond effluent water quality will be checked for acceptable levels of BOD, dissolved oxygen, oil and grease, suspended solids, color and odor prior to discharge to Orca Bay.

The proposed LNG tankers will comply with the stipulations of the Noise Control Act (1972) and the Maritime Administration Standard Specification for Merchant Ship Construction.

The LNG tanker fleet will be equipped with the most advanced type of total waste treatment facilities. The treated effluent which is not incinerated or evaporated will be treated and retained in a holding tank, monitored, and released at sea with other remaining sanitary waste in compliance with U. S. Coast Guard Regulations. Solid waste will be compacted and baled for appropriate disposal.

Emissions of particulates, hydrocarbons, SO_2, NO_x, and CO from various combination sources will occur from the tanker while it is in port, but associated ground level concentrations will be very low and therefore no measures to mitigate these emissions are planned.

4.3 RESTORATION AND ENHANCEMENT

4.3.1 Biological

After construction, all disturbed areas will be revegetated and restored as nearly as possible to pre-construction conditions. Restoration measures currently planned include (as a minimum) revegetation of the pipeline right-of-way, restoration of construction camps, borrow pits, storage yards, and working areas, and restocking of game fish which may be lost during the construction process.

The pipeline right-of-way will be graded, reseeded, and maintained to ensure prevention of potential damage from erosion and permafrost degradation.

Fertilization will be provided to ensure optimum plant growth in such a manner as to minimize leaching (and resultant eutrophication) into existing streams and rivers. Additional nutrients will be provided by the distribution of mulched slash along the right-of-way.

The pipeline right-of-way will remain a visible feature through forested areas for the lifetime of the Project. However, revegetation of the right-of-way will reduce short-term adverse aesthetic effects.

Extensive precautions will be taken at river and stream crossings to prevent adverse environmental impacts upon resident species. Construction of stream and river crossings will be conducted in winter months, thereby minimizing siltation and its undesirable effects on aquatic biota. Waste materials will not be dumped into streams and rivers during construction. There is little probability of petroleum product spills or gas leaks along the stream and river crossings, because fuel oil storage areas will be located away from streams, and gas leaks will be minimized by block valves placed on each bank of major rivers crossed by the pipeline.

Maintenance stations and compressor stations will be fenced to prevent wildlife intrusion. Firearms will be prohibited, noise levels will be minimal, and activity on access roads will be controlled. Provisions to protect unique habitats will be employed during all phases of construction and operation.

After construction of the proposed LNG Plant, all areas not required for plant operation will be restored and revegetated. Overburden and vegetation removed during construction will be disposed of by spreading and grading to enhance the drainage patterns of the site. An undisturbed buffer zone adjoining the plant site will serve to provide aesthetic enhancement. Extensive use of landscaping and environmentally harmonious paint colors will further aid in restoring the aesthetics of the plant site.

During operation of the plant, precautions will be taken to insure a minimum of noise. Additionally, a security fence will surround the plant.

In case of eventual abandonment, the plant site will be restored to original contours and revegetated. Materials used for construction can be utilized as fill material during site restoration.

Archeological and paleontological clearances will be obtained for the entire pipeline route, compressor and maintenance station sites and LNG Plant and marine terminal locations. Any archaeological or paleontological finds will be reviewed for significance and be handled in accordance with appropriate guidelines.

4.3.2 Socioeconomics

Construction activities on the Alaskan Gas Pipeline, LNG Plant and marine terminal will generate the principal socioeconomic impacts of the Project. Operating impacts of land-based systems on the Alaskan people and their economy will, on the other hand, be negligible except in the case of the City of Cordova, which will be significantly affected by the housing and public services requirements of the LNG Plant and marine terminal operating personnel.

Mitigating measures that will be taken to reduce or eliminate undesirable socioeconomic effects will, accordingly, be focussed primarily on short-term or temporary phenomena associated with the deployment of large numbers of construction personnel near communities along the pipeline route, and the logistics of implementing the massive construction effort.

The economy and social sectors of the Alaskan environment will have already experienced the effects of construction of the Alyeska oil pipeline along the same pipeline corridor to be occupied by the gas line. The oil pipeline project will have set in motion a number of government and private activities to deal with such problems as scarce housing and inadequate public utilities and government services, rising public health and safety protection requirements, and expanded demand for retail goods and services. Not only will public and private organizations and interests be taking steps to accommodate the Alyeska pipeline project, but they also will be planning to accommodate the additional, or incremental impacts of the gas pipeline project. Implementation of the proposed Alaskan Project, immediately upon completion of the Alyeska project, will provide a continuity to expansion of the state's public and private social and economic infrastructure, and reinforce the long-term growth of employment, personal income and general welfare. As a result, the relative impact of the negative aspects of the gas pipeline construction effort will be substantially reduced, compared with those generated by the Alyeska project. By the time work begins on the Alaskan Gas Pipeline in 1977[1], the state will be much better prepared to accommodate its associated construction impacts than it was in 1974 when work began on the oil pipeline, primarily because a momentum will have been developed in the creation and expansion of public and private services and facilities.

Much of the potential direct pressure of the gas pipeline project on the state's public and private resources will be mitigated by the manner in which the construction effort will be conducted. The project will involve construction of virtually self-contained work camps for the construction workers, development of independent supply headquarters, and utilization of existing roads and highways to the greatest extent possible, and--of particular significance--employment of workers, coming off the Alyeska oil pipeline project, which will be nearing completion in 1977. Utilization of the ex-Alyeska workers will not only reduce post-oil pipeline unemployment in the state, but will also reduce the attraction of out-of-state workers who might wish to relocate in order to find work on the gas pipeline project.

Specific measures to mitigate adverse effects of construction of the gas pipeline during the period 1977-1981 cannot be precisely formulated at the present. Adverse socioeconomic impacts are mainly indirect in nature, deriving primarily from the activities of the project work force rather than from the actual construction activities. Specific information as to the timing and magnitude of construction labor deployment at specific locations along the pipeline route is not yet available. Also, it is uncertain how extensive development will be, by late 1977, of housing, public utilities and services (including water and waste treatment system and police, fire and public health facilities) by the various communities along the pipeline route. Additions to capacity of these facilities usually cannot be accomplished in small units, but instead must be carried out in large increments. Consequently, the degree to which the supply of such services exceeds or falls short of demand at any given point in time is difficult to predict.

The principal mitigating measure that can be indicated at the present time for potential adverse socioeconomic impacts is the interest and intention of Applicant to work with state and local government officials and agencies in planning the orderly development of community facilities. Local business interests will also be provided with timely advance information on project activities so that their expansion activities may be efficiently planned.

It will be recalled from subsection 3A.2.5.2.1, which dealt with potential socioeconomic impacts of the gas pipeline project on taxes and public finances, that short-term cash flow problems would be a major

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[1] Date of initiation of construction in Alaska is specified for purposes of socioeconomic analysis only. Project engineering planning dates may vary.

factor affecting the development of public service facilities by communities along the pipeline route. The cities and boroughs of Fairbanks and Anchorage would not be seriously affected because they are incorporated and have taxing powers over property. However, such communities as Cordova, Valdez, Copper Center, Glennallen, Delta Junction, and such predominantly native communities near the pipeline route as Minto, Stevens Village and Bettles, among others that are not as yet in organized boroughs, will experience impacts of pipeline workers visiting or residing in the towns and generating requirements for community services. These communities lack powers to tax the pipeline properties, which would be the base for additional funds to finance the increased community services. While it is the responsibility of the state and local officials to determine administrative, organizational, and financial arrangements of local political jurisdictions, Applicant recognizes its role as a factor of change. Accordingly, Applicant is desirous to provide planning support and, as necessary, active involvement in the development of local community development programs designed to mitigate impacts resulting from Project construction and operation activities.

The concern and interest of Applicant in smoothing the introduction of the Alaskan Project is particularly acute with respect to the City of Cordova, where much of the construction work on the LNG Plant and marine terminal will be staged, and where most of the plant and terminal operating personnel will reside. Applicant is concerned that its Project and personnel will be welcome and absorbed into the community, and it will work closely with local governments and business interests to facilitate the process.

During construction there will be a high level of barge traffic to the LNG Plant site. This traffic probably will necessitate some changes in local fishing activities. As a mitigating measure to prevent loss of crab pots and scouring of crab grounds, or to prevent fouling of tugboat propellers and towing bridles, a barge channel will be surveyed and marked, and construction navigation will be restricted to this channel. Similar measures will be taken to mark the channel for the LNG carriers when commercial operations begin.

The benefits which will ultimately accrue to the State of Alaska from the construction and operation of the Alaskan Project will be determined largely by the uses the state makes of its royalty gas, and the uses the state and local governments make of production, royalty, and property taxes made possible by the gas pipeline. Applicant is interested in maximizing the benefits deriving from its investment in Alaska. Compensating for the inevitable unfavorable side-effects of the construction effort, which accompany any large capital undertaking,is a necessary part of the benefit maximization process, and Applicant reiterates its intention to provide whatever support possible to realize this end.

SECTION 5 - UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

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5 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

5.0 INTRODUCTION

This Section discusses those unavoidable adverse abiotic, biotic and socioeconomic effects which Applicant predicts will result from the construction and operation of its proposed Alaskan Project.

As detailed in Section 3 of this Report, most environmental impacts attributable to the Project will occur during its construction phase. Where possible, unavoidable impacts are defined in specific terms when unique to a given physiographic region or project component. Unavoidable impacts are further defined in the following manner: short-term impacts (i.e., those occurring one time or repetitively during the life of the Project); and long-term impacts (i.e., those which persist beyond the termination of the Project).

5.1 ABIOTIC

5.1.1 Land Features

In general, major unavoidable adverse impacts to land features will result from earthwork, gravel extraction, and solid waste disposal activities.

Long-term, unavoidable impacts from gas pipeline construction will include alteration of existing topography where land cuts, blasting and gravel extraction are required. The lasting effects will be: some permafrost degradation; residual gravel pads of compressor and maintenance stations; borrow pits; rip-rap and gabion reinforcement at river crossings and side cuts; and excess materials excavated by trenching and blasting. Approximately 742 acres of compressor and maintenance base sites, and 1,533 acres for communication bases, helipads, and permanent gravel-based roads will persist beyond the life of the Project. Furthermore, 395 acres of land required for the liquefaction plant will be altered for the long-term.

Short-term, recurring unavoidable impacts of construction and operation are, in many cases, relatively minor, but include the disposal of solid wastes in approved dumping areas, and potential erosion at stream crossings and land surfaces. Aesthetic impacts can be expected from construction equipment, materials, manpower and aboveground operating facilities.

5.1.2 Land Use

The majority of the land along the proposed pipeline alignment is state- or federally-owned, and has been set aside as a Utility Corridor. Only a small segment of the proposed gas pipeline route in southern Alaska is outside this Corridor.

The dominant land use in the regions traversed by the Corridor is forest and woodland area. A limited portion is used for homesteading, native subsistence and commercial activities.

Applicant's proposed land use is described by Project component in Section 1.3, Land Requirements. The immediate, unavoidable short-term impact will be the exemption of this land from its present uses. This could lead, in the near-term, to some increased accessability of the area. It will also lead to some alterations in present land use patterns.

5.1.3 Climate and Air Quality

Unavoidable construction impacts to air quality will be short-term (of a one-time occurrence), and will result from localized increases in fugitive dust and equipment emissions. Unavoidable operational impacts from the compressor stations, the LNG Plant, the marine terminal and the fleet will also be short-term, but will persist for the life of the Project.

The minor, but unavoidable impact of fugitive dust and emissions from equipment and solid waste incineration will be localized effects on air quality.

Operational emissions from the compressor stations, the LNG Plant, at the marine terminal, and from the fleet will consist of water vapor, carbon dioxide and oxides of nitrogen. Small amounts of sulfur dioxide are also anticipated.

Unavoidable effects from emissions during construction and operation include a slight decrease in ambient air quality, and increased ice fog in winter at some locations. The analysis presented in Section 3A.4.2, demonstrates that, in general, expected impacts on ambient air quality will be minor.

5.1.4 Water Resources

Unavoidable impacts to water quality will accrue from direct construction effects on riverine systems, and indirectly from the disruption of the surficial environment, which leads to an increase in natural erosion and leaching processes. The expected unavoidable impacts from these once-occurring activities include the following.

1. Alteration of natural surficial and riverine drainage by access roads,

2. Increased siltation in rivers during construction and from maintenance activities,

3. A potential increase in siltation and decrease in oxygen from the possible temporary impoundment of Harris Creek near the LNG Plant site,

4. Increased biological oxygen demand loading of freshwater along the pipeline route,

5. Minimal contamination of surface waters from accidental fuel oil spills, and

6. Minimal increase in nutrient loading from potential leaching of burned areas, and from fertilizer from Applicant's revegetation programs--possibly leading to eutrophication of drainage waterways.

Potential short-term, recurring unavoidable impacts resulting from operation and maintenance of the proposed facilities include those discussed above. Some will be continuous over the life of the Project, while others (resulting from maintenance) will be intermittent. However, all unavoidable impacts expected during Project operations will be several magnitudes less than those during construction.

5.2 BIOTIC

5.2.1 Terrestrial

Unavoidable adverse impacts to the terrestrial biota during the construction and operation of the proposed facilities will result from: grading, snowpad preparation and use, excavation by blasting, digging, or trenching, clean-up operations, and maintenance of the pipeline right-of-way.

The only long-term unavoidable adverse effects from these physical disturbances will be the localized modification of surface vegetation along the pipeline route, and at borrow pits and construction camp sites and the aesthetic impact of the right-of-way extending from Prudhoe Bay to Gravina Point. Also, vegetative cover at the LNG Plant site may be lost for a period extending beyond Project termination; however, revegetation of the site and natural succession thereafter could markedly reduce this impact.

The short-term (once-occurring) unavoidable impacts to fauna from the construction of the gas pipeline and LNG Plant will include localized extirpation, fright reactions from equipment and manpower, and the potential impediment of movement from snow fences and deep snow in cleared rights-of-way.

Short-term repetitive, and continuous unavoidable impacts from construction, restoration, operation and maintenance are as follows:

Repetitive

Fright reactions from air surveillance activities;
Temporary and localized effects of pesticide use;
Temporary phytotoxic effects of small fuel oil spills;
Minimal nutrient loading from potential man-induced wildfires; and
Some increased road kills of mammals.

Continuous

Noise effects;
Vegetative changes during maintenance;
Possible local inhibition of the revegetative scheme and ponding of groundwater from potential ice encapsulation in the area of the gas pipeline.

5.2.2 Aquatic

The major unavoidable adverse impacts to aquatic biota will occur during construction. Similar, but lesser impacts will be associated with the restoration, operation and maintenance phases.

Unavoidable, short-term repetitive impacts predicted include the loss of plankton, plants, and, to a lesser extent, fishes, from increased siltation, nutrients, and possible fuel oil spills.

The short-term, continuous impacts, though more difficult to predict, may include some obstruction to fish migration by drainage culverts, and increased recreational fishing.

The above impacts are expected to be incremental to those resulting from construction and operation of the Alyeska oil pipeline, but will be attenuated by the mitigation measures discussed in Section 4 of this Report.

5.2.3 Marine

The single, long-term unavoidable impact to marine biota will be the local alteration of the physical and biological environments due to the presence of the proposed small boat harbor.

The expected once-occurring unavoidable impacts of constructing the LNG Plant and marine terminal include direct, but localized disturbance of marine life from increased siltation, physical disturbance of the ocean floor and potential petroleum spills.

Short-term, continous unavoidable impacts will result from discharges from the LNG Plant and fleet. Cooling water and ballast water from the fleet and from the proposed seawater cooling system may be the most obvious sources, with the following expected impacts: physical and chemical effects of impingement, entrainment, thermal shock and chlorination. The remainder of the unavoidable discharge impacts will be minimal, resulting from treated effluent discharges.

5.3 SOCIOECONOMICS

Several unavoidable adverse, impacts from the proposed project will accrue to the socioeconomic environment of Alaska. As with other impacts on other sectors of the Alaskan environment, the majority of unavoidable socioeconomic impacts will be the direct result of construction activity. With few exceptions, such effects will be incremental or will have a prolonging effect on those of the Alyeska oil pipeline project. The following discussions focus on five general socioeconomic areas which are expected to receive the major unavoidable impacts; housing, social services, cultural, transportation, and commercial fisheries in Prince William Sound.

5.3.1 Housing

Unavoidable impacts to housing are expected to be the most significant in the Interior and South Coastal Regions.

Unavoidable housing impacts in the Interior Region will be concentrated in the Fairbanks area, but will also occur in such Utility Corridor communities as Delta Junction, Glennallen and Copper Center. Immediate unavoidable affects will be aggravation of the housing shortage attributable to the oil pipeline project. Secondary unavoidable impacts may include increased land speculation and inflated housing costs.

Similar impacts are expected in the South Coastal Region. The majority of the impacts in Anchorage and Valdez will be additive to those of the Alyeska Project. Potential effects at Cordova will be directly attributable to Applicant's Project.

5.3.2 Social Services

The pattern of unavoidable impacts to social services will parallel those discussed for housing. Primary unavoidable impacts will be possible shortages of public health facilities. Other impacts could include straining of local public safety and education resources.

5.3.3 Cultural

Long-term and additive dislocations of native cultures are an expected consequence of Project construction. The principal influence will be increased cash flows and development of new skills which may be only partially useful elsewhere following construction. The imposition of this cash culture on the (relatively) more stable subsistence culture, and dislocation of a portion of the native population base to developing technological areas in Fairbanks and Anchorage, may be considered by some to be adverse effects.

5.3.4 Transportation

Since Applicant proposes to use, to the extent feasible, existing transportation media in Alaska, there will be significant impacts accruing to the railroad and highway systems. The highway systems serving Fairbanks will be congested by the transport of manpower, equipment and supplies for the Project. This will require additional policing of these routes for safety, as well as increased maintenance requirements.

Of the other cities impacted directly by Applicant's Project, Cordova will experience most of the unavoidable transportation impacts due principally to its proximity to the LNG Plant site. Some of Applicant's materials and supplies for the LNG Plant will be received at Cordova.

5.3.5 Fisheries in Prince William Sound

The expected level of waterborne traffic in Prince William Sound will have some unavoidable short-term and continuous impacts on the local fishing fleet and crab fishery. The effects of the LNG carrier route (marked by buoys) may be significant. This combined activity will cause this small area to become inaccessable (for use as a fishery) for the life of the Project.

5.3.6 Summary

In general, the most significant adverse unavoidable impacts to the socioeconomic environment will be the increased demand for housing, social services and transportation at Cordova, directly induced by Applicant's proposed Alaskan Project. Other unavoidable impacts will be those imposed upon the local fishery in Prince William Sound. Certain of the measures described in Section 4 of this Report, however, will minimize many of these unavoidable impacts to the socioeconomic environment of Alaska.

Section 6
Uses Vs. Productivity

SECTION 6 - RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

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6 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed Alaskan Project will result in use of portions of the Alaskan and North Pacific environments for the principal purpose of transporting Prudhoe Bay natural gas reserves to consumers in Alaska and the Lower 48 States. Implementation of the Project will cause diminishment of North Slope natural gas reserves over the long-term, though such fact should not be construed as being an adverse effect on that area's productivity, since man's demands for premium fuels will require the production of Alaskan gas reserves in the near-term future.

6.1 SHORT-TERM BENEFITS

Energy Supply

The most obvious and most significant benefit of the proposed Alaskan Project will be the availability of an additional 1189.7 trillion Btu annually to U.S. natural gas markets. In the Lower 48, this base load energy supply will be used principally in residential and commercial market sections. In Alaska, the Alaskan Project will not only provide natural gas to some residential markets for the first time, but may provide both energy base and feedstock for the development of new industrial enterprises as well.

Employment

The Alaskan Project will require over 21 million man-hours of labor to construct the gas pipeline and associated facilities, and over 32 million man-hours for the LNG Plant and marine terminal. During operation, total manpower requirements for operation and maintenance of the pipeline will be 197 permanent and 71 service personnel, 272 operating employees and 37 service persons at the LNG Plant, and 578 employees manning the LNG Carrier Fleet. In addition, there will be 94 permanent fleet administration and support employees. The short-term socioeconomic benefit of the increased employment is two-fold. First, and of greater magnitude, is the benefit of providing employment for construction workers at a time when high unemployment rates are forecast due to the completion of the oil pipeline. The other benefit will be the employment of operational personnel for the life of the Project, and the requirements for the associated Project and personnel support services.

Increased Revenue

Tax and royalty revenues accruing to the State of Alaska have been projected (see Section 3A.2.5) to be $176.1 million annually over the life of the Project. Additional tax revenues will accrue to the Federal Government.

Indirect benefits of these increased revenues will be expanded social services, and a tax base for economic and social development of organized as well as unincorporated regions of the state.

Land Use

The gas pipeline route will, for the most part, follow the designated Utility Corridor. By using this corridor, and by using many of the same roads and other sites constructed and developed by Alyeska during construction of the oil pipeline, additional land required for the Alaskan Project will be greatly reduced. The short-term benefits of this action can be directly translated into decreased disturbances on the Alaskan environment, and only incremental localized land use requirements.

Public Health

The displacement of alternate fuels with clean-burning natural gas will aid in preserving or improving present air quality. This will have a direct beneficial effect on public health of residents for the life of the Project. Additionally, increased state revenues in Alaska can be used to build medical facilities, thereby benefiting the health of the state populace.

6.2 LONG-TERM PRODUCTIVITY

No adverse effects on long-term biological productivity are anticipated from this Project. None of the land requirements of the proposed Project is permanent in the sense that they will remain after termination of the Project, though the topography of some will be altered.

As a result of the mitigating measures described in Section 4, few potential impacts will be irreversible, and none are considered as having a significant effect on long-term productivity.

All permanent commitments of resources are discussed in Section 7 of this Report. No continuing requirement for resource use or consumption for the proposed Project will exist beyond its life.

Section 7
Irreversible Commitments

SECTION 7 - IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

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7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Construction and operation of the proposed gas pipeline, LNG Plant, marine terminal, and carrier fleet will involve the consumption of significant amounts of certain resources. Irrevocable effects of such resource uses are discussed in the following subsections.

7.1 LAND FEATURES AND USE

Approximately 5,752 acres of land will be permanently dedicated to the Alaskan Project during its useful life. To the knowledge of Applicant, there are presently no conflicting plans for use of this land.

Other than the land to be occupied by the proposed facilities (and the wildlife habitat thereon), Applicant has identified no resources, (other than natural gas produced at and transported from Prudhoe Bay), the use of which would be directly lost or preempted by construction and operation of the project.

7.2 ENDANGERED SPECIES AND ECOSYSTEMS

No rare and endangered plant species are known to occur in Alaska; therefore, there will be no irreversible or irretrievable commitments of significant plant species during implementation of the proposed Project. Similarly, marine plant species will not be adversely affected.

Three species of birds are listed in the Department of the Interior's "Threatened Wildlife of The United States" (1973 Edition) as occurring in Alaska. These are the Aleutian Canada goose (Branta canadensis leucopareia), the American peregrine falcon (Falco peregrinus anatum), and the Arctic peregrine falcon (Falco peregrinus tundrius). Considering the breeding and migrating ranges of these species, only the peregrine falcon occurs in the area of the proposed Alaskan Project. However, since winter construction is planned in the northern areas of Alaska (where the peregrine falcon breeds in summer), the likelihood of encountering these birds is extremely remote.

Two other bird species, the Eskimo curlew (Numenius borealis) and the short-tailed albatross (Diomedea albatrus), are considered rare and endangered species. According to their historical breeding and wintering patterns, however, it is unlikely that these species would be encountered during Project construction.

Several resident species of "status-undetermined terrestrial and marine mammals" in Alaska include the polar bear (Thalarctos maritimus), the pine marten (Martes Americana), the Canada lynx (Lynx canadensis), the elephant seal (Mirounga angustirostris), and the wolverine (Gulo luscus). In addition, the glacier bear (Ursus americanus emmonsii), a threatened mammal species, is known to occur in southern Alaska along the upper Copper River and southeast to Tracy Arm and Chickamin River. The potential of encountering these mammals during Project construction is considered remote.

With respect to the LNG Carrier Fleet trade route, the short-tailed albatross, the Canada goose and the Aleutian Canada goose (all endangered species) are known to occur in the North Pacific. However, the possibility of interfering with such species by an LNG Carrier is considered extremely remote.

In summary, it is Applicant's belief that no loss of any of the above species would result from implementation of its proposed Project.

7.3 SOCIOECONOMIC CONSIDERATIONS

Construction of the proposed Alaskan Project will have certain irreversible, but not necessarily adverse, effects upon the social structure and economics of Alaska, though they would be incremental to those resulting from the construction of the Alyeska oil pipeline. On the other hand, construction of the Alaskan Project on the heels of the Alyeska Project will provide continuity to the state's economic and social growth.

Irreversible and irretrievable labor resources will be committed to construction and operation of the Project. Approximately 21,700,000 man-hours of labor will be required to construct the gas pipeline and its associated facilities. An additional 33,000,000 man-hours will be required to build the LNG Plant and marine terminal, and 66,000,000 man-hours will be expended in constructing the 11 LNG carriers. The significant financial resources required in implementing the Project will be irreversibly committed, and will therefore be unavailable for other purposes. Manpower necessary for operation and maintenance of the pipeline over the 25-year Project life will total 268 men. The LNG Plant and marine terminal will require 309 permanent workers, and the fleet will be manned by 672 operating and support personnel.

Alaskans will be affected through Project-generated tax revenues to the State and to the native Corporations. Certain cultural changes will result from the development of Alaskan resources, as discussed in Sections 3 and 5 of this Report.

7.4 RESOURCES LOST OR USES PREEMPTED

Irretrievable commitments of finite resources associated with the Project are described below.

7.4.1 Fossil Fuel

Equipment used in constructing the pipeline, LNG Plant and marine terminal will consume approximately 197,700 tons of fuels and lubricants.

The annual average day operational fuel requirements (natural gas, diesel fuel and Bunker "C") for the Project are estimated to be 500.49 billion Btu. Fuel use by Project component is as follows:

Project Component	Billion Btu/d
Gas Pipeline	105.36
LNG Plant	290.24
LNG Carriers and Service Vessels	104.89
TOTAL	500.49

7.4.2 Materials

The materials and equipment required in construction of the proposed facilities (excluding fuel, sand and gravel) total 1,679,200 tons. Preliminary estimates indicate that gravel and fill material requirements for the Project will total 6,667,700 cubic yards.

During the operation of the gas pipeline, marine terminal and LNG carriers, the commitment of material resources will primarily involve consumption of minor amounts of repair parts, food and other consumables. Operational material consumption for the LNG Plant will be more extensive, as shown in Table 7.4-1.

TABLE 7.4-1

LNG PLANT MATERIAL CONSUMPTION
(Approximate Quantities)

Material	Initial Charge	Consumption Rate (Per Year)
Molecular Sieve	500 tons	170 tons
Alumina	2,800 cu ft	--
DGA (100%)	67,000 gal	261,000 gal
Corrosion Inhibitor	400 gal	1,300 gal
Misc. chemicals	--	2,600 tons
Propane	600,000 gal	--
Diesel Fuel	--	460,000 gal
Nitrogen	1,600 tons	--

SECTION 8 - ALTERNATIVES

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8 ALTERNATIVES

8.0 INTRODUCTION

The purpose of this Section is to supply substantive information on alternatives to the proposed Alaskan Project in order to assist the Commission in carrying out its responsibilities under the National Environmental Policy Act ("NEPA"). It should be noted that Applicant intends to adhere to the rule of reasonableness espoused in *Natural Resources Defense Council v. Morton*, 458 F.2d 827 (D.C. Cir. 1972), and expressly adopted by the Commission, Implementation of the National Environmental Policy Act of 1969, 18 C.F.R. §2.80-2.82(1973), and by the Council on Environmental Quality, Guidelines for Federal Agencies under the National Environmental Policy Act, §1500.8(a)(4), 38 Fed. Reg. 20549, 20553 (August, 1973). Therefore, Applicant will offer environmental analyses only for those alternatives which are realistic and reasonably available, or that are capable of implementation within the time frame of this Project. Applicant will include a preliminary analysis for all alternatives considered which shows how the rule of reasonableness was applied.

In order to avoid duplication and repetition, Applicant, wherever possible, refers to and incorporates by reference, existing material containing discussions pertinent to the subject of this section. Such procedure is approved in Commission Order No. 485 and expressly authorized in the Council on Environmental Quality Guidelines for Federal Agencies under NEPA.

8.1 ALTERNATIVE ENERGY SOURCES

8.1.0 Energy Outlook - Action vs. No Action

Section 1.1.2 of this Report demonstrates that, even including predicted supplements to gas supply, the demand for gas by firm natural gas users, including high priority residential, commercial and small industrial users will exceed the supply within the period predicted for delivery of natural gas from the North Slope of Alaska. For this reason, the alternative of no action is deemed unrealistic by Applicant.

8.1.1 Alternative Natural and Synthetic Gas Supply Systems

The discussion in Section 1.1.2 demonstrates the need for making Prudhoe Bay natural gas available for consumption in the lower United States. Because conservation, demand reduction and other energy consumption reduction methods will not be sufficient to assure an adequate supply of natural gas in the future, and because firm natural gas users, including high priority residential, commercial and small industrial users, cannot be expected to utilize other forms of energy, it is Applicant's position that only those energy systems available presently or in the near future to supplement the supply of natural or synthetic gas are realistic or reasonable alternatives to the proposed Project. Such systems include:

(1) Coal gasification,

(2) NGL and petroleum derivatives gasification,

(3) Biological energy (municipal and animal waste gasification),

(4) Increased supply of natural gas from existing sources (infill drilling, pressure decline programs, recompletion and workovers),

(5) Stimulation of tight reservoirs (nuclear, massive hydraulic fracturing), and

(6) Expanded exploration and acquisition, including modification of FPC pricing policies (domestic-on-shore and off-shore, foreign - Middle East, South America, Africa, etc.) and LNG importation of foreign natural gas reserves.

For a discussion of the relative environmental impacts of each of the above listed energy systems, see, U. S. Department of the Interior, "Energy Alternatives and Their Related Environmental Impacts," September, 1974. In addition, it is Applicant's understanding that the Council on Environmental Quality, with assistance from the Commission, is presently drafting a document to be titled "NEPA - Energy Alternatives Reference Document" which will expand upon the analysis of the Department of the Interior treatise. Applicant understands that the Council on Environmental Quality's proposed publication will include a computer program for assessing the environmental impacts of any energy project in terms of relative environmental impacts of alternative systems providing the same quantum of energy. Because this document and program are scheduled to be available within the probable Commission review period for this Project, Applicant respectfully submits that the Commission will desire to utilize them to whatever extent possible for additional environmental analysis.

For more specific discussions on environmental impacts of some of the above, Applicant suggests the use of the following documents:

Coal Gasification - El Paso Coal Gasification Project, New Mexico, Draft Environmental Statement, Bureau of Reclamation, July 16, 1974.

LNG Importation - El Paso Eastern, et al., Docket No. CP73-258.

Eascogas LNG, Inc., et al., Docket No. CP73-74,

Hydrocarbon Reformation - Algonquin SNG, Inc., Docket No. CP73-35.

Cities Service SG Co., CP73-304.

Coastal States Energy Co., CP73-67.

Nuclear Stimulation of Tight Reservoirs - Environmental Statement, Wagon Wheel Stimulation Project - Sublette County, Wyoming - April, 1972, WASH - 1524 Atomic Energy Commission Document.

Environmental Statement - Rio Blanco Gas Stimulation Project Rio Blanco County, Colorado - April, 1972, WASH - 1519 Atomic Energy Commission Document.

Environmental Statement - Rio Blanco Gas Stimulation Project - Rio Blanco County, Colorado - March, 1973 WASH - 1519 (Addendum) Atomic Energy Commission Document.

Offshore Gas Production - OCS Oil and Gas - An Environmental Assessment, A Report to the President by the Council on Environmental Quality, April, 1974.

8.1.2 Non-gaseous Energy Alternatives

It is possible, within the time frame of the proposed Project, to obtain more energy by utilizing to a greater degree the following energy systems; however, because such systems do not provide additional supplies of natural or synthetic gas, Applicant does not consider them to be realistic alternatives to the proposed Project:

(1) Increased production of coal for use as fuel,

(2) Increased production of oil for use as fuel,

(3) Increased importation of oil for use as fuel,

(4) Production of oil from oil shale, for use as fuel,

(5) Increased production of electricity from nuclear energy - conventional and breeder reactors, and

(6) Production of electricity from geothermal resources.

The relative environmental impacts of these energy sources are described in Department of the Interior's Energy Alternatives, referred to above, and Council on Environmental Quality, NEPA - Energy Alternatives, referred to above.

8.1.3 Future Energy Alternatives

Other potential energy sources, as listed below, exist for development in the future; however, Applicant believes that their development is not possible within the time frame of the proposed Project and, therefore, they are not discussed herein:

(1) Solar energy,

(2) Fuel cells,

(3) Tidal energy,

(4) Wind power,

(5) Liquid hydrogen,

(6) Magnetohydrodynamics

(7) Thermionic generation, and

(8) Thermoelectric.

For a general discussion concerning the availability of such sources, see Department of the Interior's Energy Alternatives, referred to above, and Council on Environmental Quality, NEPA - Energy Alternatives, referred to above.

8.2 ALTERNATE SYSTEMS OF NATURAL GAS TRANSPORTATION

8.2.1 Introduction and Criteria for Selection

Nine alternate methods of transporting natural gas energy from the North Slope of Alaska to the Lower 48 United States will be examined. The ice-breaking LNG tanker and long-distance LNG pipeline are elaborations on systems which Applicant has incorporated in its proposal. The LNG railway, LNG monorail, LNG submarine, LNG airplane, and LNG heliofloat are closed, mobile transport forms. A dense-phase gas pipeline represents a continuous flow approach similar to the LNG pipeline. All seven of these systems are in the initial stages of development. The two remaining systems--methanol conversion and high voltage electrical transmission--are developed to a degree allowing immediate implementation.

The systems mentioned will be examined in terms of the following criteria to determine their suitability: (1) The underlying technology and applicable engineering skills must be sufficiently developed by the anticipated date of final agency action to enable the system to be applied within the time frame of Applicant's proposal; when such is not the case, the alternative is eliminated as "not available." (2) The alternative must be economically feasible from the standpoint of both the supplier and the consumer; an alternative that clearly fails to meet this criterion is eliminated as being "not reasonable."

The trans-Canada natural gas pipeline, involved in the Arctic Gas proposal, and any other trans-Canadian alternatives are not considered, as the burden of assessing the environmental impacts of all such proposals, in Canada or in this country, should, in this proceeding, fall upon the sponsoring companies and the appropriate reviewing agencies.

8.2.2 Transport Systems Available but Unreasonable

The following discussion of the overall energy losses associated with both methanol conversion and electrical generation make these systems, within the concept of the proposed Project, economically infeasible.

8.2.2.1 The Methanol System

Alaskan natural gas could be transported to a facility in Alaska for conversion to methanol. The methanol could be transported from Alaska to the continental United States where it could be either: (1) converted to synthetic gas for transmission in a gas pipeline, or

(2) utilized directly as an energy source. A number of methods of transport are available for the initial and intermediary transport steps. However, gas pipelines and ocean tanker transport are the only two with well-established technology. The employment of a methanol system (as opposed to an LNG system) has two serious disadvantages: (1) increased energy consumption, and (2) greatly increased capital and operating costs.

The overall thermal efficiency for Alaskan LNG production, transportation and regasification is about 88%. The overall thermal efficiency for methanol production, transportation and reconversion is about 55%. That is, only 55% of the field gas energy content would be delivered to the consumer for methanol, whereas 88% would be delivered for LNG. The lower thermal efficiency of methanol conversion is due primarily to the following reasons: (1) fuel requirements associated with feed gas compression, (2) fuel requirements for heat input to the feed gas reforming step, and (3) the 20% lower heating value of methanol compared to natural gas.

In the methanol conversion process, natural gas is reformed to produce a mixture of carbon monoxide, carbon dioxide and hydrogen, which is then catalytically converted to methanol. The reforming step requires a large heat load which adds significantly to the utility cost for fuel. The fuel consumption for reforming and steam generation (for compressor turbine drivers) amounts to about 25% of the plant feed gas. The thermal efficiency of the methanol conversion process is about 60%, resulting in significantly reduced quantities of energy delivered to the consumer at greatly increased cost.

For the situation where natural gas would be liquefied in a coastal facility, transported via tanker and regasified in a coastal facility for injection to a gas pipeline, the overall energy consumption would be 10-20% for LNG and 40-50% for methanol. The cost of shipping methanol is much less than for LNG, since slightly modified crude oil tankers may be used. LNG must be shipped in more expensive cryogenic tankers at -256°F. For the 1902 nautical mile Alaska-California route, however, the distance is not great enough to justify a methanol conversion facility. An examination of break-even shipment distances for methanol conversion versus LNG based on different natural gas prices is given below:

BREAK-EVEN DISTANCES FOR METHANOL PRODUCTION VS. LNG PRODUCTION

Feed Gas Price (¢/MMBtu)	Methanol to SNG (Nautical Miles)	Direct Utilization of Methanol (Nautical Miles)
29.74	10,783	8,639
18.41	9,730	7,551
10.00	8,883	6,699
0.00	7,351	5,621

Table 8.2-1 demonstrates that synthetic gas from methanol shipped 1,875 nautical miles, a distance comparable to the Alaska-California route, would cost 60% more than regasified LNG at the inlet to the continental pipeline system based on a gas inlet price of about 29¢/MMBtu.

Although the technology exists to produce methanol from natural gas, the methanol alternative is "unrealistic and unreasonable" in comparison to the proposed Project, due to the substantial loss of natural gas energy in the methanol system and the increased price of product fuel. The same applies to any combination of plant location, pipeline system and tanker employment to transport natural gas as methanol from Prudhoe Bay. The losses due to thermal inefficiency and conversion are unaffected by such system combinations.

8.2.2.2 Electrical Generation and Transmission

Electrical generating plants could be built at Prudhoe Bay to convert Alaskan natural gas to high voltage alternating current (HVAC) electricity. The HVAC would further be converted to high voltage direct current (HVDC) electricity for transmission to the contiguous United States via HVDC transmission lines. HVDC transmission is preferred over HVAC because of the lower line losses. Once at a location where it is to be utilized, the HVDC would be converted to alternating current for consumption. The present state of technical confidence in all aspects of this system is high.

The drawback of the outlined system is the efficiency of conversion as the following indicates:

STEP-WISE EFFICIENCIES

Alaskan Generating Plant	36.8%
Alaskan AC/DC Converter	96.25%
Transmission Lines (Alaska-United States)	88.3%
Market DC/AC Converter	96.25%
Overall Efficiency of System	30.1%

Of the energy present in the Alaskan natural gas moving into the generating facility, 69.9% is lost by the time such energy is utilized by consumers in the continental United States. Such inefficiency makes the electrical generating scheme infeasible and unrealistic.

8.2.3 Transport Systems not Available within the Time of Anticipated Agency Action

Both the technology and the engineering skills presently existent or under development are insufficient to allow the application of any of the systems described below to the movement of Prudhoe Bay gas

TABLE 8.2-1

COMPARISON OF ECONOMICS OF LNG AND SG FROM METHANOL AT VARYING PLANT INLET GAS PRICES

Method	LNG	SG from Methanol
Ship Size	125,000 M^3	250,000 dwt
Distance	1,875 naut. mi.	1,875 naut. mi.
CASE A		
Gas Costs Based on 29.24¢/MMBtu		
Raw Material Costs	34.14¢	61.00¢
Total Operating Costs	42.75¢	102.67¢
Shipping Costs	43.68¢	32.09¢
Total Delivered Cost	120.57¢	195.76¢
Methanol	62.36% More Expensive	
Case B		
Gas Costs Based on 18.41¢/MMBtu		
Raw Material Costs	21.50¢	38.41¢
Total Operating Costs	42.75¢	102.67¢
Shipping Costs	43.68¢	32.09¢
Total Delivered Cost	107.93¢	173.17¢
Methanol	60.45% More Expensive	
Case C		
Gas Costs Based on 5¢/MMBtu		
Raw Material Costs	5.84¢	10.43¢
Total Operating Costs	42.75¢	102.67¢
Shipping Costs	43.68¢	32.09¢
Total Delivered Cost	92.27¢	145.19¢
Methanol	57.35% More Expensive	

Notes:

Raw Material Cost is that cost of feed gas required to produce 1.0 MMBtu of gas for insertion into a continental pipeline.

Total Operating Cost is the combination of capital associated and operating costs for conversion and regasification plants.

Shipping cost is the cost of tanker transport.

within the time frame of the proposed Project. Where the technology is developed, years devoted to the study of prototype systems would have to be expended to develop the engineering skills necessary. Where technology is less advanced, additional years will be required to reach the prototype stage.

Further, the costs of developing the requisite knowledge and skill, the increased costs of production at a future date, and the greater expense of producing systems of greater complexity than the proposed system cumulate to cause the final system in each case to be substantially more expensive than Applicant's proposed system. It is, therefore, not economically feasible to implement any of these alternatives.

It is noted that liquefied natural gas (LNG) is the physical material being transported in all systems save the dense-phase pipeline system. Natural gas occupies too large a volume per unit of energy contained (approximately 1000 cf/MMBtu) relative to LNG (approximately 1.7 cf/MMBtu) to be transported economically over the distances involved other than by natural gas pipeline. Where applicable, it will be assumed that a liquefaction facility must be built at the point of initial ship transport for the system under consideration, and that a regasification unit must be constructed at the point of delivery. Discussions of alternative designs for such facilities are presented in Section 8.5 of this Report.

8.2.3.1 Alternate LNG Tanker - LNG Pipeline Systems

This Section is devoted to expanding the possibilities of the LNG pipeline used in LNG tanker loading/unloading operations, and the conventional LNG tanker--the ordinary means of LNG marine transport. The basic systems are utilized in Applicant's proposal and have previously been considered in this Report.

8.2.3.1.1 Transport by Ice-Breaking LNG Tanker

The formation of sheet ice, or the passage of ice floes greater than 12 inches in thickness, present a navigational hazard to the type of LNG tanker presently being designed and built. Only ports in southern Alaska are ice-free to the extent required for year-round operation of conventional LNG tankers. To transport LNG from ports located elsewhere in Alaska on a continuous basis would require LNG tankers with ice-breaking capability.

An ice-breaking LNG tanker has yet to be designed. The problems involved are those of both ship construction and specialized systems construction. Not only must a hull configuration and power plant be developed to meet the demands of continuous arctic operation, but a specialized cryogenic tank system must be designed to sustain the violence of operations in ice-congested waters. The techniques for accomplishing both requirements must be developed before any construction can begin.

In addition to problems of design and development, there may be some doubt that the ship-building industry would be able to complete the number of ice-breaking LNG tankers required within a reasonable time frame once the developmental problems have been solved. If new shipyards were required to meet this special tanker demand, their construction would add to the final cost of the product.

Besides the prevailing problems with the ships themselves, terminal loading structures and offshore LNG pipelines are presently not fully understood. Either a program of research and development [to obtain such information] must be undertaken prior to fleet operation, or facilities constructed in the traditional manner must be modified while in operation to accommodate arctic conditions. The choices are either initial delay and expense, or later and intermittent delay and expense upsetting the orderly movement of gas. Gearing a fleet up to operational status might be further delayed by the lack of qualified tanker deck officers experienced in ice-infested waters. Poor continuity of service is to be expected, at least initially, owing to the great variance in ice thickness and type making difficult any fixed system of arrivals and departures. Field trial and ice-breaker assistance may eventually allow for more regular activities.

These problems set the date an operating fleet could be available at least 10 years in the future. This is well beyond Applicant's proposed gas delivery schedule, and even further advanced from the point of proposed agency action. The capital and operating costs of an ice-breaking LNG tanker system make it significantly more expensive per unit of energy than Applicant's proposed natural gas pipeline/LNG tanker system.

8.2.3.1.2 Extended LNG Pipeline Systems

The longest cryogenic pipeline used to transport LNG which has been proven operational is the 2.5-mile long cryogenic pipeline at the Brunei installation on the Island of Borneo. Such pipeline maintains the LNG at a temperature of -161°C to minimize LNG vaporization rates. The complexity of such a system results in elevated construction expenditures and significant maintenance costs. Were it possible substantially to extend this system, such extension would likely be so costly as to be prohibitive.

The feasibility of an extensive cryogenic pipeline system, however, has not yet been demonstrated. It is very unlikely that the cooling and insulation techniques currently being employed could be used to construct a cryogenic pipeline hundreds of miles in length. It would be necessary to develop and test model systems to check experimentally the adaptability of present configurations. If the present system is not suitable for adaptation, new cryogenic insulations and cooling systems, possibly demanding years to refine and implement, would have to be developed. Because the extended cryogenic pipeline system is the first of its kind, many new techniques of pipeline construction would be required to effectuate installation. The resulting pipeline would be much more expensive than the Applicant's proposed natural gas pipeline, which requires only minimal insulation to protect against corrosion and relatively little cooling to render it compatible with a permafrost environment.

For these reasons, it appears that an operational LNG pipeline system could not be applied to Alaskan natural gas within the time frame of the proposed Project.

8.2.3.1.3 Conclusion: LNG Pipeline - LNG Tanker Systems

The above discussion shows that both ice-breaking LNG tankers and long-distance LNG pipelines are not feasible within the time frame of the proposed Project.

8.2.3.2 Closed Transport System Alternatives

The alternatives contained in this Section all provide for transfer of LNG either directly to the continental United States or to a point of exchange in Alaska by means of closed mobile transportation units moving on land, under the water or in the air.

8.2.3.2.1 Railway Transport of LNG

No railroads presently serve the Prudhoe Bay region. A railroad from the North Slope to Fairbanks and upgrading of the existing railroad to a southern coastal terminal would take substantially longer to build than the proposed Alaskan Gas Pipeline. The actual construction of the railroad is not the sole restraining parameter; the hardware to move large volumes of LNG via railway would have to be obtained.

In order to facilitate a scheme employing railway transport, it would be necessary to build and test: (a) special purpose, large-volume LNG tank cars and related refrigeration techniques; (b) new types of loading and unloading facilities; (c) improved systems of train operation; and (d) special safeguard systems. The associated developmental programs would further delay the earliest date the system could be operative, in addition to increasing the overall cost of the system.

The technology does not presently exist, and it will not be available in the near enough future to justify a full comparative analysis of an LNG railway transport system. Even if it were, this alternative would not be economically feasible.

8.2.3.2.2 Monorail Transport of LNG

A monorail system is composed of an elevated track guideway, upon or over which railway-like vehicles move. Some small-scale examples of a system composed of wheeled vehicles on steel rails are presently in operation. This system requires a much larger capital outlay than that required for a conventional railway and, for this reason, is dismissed as economically infeasible.

A system utilizing principles of magnetic levitation to allow movement over elevated guideways is currently under development. Twenty-five miles of experimental track have been laid. Research is focused, however, at the development of a system lending itself to urban mass-transit usage. For this reason the lift levels being examined are 3 to 4 times below those which would be required for non-LNG cryogenic tank cars currently used in conventional railway operations.

There exist no detailed designs for a magnetic levitation monorail system. The physical requirements of cars, locomotives, and other basic equipment have not been developed. No projection as to practicable safe speeds can be made. The safety aspects of loading and unloading LNG cargo from such a transport system have never been examined. The research and development of these and related areas would take at least five years. An operable system must wait at least 10 years, based on the most optimistic forecast. Applicant's proposed system allows for initial gas delivery 42 months after field construction commences. The cost of monorail systems cannot be adequately determined at this time, but they would likely exceed those of an LNG railway system.

8.2.3.2.3 Submarine Transport of LNG

Large-scale, nuclear-powered, cargo submarines capable of sub-ice navigation could be constructed to move LNG directly from the North Slope to the Lower 48 States, or from some ice-bound port in western Alaska should the water depth in the Bering Strait foreclose submarine passage. The technology necessary to build such submarines is not necessarily available and has certainly not been developed or tested. It would take several years to construct, test, and evaluate a prototype; fail-safe rescue systems for ice-trapped submarines would have to be developed. Furthermore, because the specific gravity of LNG is one-half that of water, the submarine would have to be designed to accommodate large amounts of high-density ballast, thus wasting valuable cargo space.

There exist no underwater terminals capable of servicing LNG submarines. Owing to the water depths required for submarine berthing, substantially more than 2.5 miles of cryogenic pipeline (see subsection 8.2.3.1.2) would be required. Such a pipeline would be exposed to damage from drifting or grounded ice. Special procedures for routine underwater maintenance of terminal facilities would have to be devised, along with a system of sea-bed navigational aids to guide the submarine.

Considering the substantial progress which must be made in order to produce an operative system, it is conservative to estimate a lag of eight years before submarine LNG cargo traffic could commence. The required specialized and complex systems indicate a system much more costly than Applicant's proposed transport system.

8.2.3.2.4 Air Transport of LNG

Boeing has proposed a twelve-engine airplane capable of carrying 2,000,000 lbs. of LNG. This airplane, termed the RC-1, would be four times the size of the Boeing 747 and three times larger than the Lockheed C-5A. Such a mammoth airship is considered to be within the limits of existing technology. However, extensive efforts would be required in engineering design to permit actual manufacture.

A feasibility study of the plane itself, related aircraft, and airfield systems would first have to be completed and reviewed. Boeing has estimated that the study would take two years and would be followed by a four to five year wait on production of the first airplane. Even these minimal projection dates place initial deliveries far beyond the dates Applicant has projected.

8.2.3.2.5 Heliofloat Transport of LNG

A heliofloat is a form of aircraft combining characteristics of a heliocopter, a buoyancy craft and an airplane. One has never been built or flown. There exist no current designs. The craft is most definitely only at the research and development stage and any advancement beyond that stage is uncertain. It is estimated that it would take from nine to ten years to develop a heliofloat capable of moving the quantities of LNG necessary to make the system economically feasible.

8.2.3.2.6 Conclusion: Closed Transport Systems

Of all the closed systems of LNG transport considered in this Section, only the railway alternative could possibly lend itself to initial construction contemporaneous with Applicant's proposed natural gas pipeline. This construction would be limited to the laying of track, since the availability of the associated hardware for the rail system is dependent on time-consuming developments. Construction of the basics of all the remaining systems must wait years on technological and engineering advancements. Where the technology has been refined, as in the cases of railroads, submarines and airplanes, the expansive innovations required for an LNG transport system would add years. Where technical development is minimal, as in the cases of magnetic-levitation monorails and heliofloats, years would be expended in reaching the design-testing stage.

Every system must be considered beyond the scope of present knowledge, either established or applied. The economics of every system, except the railway, are purely speculative; and the railway alternative is not economically comparative to Applicant's natural gas pipeline proposal. No such system can make Alaskan natural gas available to the continental United States within the time frame of the proposed Alaskan Project. No other system will be available in its entirety within the time of expected agency action, or within years thereafter. This lack of availability eliminates the need for further consideration of closed transport alternatives.

8.2.3.3 The Dense-Phase Pipeline System Alternate

Natural gas cooled to a temperature of between 115°F and 150°F, and maintained at pressures between 400 psig and 1000 psig is approximately twice as dense as the gas contained in conventional pipelines. This is what is referred to as the dense-phase state. Because of the decreased volume of gas in such state, a smaller diameter pipeline, possibly with thinner walls, can be employed. The low temperature of dense-phase natural gas allows its transport through permafrost without additional cooling.

A dense-phase system in Alaska would employ a refrigeration (dense-phase) plant located in the North Slope area, a trans-Alaska, dense-phase gas pipeline, and a liquefaction plant in southern Alaska. If the dense-phase gas were to be piped directly to the Lower 48 States, a regasification plant would be the terminal facility. A commercial dense-phase refrigeration or regasification plant has never been constructed, but such plants would simply be scaled versions of existing LNG facilities.

The development of a dense-phase gas pipeline, on the other hand, poses problems, however, since one has yet to be constructed. There are numerous problems associated with the chemistry of the pipe, the sub-earth contacts of that pipe, and the operational feasibility of the over-all pipeline. Substantial delays can be expected in order that acumen in each of these areas be attained to allow the development of an operational system.

In order to supply the low temperature pipe required, special manufacturing facilities need to be developed. The know-how does not exist to insure the safe transport, storage, and installation of the thin-walled pipe once manufactured. Field welding of the pipe would require new refinements of old techniques. The stress effects of thermal contraction on the pipe require extensive investigation prior to commercial application.

The durability of both the polyurethane insulation and vapor barrier surrounding the pipe also requires study and testing. The development of entirely new techniques might be required in any or all of these areas.

Maintenance of continuous service is dependent on significant technical and engineering advances. The initial insertion of dense-phase gas into a pipeline is seen as inevitably resulting in the formation of a two-phase zone. A start-up system must be designed to counter the ill effects of this two-phase formation. Any system shut-down and any localized 30°F increase in temperature will result in two-phase situations with pockets of low-density gas forming in the line. Such contingencies require that the system be designed to prevent over-pressuring.

The above discussion demonstrates that the construction of a commercial dense-phase gas pipeline is years away. Neither the technology nor the engineering skills required are developed sufficiently to allow implementation within the contemplated time of final agency action on the Alaskan Project. This alternative is therefore not considered "available."

Section 8.3
Site and Route Selection

8.3 SITE AND ROUTE SELECTION

8.3.0 Introduction

The purpose of this section is to present the results of a site and route selection evaluation that was undertaken to identify the best location for the Alaskan Gas Pipeline, LNG Plant, and marine terminal.

The initial element of the study involved a determination of the criteria that would govern the selection of a site and the pipeline route that would serve it. These criteria are summarized in subsection 8.3.1 below. The coast of Alaska was then evaluated on a regional basis in terms of the established criteria. This evaluation, summarized in subsection 8.3.2, demonstrated that the segment of the Prince William Sound shore between Valdez and Cordova offered the best prospect for an LNG Plant and marine terminal site, and that a natural gas pipeline route generally following the alignment of the Alyeska crude oil line was feasible and desirable. The regional evaluation was followed by detailed investigation (see subsection 8.3.3) of four candidate sites between Valdez and Cordova, and by evaluation of the gas pipeline route alternatives.

8.3.1 Site and Route Selection Criteria

Selection of an economically feasible and environmentally acceptable site and route system for a complex project such as is proposed by the Applicant requires the optimization of a complex fabric of considerations, few of which can be totally quantified. Applicant has conducted an examination of all reasonable sites and routes--this evaluation has been based on criteria that reflect the design, construction, and operating requirements of the pipeline, LNG Plant, marine terminal, and LNG Carrier Fleet. These criteria are discussed below.

8.3.1.1 Pipeline Route Criteria

Pipeline routes were evaluated and selected with the objective of optimizing the following factors:

(1) Minimum total distance.

(2) Minimum route distance in areas requiring substantial grading for right-of-way preparation.

(3) Minimum number of crossings of streams, highways, and other pipelines.

(4) Maximum route distance in soil having favorable pipe support conditions and excavation characteristics.

(5) Minimum route distance on flood plains, poorly drained areas, and other terrain subject to flooding or erosion.

(6) Avoidance of areas in which construction and operation of a gas pipeline could present conflicts with other land uses.

(7) Avoidance of areas potentially presenting special hazards such as avalanches or slope failure.

(8) Maximum availability of granular borrow.

(9) Maximum use of existing transportation facilities for construction materials delivery and maintenance access.

Although the above criteria are framed in terms of engineering feasibility and cost, they also reflect the Applicant's objective of selecting an environmentally sound alignment. For example:

(1) The minimization of grading along the route reduces the consumption of granular borrow, the loss or modification of wildlife habitat, and the visual impact of the pipeline.

(2) Minimization of stream crossings and distance on floodplains avoids potential impact upon water quality and fisheries resources.

8.3.1.2 LNG Plant Site Criteria

The design, cost, operation and safety of the liquefaction plant are all strongly influenced by site conditions. The criteria included in this section describe the plant site characteristics which would optimize the above factors.

Size of Area Available

The total amount of land required is approximately 1200 acres. A minimum of 500 acres should be available for the LNG Plant and shoreside facilities. An additional 700 acres is preferred for a buffer zone around the plant facilities.

Topography

The potential plant site should satisfy certain topographic requirements which are imposed by safety considerations and the desire to minimize site preparation work.

The most important topographic requirement is that the plant site be above the area potentially affected by tsunami. For purposes of this study, a maximum tsunami run-up to 100 feet (MSL) has been used as a generalized site evaluation criterion.

Ideally, the preferred maximum elevation of the plant site should not substantially exceed 100 feet. If there is a large differential in the overall elevation of the plant site, the cost of the liquefaction plant will be increased due to a need for additional booster pumps and related equipment used to circulate seawater for cooling purposes.

The land should have a slight to moderate slope and minimal topographic irregularities. A slight slope is desirable to insure adequate drainage. Large topographic irregularities could require extensive preconstruction site preparation work.

Distance from Plant to Shore

The distance from plant site to shore should be as short as possible to minimize the length of the cryogenic pipelines used to carry LNG. A length of 2.5 miles is considered the maximum acceptable.

Even though such a pipeline is insulated, it should still be as short as possible to minimize LNG vaporization. In addition, a short pipeline will reduce construction and maintenance costs.

Soil Characteristics

For the plant site, it is desirable to have soils which are dense and granular for strength and drainage, and well graded for resistance to settlement. Firm to stiff clays are also suitable, provided they have a high remolded strength.

Shallow bedrock is desirable because there will be no high tension pile loads. However, the bedrock should be at a sufficient depth to avoid interference with site preparation work. If the bedrock is deep enough so that some large loads are supported only on spread footings or friction piles, then the soils should be such that they will not undergo liquefaction during earthquakes.

Proximity of Fault Zones

The plant site should not be located on or adjacent to an area in which active fault zones exist.

Proximity of Nearest Community

The minimum desired distance from the plant site to the nearest community is 10 miles, in order to provide an adequate buffer zone around the plant and marine terminal. It is believed that this distance will provide sufficient isolation of the facilities from population centers. The buffer zone could be safely reduced if certain favorable physical site characteristics are present.

8.3.1.3 Marine Terminal Criteria

The location of the marine terminal site should satisfy requirements dictated by the design, construction and operation of a marine terminal, as well as by the operational characteristics of LNG carriers.

Water Depth at Berth

The minimum acceptable water depth at the berth at lowest water, with relatively calm sea conditions, should be equivalent to the draft of the largest LNG carrier plus an additional five feet. A 200,000 m^3 LNG carrier, with a draft of 42 feet, is the largest ship which would utilize the marine terminal.

If the site is exposed to waves that could cause substantial vertical movement of a ship, then the minimum acceptable water depth may have to be greater to accommodate the apparent increase in the ship's draft due to pitching or rolling. In order to provide a safe margin, a 50-60 foot minimum water depth was chosen.

Distance from Marine Terminal to Shore

The distance from the terminal to shore should be as short as possible. A short access trestle will minimize LNG vaporization in the cryogenic pipeline and reduce the cost of construction and operation.

Soil Characteristics

The marine terminal structures will be supported on steel piles. Some of these piles will have very high compression loads, and depending on the final design, some could have high uplift and lateral loads. To sustain these loads, the preferred subsoil should be cohesive or granular material with high shear strength. Normally, this soil would have strength properties that would permit pile installation by conventional construction methods. If clays are present, they should have a high remolded strength so that they will not weaken after a pile has been driven.

Some very fine-grained soils tend to liquefy when disturbed by a shearing force such as a dredge cutter head or an earthquake. Soils prone to liquefaction should be avoided whenever possible.

Ideally, bedrock should be at least 100 feet below the sea bottom so that the tensile and lateral pile loads can be transferred to soil. If bedrock is shallower, the piles are installed in the bedrock utilizing conventional construction methods.

Proximity of Fault Zones

The marine terminal site should not be located on or adjacent to an area in which active fault zones exist.

Marine Terminal Exposure

The site should offer as much protection as possible from winds, waves and currents.

Winds are a major factor because the exposed portion of a ship's hull and superstructure constitutes a large surface, or "sail area", upon which the wind can exert a substantial force. Winds acting upon this surface may hinder an LNG carrier when maneuvering in the vicinity of the berth, thereby preventing safe docking. High winds can also require a ship to vacate a berth because of the excessive loads upon the mooring lines or on the fendering system.

Winds exceeding 30 miles per hour should have a low frequency and minimal persistence. The mooring system at each berth will be designed to hold an LNG carrier in winds up to 60 miles per hour.

Wave action can also cause a ship to move at the berth and raises the possibility of hull and berth damage and interference with cargo loading operations.

The effect of waves depends not only on the height and period but also on the direction in which the waves are traveling relative to the longitudinal axis of the ship. When waves are approaching a ship's axis at a large angle, significant wave heights in excess of four feet could result in excessive ship movement at the berth.

The configuration of the offshore site should allow orientation of the terminal along an axis parallel to the direction of prevailing wave movement to minimize potential downtime due to wave action. The frequency of occurrence and persistence of significant wave heights equal to or greater than four feet should be minimal.

Currents are another factor which can adversely affect the maneuverability of ships and small craft. Experience has shown that currents with speeds of up to two knots should not cause difficulties in the operation of the terminal.

Maneuvering Area Required

If the marine terminal is to be located on, or adjacent to a channel, it is desirable that the channel have a minimum width of three times the beam of the ship (if traffic is limited to one ship at a time), or six times the beam of the ship (if two-way traffic is expected). These widths insure that an LNG carrier will have sufficient clearance on either side. If the marine terminal site is located in a relatively confined area, a turning basin will be required. The minimum acceptable diameter of a turning basin is one and one-half to two times the length of the ship.

The minimum acceptable water depth for a channel or turning basin is the same as that at the berth. A channel, or turning basin should be free of obstructions or submerged hazards. Locations which require dredging would be subordinate in preference.

8.3.1.4 Navigable Waterway Approach Criteria

Size and Depth of Channel

It is desirable that the minimum width of any approach channel should be three times the beam of the ship when traffic is limited to one ship at a time, and six to eight times the beam of the ship when two-way traffic is expected.

The minimum acceptable depth of a channel is influenced by the exposure of the channel to wave activity and the speed of the LNG carriers when maneuvering in the channel. In order to assure a safe margin, a 50-60 foot depth contour is desired. The areas in which the LNG carriers will maneuver should not require dredging.

Channel Contours and Constraints

The channel should not have any features which may make navigation unsafe or otherwise difficult under any conditions. Generally, turns which have a radius of curvature of less than three ship lengths should not be utilized.

Any structures which pass over the channel should have a minimum elevation of 150 feet above mean higher high water. This elevation will permit passage with adequate clearance during any stage of the tide.

Vessel Traffic Patterns and Safety Systems

It is desirable that there be a minimal amount of vessel traffic. In areas where there is a moderate or heavy concentration of vessels, the traffic patterns should be well defined, with all ships moving along approximately parallel courses. Well-developed ports which accommodate a large number of vessels moving in numerous directions are undesirable.

Areas in which traffic safety systems are in service should be utilized, if possible. These systems generally consist of two separation lanes with a buffer zone between the lanes. Each lane is for traffic which is moving in a single direction. While the use of these separation lanes is not mandatory, most ships do comply with their provisions, thus reducing random traffic patterns and improving safe transit.

Aids to Navigation

The land bordering the areas in which the LNG carriers will maneuver should be well marked (or capable of being marked) with lighted aids to navigation.

Anchorage Areas

At least one area suitable for off-shore anchoring should be available near the site. It should meet four primary requirements:

(1) The sea botton should provide good holding for a ship's anchor. No underwater obstructions should be present

(2) The water should not be deeper than 200 feet. To obtain good holding, a ship generally lets out a length of chain equal to five to seven times the depth of the water,

(3) The area should be large enough to allow a ship to swing with the wind or current while at anchor, and

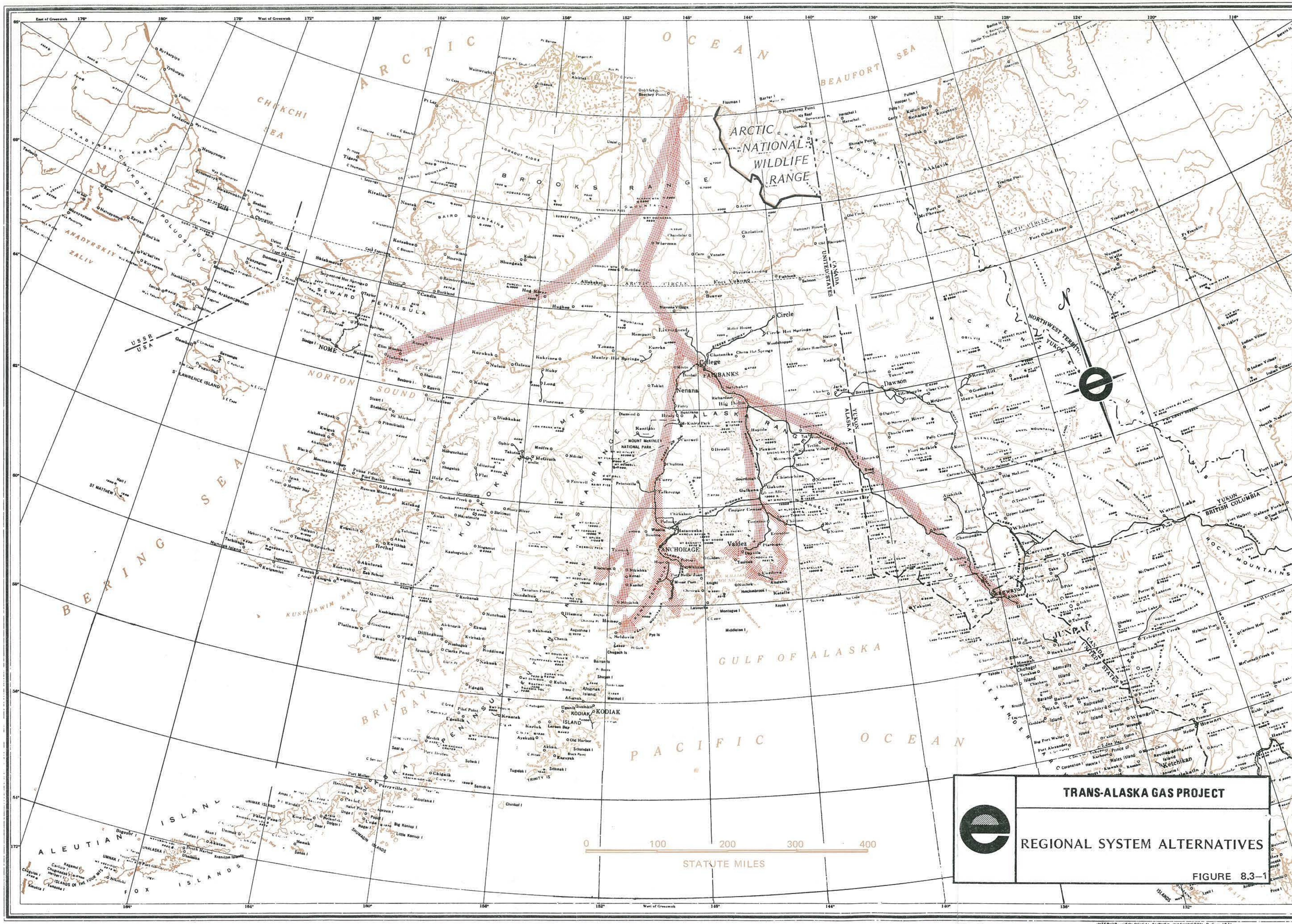
(4) If possible, the anchorage area should provide some shelter from wind and waves. This is especially important if the water is deep, or if the bottom does not provide good holding power.

Ice Conditions

The formation of sheet ice, or the passage of ice floes greater than 12 inches in thickness, will not be acceptable on the waters in which the LNG carriers will operate. In addition to creating a navigational hazard, the presence of ice can force a ship to depart from the terminal prematurely. The formation of ice can also hinder the ability of small support craft to function.

8.3.2. Regional Evaluation

The process of selection of a pipeline route, and an LNG Plant and terminal site initially considered four regional alternatives (Figure 8.3-1):



TRANS-ALASKA GAS PROJECT

REGIONAL SYSTEM ALTERNATIVES

FIGURE 8.3–1

INTERIOR—GEOLOGICAL SURVEY WASHINGTON D.C.—1971

(a) Prudhoe Bay to a western Alaska port on Norton Sound or Bristol Bay,

(b) Prudhoe Bay to Fairbanks, then parallel to the Alaska Highway and the Haines Cut-off to a port on Upper Lynn Canal,

(c) Prudhoe Bay via a pipeline route generally parallel to the Alyeska route to near Fairbanks, then following the Alaska railroad to a port located on Cook Inlet or West Prince William Sound, and

(d) Prudhoe Bay via a pipeline route generally parallel to the Alyeska route for the most of the distance to a port located on East Prince William Sound.

From this regional evaluation, the Applicant concluded that alternate (d) above is the most favorable, in terms of the engineering and environmental site and route selection criteria. The results of Applicant's regional evaluation are summarized below.

Prudhoe Bay to Western Alaska Ports

A pipeline to a western Alaska port on Bristol Bay or Norton Sound was rejected without detailed study, as unrealistic and unreasonable, for the following reasons:

(a) Ice conditions in the Bering Sea would seriously restrict reliable year-round operations of the LNG Carrier Fleet, and would result in higher capital and operating costs, and

(b) Even under favorable sea conditions, sailing time would be several days longer, compared to a port in South Central Alaska.

Prudhoe Bay to Lynn Canal

This route, entirely parallel to existing highways, is relatively attractive in terms of access, topography, and soil conditions. However, such a route would be substantially longer than one to a Cook Inlet or Prince William Sound port (1010 miles compared to approximately 800 miles) and would be subject to navigational hazards in and on the approaches to Lynn Canal. For these reasons this alternate was considered unreasonable and unrealistic and was rejected.

Prudhoe Bay to Cook Inlet and West Prince William Sound

Location of the LNG Plant and marine terminal on Cook Inlet, or on that segment of Prince William Sound from Resurrection Bay (Seward) to Whittier would require a pipeline route generally parallel to the

Alyeska route (or some other Brooks Range corridor) to a point near Livengood, 50 miles northwest of Fairbanks. From this point, the route would head south to near Dunbar, 30 miles west of Fairbanks on the Alaska Railroad, and would parallel the railroad to near the head of Cook Inlet. From this point, several alternate routes are available, depending on the specific terminal site under consideration.

In terms of economics, topography, access, soil conditions, and environmental factors, a pipeline route following the Alaska Railroad between Dunbar and Cook Inlet is attractive. However, because no port serving this route meets the site selection criteria, this alternate was eliminated from further study. A summary of the port areas (Figure 8.3-2) considered is given below.

Upper Cook Inlet

That part of Cook Inlet north of Cape Starichkof was eliminated from further consideration because existing LNG carrier operations in the area have demonstrated that intermittent sea ice can present hazards to vessel operations. In addition, currents and a large tidal range are present in some areas of the Inlet, and sufficient water depth for carrier operation is rarely found close to shore.

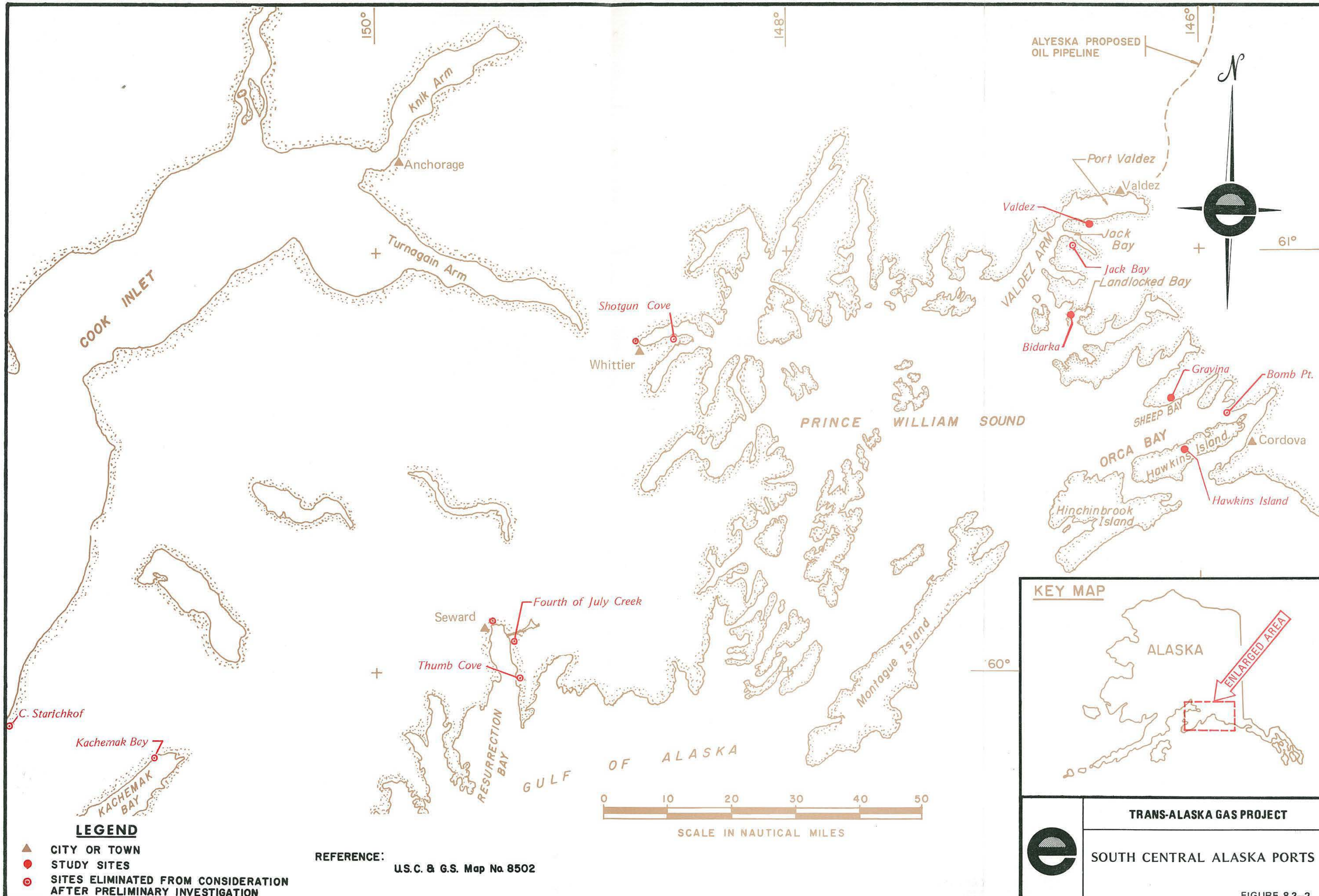
Cape Starichkof

Cape Starichkof, on the eastern shore of Cook Inlet on the Kenai Peninsula, has adequate land area available west of the Sterling Highway.

The oceanographic and ice conditions at this site are more severe than at sites in southern Cook Inlet. Swells and waves are reported to be excessively high, and the ice would cause a substantial increase in capital and operating costs. During winter, the formation of sea ice and the strong tidal currents would adversely affect the safe maneuverability of the LNG carriers. Because of ice and weather conditions, and because the 50 to 60-foot water depth contour is about 6,000 feet offshore (thus requiring a long access trestle to the loading and service platforms), a site at Cape Starichkof was eliminated from further consideration.

Kachemak Bay

Kachemak Bay is located on the eastern shore of Cook Inlet near its entrance. The proposed site would be located on the north shore near the head of the Bay. Adequate land is available, but the shallow water near shore would require a significant amount of dredging in order to provide an access channel from Cook Inlet. In addition, construction of the access trestle to the loading platform would be difficult and costly because of the relatively long required length. For these reasons a site on Kachemak Bay was eliminated from further consideration.



TRANS-ALASKA GAS PROJECT

SOUTH CENTRAL ALASKA PORTS

FIGURE 8 3–2

Thumb Cove

Thumb Cove lies on the east shore of Resurrection Bay, about 8 miles south of Seward. The site would be located on the northern shore of the Cove.

Thumb Cove has several disadvantages. The site location at the head of the Cove offers only a minimum amount of land that does not require considerable excavation of the nearby upland. In addition, the Cove is small, and LNG carrier maneuvering would be very difficult. Under certain conditions, the site is exposed to adverse wind and wave conditions. Therefore, a site on Thumb Cove was eliminated from further consideration.

Seward

A potential site could be located adjacent to Seward on the delta of Salmon Creek. However, in order to reach water depths of 50 to 60 feet, the marine terminal would have to be located near the toe of the delta and would be subject to submarine slope failure of the deltaic material in the event of a severe earthquake. In addition, meteorological conditions are not favorable. Therefore, a site at Seward was eliminated from consideration.

Fourth of July Creek

A site could be located at Fourth of July Creek on the eastern side of Resurrection Bay, approximately three miles southeast of Seward. Adequate land area and water depth is available immediately south of the delta of Fourth of July Creek. Marine and meteorological conditions appear to be generally favorable for LNG carrier operations. However, because of the disadvantages listed below this site was not considered to be feasible:

(1) Parts of the site have very steep slopes and elevations ranging from 500 to 900 feet. These areas would require extensive grading,

(2) The plant site would be located approximately 2.4 miles from shore. The total distance from the Plant site and marine terminal would be about 2.5 miles. This distance is marginal for efficient and economical operation of a cryogenic pipeline,

(3) Seward is located 4.5 miles northwest of the Plant, and there are no upland areas between the site and Seward,

(4) Because of water depth, there are no suitable locations for an anchorage area in the bay. Areas that have a satisfactory water depth are located immediately off shore, and maneuvering room would be severely limited.

(5) The plant site would have to be located on the delta of Fourth of July Creek, with the marine terminal, in order to reach water depths of 50 to 60 feet, being located at the margin of the same delta. Because this sector of the delta is extremely sensitive to slope failure under seismic acceleration, the integrity of the terminal could be endangered.

Shotgun Cove

Shotgun Cove lies on the south side of Canal Passage, approximately six miles east of Whittier. Only 300 acres of land are available for a plant site. Another disadvantage of the site is that it lies in an area under consideration for development as a sport fishing and recreational boating harbor.

Although this site has favorable oceanographic and meteorological characteristics, it was eliminated from further consideration for the reasons identified above.

Whittier

The vicinity of the Town of Whittier was examined for potential sites. The only areas where adequate relatively flat land exists are on seismically sensitive river deltas. A terminal at a 50- to 60-foot water depth at these locations would generally lie near the edge of the deltas, thus presenting a hazard to the marine terminal in the event of a severe earthquake. The U. S. Department of the Interior, in evaluating alternate sites to the terminus of the proposed trans-Alaska oil pipeline stated:

> There are no sites at either Seward or Whittier with acceptable foundation conditions, security from potential landslide damage, and/or security from potentially damaging seismically induced sea waves (USDI, 1972, Vol. 5, p.47).

On the basis of the foregoing, Whittier was eliminated from further consideration.

Prudhoe Bay to East Prince William Sound

A pipeline route between Prudhoe Bay and that sector of the Prince William Sound shore between Valdez and Cordova would, for most of its length, lie in the Utility Corridor and near the alignment of the proposed trans-Alaska oil pipeline now under construction.

In evaluating potential port sites to serve this pipeline corridor, six locations (Jack Bay, Bomb Point, Bidarka, Valdez, Hawkins Island, and Gravina) were identified (Figure 8.3-2). Of these six, Jack Bay and Bomb Point were rejected after a preliminary evaluation, described below.

The remaining four sites, after preliminary evaluation, appeared to merit additional detailed appraisal. The results of this detailed appraisal demonstrated that Gravina most closely fits the criteria established for the study. The results of the evaluation of sites at Valdez, Hawkins Island, and Bidarka are given in section 8.3.3 of this Report.

Jack Bay

Jack Bay lies at the southern end of Valdez Arm immediately south of Valdez Narrows. The site lies in the Chugach National Forest, just outside the city limits of Valdez.

An LNG Carrier, maneuvering into Jack Bay, would be exposed to the prevailing winds issuing south through Valdez Narrows. If these winds blow at sustained high speed while the vessel is turning slowly, the maneuverability and safety of the vessel would be seriously impaired. For this reason, Jack Bay was eliminated from further consideration.

Bomb Point

Bomb Point is located in the southeastern sector of Prince William Sound on the northern side of the Orca Bay Narrows. The primary disadvantage associated with this site is the terrain that would be occupied by the plant. Most of the land at the tip of Bomb Point lies below elevation of 100 feet. To the east of Bomb Point, the land is characterized by very steep slopes with elevations in excess of 500 feet. Consequently, this area would require extensive site preparation and was therefore eliminated from further consideration.

8.3.3 Detailed Site Evaluations

This section presents the results of a detailed evaluation of three sites in Prince William Sound, between Valdez and Cordova. These sites, in addition to the proposed site at Gravina, were selected for detailed evaluation subsequent to and as the result of Applicant's regional evaluation described in section 8.3.2. A comparative tabular summary of all four sites (Gravina, Hawkins Island, Bidarka aand Valdez) is given on Figure 8.3-3.

PLANT SITE CRITERIA

	LAND AREA AVAILABLE	TOPOGRAPHY	DISTANCE FROM PLANT TO SHORE	SOIL CHARACTERISTICS	PROXIMITY OF FAULT ZONES	PROXIMITY OF NEAREST COMMUNITY	PIPELINE ACCESSIBILITY
	THE PLANT REQUIRES 500 ACRES AN ADDITIONAL 700 ACRES IS PREFERRED FOR A GREENBELT.	MINIMUM ELEVATION OF 100 FEET ABOVE MSL. SLIGHT SLOPE AND GOOD DRAINAGE DESIRABLE.	AS SHORT AS POSSIBLE TO MINIMIZE PIPELINE LENGTH. DISTANCE FROM PLANT SITE TO TERMINAL SHOULD NOT EXCEED 2.5 MILES.	DENSE, GRANULAR, WELL GRADED SOILS DESIRABLE FOR STRENGTH. FIRM CLAYS ALSO SUITABLE. SHALLOW BEDROCK DESIRABLE. SOILS SHOULD BE STABLE.	NO ACTIVE FAULT ZONES SHOULD BE LOCATED ON OR ADJACENT TO PLANT SITE	IT IS DESIRABLE TO HAVE A 10-MILE SAFETY ZONE BETWEEN THE PLANT SITE AND A POPULATED AREA.	NATURAL GAS PIPELINE TO SITE SHOULD BE EASY TO INSTALL.
GRAVINA SITE	PLANT SITE IS 500 ACRES. A 700 ACRE GREENBELT IS AVAILABLE.	MINIMUM ELEVATION IS 100 FEET. SITE HAS OVERALL SLOPE OF 1:25. MUCH OF SITE IS POORLY DRAINED WITH STANDING POOLS OF WATER.	CENTER OF SITE IS 2800 FEET FROM SHORE TOTAL DISTANCE FROM PLANT SITE TO TERMINAL IS 4000 FEET.	SOILS CONSIST OF ORGANIC MATTER AND SILTS. BEDROCK IS 10 TO 40 FEET BELOW SURFACE. SOILS ARE STABLE.	NO FAULT ZONES IN THE IMMEDIATE AREA.	CORDOVA IS 13 MILES S.E. OF SITE.	TERRAIN IS SUITABLE FOR CONSTRUCTION OF GAS PIPELINE.
HAWKINS ISLAND SITE	PLANT SITE IS 500 ACRES. A 700 ACRE GREENBELT IS AVAILABLE.	MINIMUM ELEVATION IS 100 FEET. OVERALL SLOPE IS 1:10. NUMEROUS TERRACES MODIFY SLOPE AND HAVE POOR DRAINAGE CHARACTERISTICS.	CENTER OF SITE IS 2600 FEET FROM SHORE. TOTAL DISTANCE FROM PLANT SITE TO TERMINAL IS 3800 FEET.	SOILS CONSIST OF A LAYER OF SILT AND PEAT OVER GRAVEL. BEDROCK IS 0 TO 30 FEET BELOW SURFACE. SOILS ARE STABLE.	NO FAULT ZONES IN IMMEDIATE AREA.	CORDOVA IS 10 MILES EAST OF SITE.	A SUBMARINE PIPELINE IN DEEP WATER IS REQUIRED TO GAIN ACCESS TO THE SITE.
BIDARKA SITE	PLANT SITE IS 500 ACRES. A 700 ACRE GREENBELT IS AVAILABLE.	MINIMUM ELEVATION 100 FEET. AVERAGE SLOPE OF PLANT SITE IS 1:10. PLANT SITE IS WELL DRAINED.	CENTER OF SITE IS 2300 FEET FROM SHORE. TOTAL DISTANCE FROM PLANT SITE TO TERMINAL IS 3300 FEET.	SAND CONTAINING PEBBLES AND COBBLES. BEDROCK IS 20 TO 30 FEET BELOW SURFACE. SOILS ARE STABLE.	NO FAULT ZONES IN IMMEDIATE AREA.	TATITLEK IS 3 MILES N.W. OF SITE.	TERRAIN IS VERY RUGGED AND DIFFICULT FOR PIPELINE CONSTRUCTION.
VALDEZ SITE	PLANT SITE ONLY HAS 200 ACRES READILY AVAILABLE ADDITIONAL ACREAGE WOULD REQUIRE EXTENSIVE SITE PREPARATION. A 700 ACRE GREENBELT IS AVAILABLE.	MINIMUM ELEVATION IS 100 FEET. 200 ACRE SITE HAS AVERAGE SLOPE OF 1:9. 500 ACRE SITE WOULD BE VERY STEEP WITH A SLOPE OF 1:6. DRAINAGE IS GOOD.	CENTER OF SITE IS 1200 FEET FROM SHORE. TOTAL DISTANCE FROM PLANT SITE TO TERMINAL IS 1600 FEET.	SOILS ARE ORGANIC SILT AND PEAT DEPTH TO BEDROCK UNKNOWN BUT BELIEVED TO BE SHALLOW. SOILS ARE STABLE.	NO FAULT ZONES IN IMMEDIATE AREA.	VALDEZ IS 6 MILES E.N.E. OF SITE.	TERRAIN IS SUITABLE FOR PIPELINE CONSTRUCTION.

MARINE TERMINAL SITE CRITERIA

	WATER DEPTH AT BERTH	DISTANCE FROM TERMINAL TO SHORE	SOIL CHARACTERISTICS	PROXIMITY OF FAULT ZONES	MARINE TERMINAL EXPOSURE	MANEUVERING AREA REQUIRED
	MINIMUM DEPTH OF 47 FEET AT MLLW. NO DREDGING SHOULD BE REQUIRED.	AS SHORT AS POSSIBLE TO MINIMIZE PIPELINE LENGTH. DISTANCE FROM TERMINAL TO PLANT SHOULD BE LESS THAN 2.5 MILES.	GRANULAR SOILS OR MEDIUM TO SOFT CLAYS DESIRABLE. SOILS SHOULD BE STABLE. DESIRABLE TO HAVE BEDROCK ABOUT 100 FEET BELOW SEABOTTOM.	NO ACTIVE FAULT ZONES SHOULD BE LOCATED ON OR ADJACENT TO PLANT SITE.	MINIMAL OCCURRENCE OF WINDS OVER 90 MPH MINIMAL OCCURRENCE OF WAVES OVER 4 FEET. CURRENT LESS THAN 2 KNOTS.	MINIMUM CHANNEL WIDTH OF 3 TIMES BEAM OF SHIP. MINIMUM DIAMETER OF TURNING BASIN EQUAL TO 1½ TO 2 TIMES LENGTH OF SHIP.
GRAVINA SITE	ADEQUATE WATER DEPTH AVAILABLE. NO DREDGING REQUIRED.	SITE IS 1200 FEET FEET OFFSHORE TOTAL DISTANCE FROM TERMINAL TO PLANT SITE IS 4000 FEET.	FINE TO VERY FINE SANDS, WITH COARSE SANDS NEAR SHORE. SOILS ARE STABLE. DEPTH TO BEDROCK IS 40 FEET.	NO FAULT ZONES IN THE IMMEDIATE AREA.	SITE IS RELATIVELY WELL SHELTERED TO THE N. & E. AVERAGE WIND IS LESS THAN 13 MPH. WAVES SELDOM EXCEED 3 FEET IN HEIGHT. CALM SEA CONDITIONS 67% OF TIME. AVERAGE CURRENT IS 1.2 KNOTS.	NO CHANNEL OR TURNING BASIN REQUIRED. AMPLE MANEUVERING ROOM ADJACENT TO SITE.
HAWKINS ISLAND SITE	ADEQUATE WATER DEPTH AVAILABLE. NO DREDGING REQUIRED.	SITE IS 1200 FEET OFFSHORE. TOTAL DISTANCE FROM TERMINAL TO PLANT SITE IS 3800 FEET	MEDIUM FIRM SILTS AND SMALL BOULDERS. SOILS ARE STABLE. DEPTH TO BEDROCK IS 10 TO 20 FEET.	NO FAULT ZONES IN IMMEDIATE AREA.	SITE IS SHELTERED TO THE SOUTH AND EXPOSED TO THE W., N. & E. AVERAGE WIND IS BETWEEN 7 AND 9 MPH. 1% OF TIME WAVES EXCEED 3 FEET. CALM SEA CONDITIONS 92% OF TIME. AVERAGE CURRENT IS 1.2 KNOTS.	NO CHANNEL OR TURNING BASIN REQUIRED. AMPLE MANEUVERING ROOM ADJACENT TO SITE.
BIDARKA SITE	ADEQUATE WATER DEPTH AVAILABLE. NO DREDGING REQUIRED.	SITE IS 1000 FEET OFFSHORE. TOTAL DISTANCE FROM TERMINAL TO PLANT SITE IS 3300 FEET.	SANDY SILT MIXED WITH PEBBLES. SOILS ARE STABLE DEPTH TO BEDROCK IS 30 FEET.	NO FAULT ZONES IN IMMEDIATE AREA.	SITE IS WELL SHELTERED. AVERAGE WIND IS 8 MPH. CALM SEA CONDITIONS 96% OF TIME. AVERAGE CURRENT IS 1 KNOT. SITE MAY BE EXPOSED TO WILLIWAWS.	ENTRANCE TO LAND-LOCKED BAY NARROWS TO 4200 FEET WHICH IS AMPLE FOR TWO-WAY TRAFFIC. TURNING BASIN ADJACENT TO SITE MEASURES 2600 FEET BY 7400 FEET.
VALDEZ SITE	ADEQUATE WATER DEPTH AVAILABLE. NO DREDGING REQUIRED.	SITE IS 400 FEET OFFSHORE. TOTAL DISTANCE FROM TERMINAL TO PLANT SITE IS 1600 FEET	TYPES OF SOILS AND DEPTH TO BEDROCK UNKNOWN.	NO FAULT ZONES IN IMMEDIATE AREA.	SITE IS RELATIVELY WELL SHELTERED. AVERAGE WIND VELOCITY ABOUT 5 MPH. WAVES SELDOM EXCEED 3 FEET IN HEIGHT. CALM SEA CONDITIONS 90% OF TIME. AVERAGE CURRENT IS LESS THAN 1 KNOT. SITE MAY BE EXPOSED TO WILLIWAWS.	NO CHANNEL OR TURNING BASIN REQUIRED.

NAVIGABLE WATERWAY APPROACH CRITERIA

	SIZE AND DEPTH OF CHANNEL	CHANNEL CONTOURS AND CONSTRAINTS	VESSEL TRAFFIC PATTERNS	AIDS TO NAVIGATION	ANCHORAGE AREAS	ICE CONDITIONS
	MINIMUM DEPTH OF 47 FEET AT MLLW. MINIMUM CHANNEL WIDTH OF 3 TIMES BEAM OF SHIP.	NO SHARP TURNS IN CHANNEL. MINIMUM ELEVATION OF 150 FEET ABOVE MHHW FOR OVERHEAD STRUCTURES.	MINIMAL TRAFFIC MOVING IN WELL DEFINED PATTERNS IS DESIRABLE. TRAFFIC SAFETY SYSTEMS PREFERRED.	SUFFICIENT AIDS TO NAVIGATION SHOULD BE AVAILABLE.	AREA SHOULD HAVE MODERATE WATER DEPTHS, GOOD SHELTER AND AMPLE MANEUVERING ROOM.	NO ICE GREATER THAN 12 INCHES. THICK SHOULD FORM ON THE APPROACH ROUTE.
GRAVINA SITE	AVERAGE DEPTH EXCEEDS 300 FEET. NARROWEST AREA IS 4 MILES WIDE	ALL TURNS ARE GRADUAL. NO OVERHEAD STRUCTURES.	MODERATE TRAFFIC MOVES NORTH-SOUTH IN PRINCE WILLIAM SOUND. LIGHT TRAFFIC MOVES EAST-WEST NEAR SITE PROPOSED U.S. C.G. SAFETY SYSTEM DOES NOT INCLUDE AREA NEAR SITE.	SUFFICIENT AIDS AVAILABLE ON THE APPROACH ROUTE. ONE LIGHT IS LOCATED NEAR THE SITE.	FAIR ANCHORAGE NEAR SITE. DEPTH AVERAGES 150 FEET. AREA IS EXPOSED TO S. & S.W. AMPLE ROOM AVAILABLE.	NO ICE FORMS ON THE APPROACH ROUTE.
HAWKINS ISLAND SITE	AVERAGE DEPTH EXCEEDS 300 FEET. NARROWEST AREA IS 6 MILES WIDE	ALL TURNS ARE GRADUAL. NO OVERHEAD STRUCTURES.	MODERATE TRAFFIC MOVES NORTH-SOUTH IN PRINCE WILLIAM SOUND. LIGHT TRAFFIC MOVES EAST-WEST NEAR SITE. U.S. C.G. SYSTEM WILL NOT INCLUDE AREA NEAR SITE.	SUFFICIENT AIDS AVAILABLE OVER MOST OF THE APPROACH ROUTE. NO AIDS LOCATED IN THE VICINITY OF THE SITE	POOR ANCHORAGE NEAR SITE DUE TO LIMITED MANEUVERING ROOM. AREA IS EXPOSED TO W, N. & E. DEPTH IN EXCESS OF 120 FEET.	NO ICE FORMS ON THE APPROACH ROUTE.
BIDARKA SITE	AVERAGE DEPTH EXCEEDS 600 FEET. NARROWEST AREA IS 0.8 MILES.	ALL TURNS ARE GRADUAL. NARROW AREA IS STRAIGHT. NO OVERHEAD STRUCTURES.	MODERATE TRAFFIC MOVES NORTH-SOUTH IN PRINCE WILLIAM SOUND. MINIMAL TRAFFIC NEAR SITE U.S. C.G. SYSTEM WILL NOT INCLUDE AREA NEAR SITE.	SUFFICIENT AIDS AVAILABLE OVER MOST OF THE APPROACH ROUTE. NO AIDS IN THE VICINITY OF THE SITE.	POOR ANCHORAGE NEAR SITE DUE TO LIMITED MANEUVERING ROOM. AREA IS EXPOSED TO E. & W. AVERAGE DEPTH IS 120 FEET.	NO ICE FORMS ON THE APPROACH ROUTE.
VALDEZ SITE	AVERAGE DEPTH EXCEEDS 600 FEET. NARROWEST AREA IS 0.5 MILES WIDE.	ALL TURNS ARE GRADUAL. NO OVERHEAD STRUCTURES.	MODERATE TRAFFIC MOVES NORTH-SOUTH FROM VALDEZ TO GULF OF ALASKA. PROPOSED U.S. C.G. SYSTEM COVERS ENTIRE ROUTE FROM VALDEZ TO GULF OF ALASKA.	SUFFICIENT AIDS AVAILABLE ON THE APPROACH ROUTE. ADDITIONAL AIDS PROPOSED BY U.S. C.G.	POOR ANCHORAGE CONDITIONS DUE TO EXTREME WATER DEPTHS.	NO ICE FORMS ON THE APPROACH ROUTE.

TRANS-ALASKA GAS PROJECT

COMPARISON TABLE
POTENTIAL SITE

FIGURE 8.3–3

8.3.3.1 Hawkins Island

A potential site for the proposed LNG Plant and marine terminal is located on the southeastern region of Prince William Sound on the northern coast of Hawkins Island at approximately 60° 33'N, 146° 04'W. The island is within the Chugach National Forest.

Two general pipeline routes to Hawkins Island are available--the proposed route and a route down the Copper River from near Copper Center, passing near Cordova. In evaluating the Hawkins Island site, Applicant examined the Copper River alternate; the results of this evaluation are given in subsection 8.4.3.

Hawkins Island is about 19 miles long and lies in a northeast-southwest direction. It has an average width of 4 miles at its southwestern end and tapers gradually to a width of 1.5 miles at the northeastern end. Numerous small lakes and streams are located over the entire island.

The northern shore of the island is very uneven, with numerous bays and coves. The major identation in the coast is located about seven miles northeast of the southwestern end of the island, where Canoe Passage extends about two miles inland. The southern shore is more even with fewer prominent points which disrupt the general trend of the coast.

The northeastern end of the island has a maximum elevation of 1955 feet above mean sea level, and slopes steeply down to the northern shore. In most areas along the southern shore, the slope is more moderate.

In the center of the island, prominent points of high elevation occur on the southern side, and the land along the shore has a relatively steep slope. The north side of the island has a more moderate topography, characterized by a series of sloping terraces descending towards the shore.

The southwestern end of the island has a very moderate topography, with gentle slopes prevailing along the northern coast. There are isolated points on the southern side which exceed 1000 feet in elevation.

The island has a well-developed vegetative cover except at the higher elevations. Vegetation on the northeastern half of the island primarily consists of dense forests. Large, grassy meadows prevail in the southwestern half of the island, especially along the gently-sloping terraces adjacent to the northern shore.

Hawkins Island is bordered by Orca Bay and Narrows to the north, Orca Inlet to the east and south, and Hawkins Island Cutoff to the south and west. Orca Bay is the primary body of water, with an average width of six miles and depths in excess of 300 feet along much of its length. Near the northeastern end of the island, Orca Bay narrows down to an average width of one mile. This stretch of water, known as The Narrows, separates Hawkins Island from the Alaskan mainland to the north.

Orca Inlet is a shallow body of water located between the island to the north and the mainland. Numerous tidal mud flats are located in the inlet and the average water depth is less than 20 feet. The City of Cordova is located adjacent to Orca Inlet on the mainland.

The southwestern end of the island is separated from Hinchinbrook Island by Hawkins Island Cutoff. The islands are separated by a minimum distance of about one mile. The water is very shallow in some sections, averaging three feet in depth. The shallow water extends into Orca Bay as Middle Ground Shoal.

The area in which the site would be located has an average air temperature ranging between 23°F and 53°F. The average annual rainfall totals about 120 inches, while snowfall averages in excess of 100 inches.

8.3.3.1.1 Potential Plant Site Description

The potential Hawkins Island plant site would be located on the north central coast of Hawkins Island between Whiskey Cove to the west and Paul Creek to the east. The plant site, which consists of approximately 500 acres of land, is located about 2,600 feet from shore. An additional 700 acres may be utilized as a greenbelt (see Figure 8.3-4 and 8.3-5).

Topography

The area in which the site would be located consists of a series of sloping terraces that range in elevation from 100 to 500 feet above mean sea level. Between the 100-and 500-foot contours the land has an average slope of about 10 percent. Below the 100-foot contour, terrain steepens to about 15 percent. The 500-acre plant site would range in elevation from 100 to 500 feet above mean sea level.

Drainage in the higher elevated portions of the site is good, primarily due to steep slopes and lack of organic sediment. However, there is poor drainage on the land between the upper areas and the sea cliff. Small streams provide the main drainage in this area.

Soil Characteristics and Geology

Soil cover at the potential site consists of organic silt and peat overlying a layer of gravel. Soil cover on the area adjacent to the beach averages 20 feet in thickness, but may vary locally from near zero to over 30 feet in depth.

Bedrock at the potential site consists of slightly metamorphosed shales and graywackes of vertical to steeply-dipping beds. Strikes tend generally to the north in the western portions of the site, gradually becoming more northwesterly in the eastern portions of the site. The contact between the shale and graywacke is depositional, and fault contacts have not been observed.

The rocks are thinly bedded and highly fractured with joint sets

PLANT SITE
GREEN BELT AREA

SCALE 1:63360

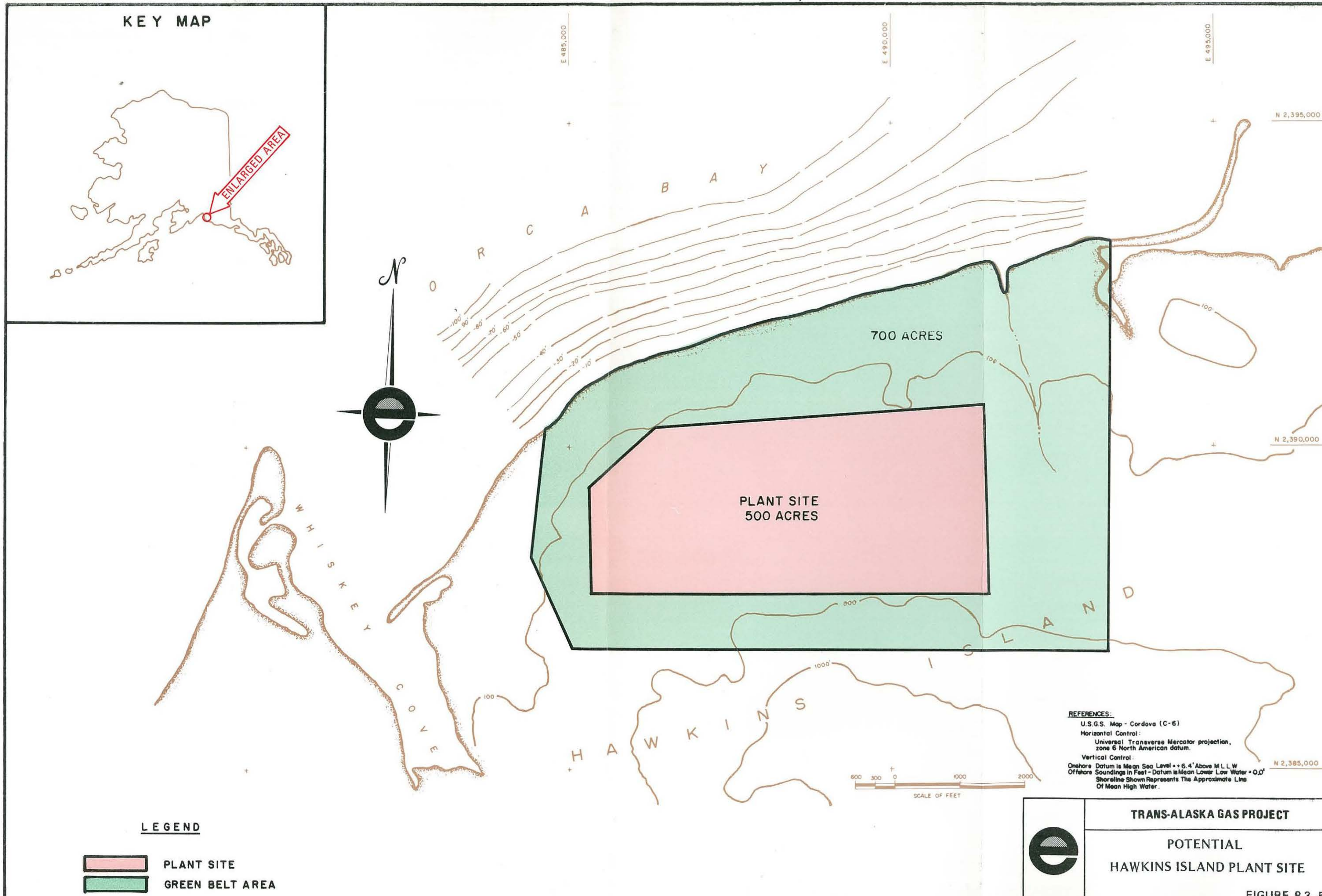
1 ½ 0 1 2 miles

REFERENCE: U.S.G.S. MAP - Cordova (C-6)

TRANS-ALASKA GAS PROJECT

POTENTIAL HAWKINS ISLANDS SITE

FIGURE 8.3–4



TRANS-ALASKA GAS PROJECT

POTENTIAL
HAWKINS ISLAND PLANT SITE

FIGURE 8.3–5

in numerous directions and spacing of less than one foot. A preliminary evaluation of the soils at the potential plant site indicates that they are not subject to liquefaction.

No active faults are known in the vicinity of the plant site. There is no evidence of ground rupturing, subsidence or uplift related to the 1964 earthquake. Some small rockslides are noted along the cliff. Their cause is not known.

Proximity of Nearest Community

The northern coast of Hawkins Island is undeveloped. The nearest community to the site is the City of Cordova, which is located approximately 10 miles east.

Accessibility of Pipeline

The crossing to Hawkins Island would involve the installation of a submarine pipeline in relatively deep water. The narrowest body of water bordering the island is located off the northeastern end of the island, approximately twelve miles east of the site. Here a one mile crossing in water depths up to 240 feet would be required.

8.3.3.1.2 Potential Marine Terminal Site Description

The potential marine terminal site is located about 1,200 feet off the northern shore of the island in Orca Bay. The minimum water depth at the site is 50 to 60 feet at mean lower low water. No obstructions are indicated on published charts of this area, and no dredging would be required.

The area adjacent to the potential site consists of a broad expanse of deep water, with ample maneuvering room. Offshore, the water depth exceeds 300 feet. There are no adjacent land masses or areas of shallow water in the vicinity of the site which would place restrictions on tanker navigation. Consequently, marked channels or designated turning basins would not be required.

Bathymetry

The distance of the 50 to 60-foot contour from shore varies slightly in the vicinity of the potential site. At the mouth of Whiskey Cove, a water depth of 60 feet occurs about 2,300 feet offshore. To the east, the 60-foot contour moves closer to shore. At the site, the 50 to 60-foot contour remains at a relatively constant distance offshore.

At the potential site, the seafloor slopes from the beach at a moderate angle to a water depth of about 20 feet. At this point the gradient flattens out and continues out past the 300-foot water depth contour. The overall slope of the seafloor is approximately 1:20.

Oceanography

Tidal information pertaining to the marine terminal site is based on data taken from tide stations in the surrounding area. This information is given in Table 8.3-1.

The potential marine terminal site is exposed to open water to the west, north and east. Since the longest fetch is available west of the site, the largest waves may be expected from that direction. However, a large percentage of the total waves at the site should originate from the northern quadrant, since this quadrant is a primary origin of prevailing winds. Information pertaining to the occurrence of normal waves at the site is presented in Table 8.3-2.

Under normal conditions, significant waves in excess of three feet in height are expected to occur less than one percent of the time. Approximately 92 percent of the time, calm sea conditions are expected to prevail at the site.

Storm waves will be of the greatest magnitude when the generating wind is from the western quadrant. Table 8.3-3 lists the anticipated significant storm wave characteristics which may occur at the marine terminal site by a storm with a recurrence interval of 100 years.

The data listed in Table 8.3-3 is based on the assumption that the storm winds originate in the western quadrant. In addition to generating significant waves of up to 12 feet in height, a 100 year storm with westerly winds would cause wave heights at the terminal site to equal or exceed six feet in height for a period of approximately 33 hours.

Available information indicates that currents at the site seldom exceed a velocity of about 1.2 knots. The affect of a current with this velocity, upon the operation of a marine terminal, is negligible.

TABLE 8.3-1

TIDAL CHARACTERISTICS OF THE POTENTIAL HAWKINS ISLAND SITE

Extreme High Water Level	17.0 Feet
Highest Astronomical Tide	15.3 Feet
Mean Higher High Water	12.1 Feet
Mean High Water	10.9 Feet
Mean Tide Level	6.2 Feet
Mean Low Water	1.4 Feet
Mean Lower Low Water (Datum)	0.0 Feet
Lowest Astronomical Tide	-3.6 Feet
Extreme Low Water Level	-5.0 Feet

Soil Characteristics and Geology

The composition of the seafloor varies to a certain extent as a function of the water depth. From the shoreline to a water depth of 20 feet, a layer of boulders two feet or less in diameter overlies the bedrock. Between the 20-foot and 35-foot contours, boulders are less common, but they may range up to three feet in diameter. From a water depth of 35 feet to the 50 to 60-foot contour, the seafloor consists of a layer of boulders and gray, medium firm silt. This layer varies in thickness from 10 feet at the 35-foot water depth contour to approximately 20 feet at the 60-foot water depth contour.

Bedrock outcrops occur along the wave-cut beach out to water depths of 40 to 50 feet. The bedrock consists of metamorphosed shale and graywacke, similar in lithology and structure to outcross.

The occurrence of subsidence or uplift has not been reported at the potential marine terminal site. The soils appear to be stable and not subject to liquefaction.

No active fault zones are known, there are no offshore bathymetric features which could amplify a tsunami wave.

Climatology

No meteorological data gathering stations are located on Hawkins Island. Data obtained from Cordova, Cape Hinchinbrook, and Middleton Island were utilized to develop the climatological characteristics of the site.

The marine terminal site is relatively well sheltered from southerly winds due to the topography of Hawkins Island. The site is exposed to long fetches of open water in the western quadrant, while fetches to the north and east are substantially shorter.

Table 8.3-4 lists a summary of the wind data derived for Hawkins Island. An analysis of such data indicates that the largest precentage of prevailing winds originate from the north and northeasterly directions, and have an average speed of between seven and nine miles per hour. Occasionally, winds from these directions may attain speeds of up to 46 miles per hour. Approximately 18 percent of the time, light breezes are expected to prevail at the site.

The information presented in Table 8.3-5 indicate that periods of reduced visibility generally last less than three hours. During periods when visibility is reduced to 0.5 miles, 80 percent of these occurrences last less than one hour, while only six percent exceed three hours. In some cases a condition in which visibility is reduced to about five miles may last in excess of 24 hours; however, these occurrences are minimal.

TABLE 8.3-2

PERCENT OCCURRENCE OF NORMAL WAVES, ANNUAL SUMMARY

Direction	Significant Wave Height (Feet) 1-3	3-6	6-10	10-15	Total
W	2.3	0.4	0.1	0.0[1]	2.8
NW	1.1	0.1	0.0	0.0	1.2
N	0.8	0.1	0.0	0.0	0.9
NE	3.2	0.1	0.0	0.0	3.3
Calm[2]	-	-	-	-	91.8
TOTAL	7.4	0.7	0.1		100.0

1/An entry of 0.0 indicates a frequency less than 0.05 percent.

2/Significant wave heights of less than one foot are included in the total for Calm.

TABLE 8.3-3

CHARACTERISTICS OF STORM WAVES AND TIDE CONDITIONS AT THE POTENTIAL HAWKINS ISLAND SITE

	Significant Wave	Maximum Wave
Recurrence Interval (Years)	100	100
Wind Speed (Feet/Second)	82	82
Storm Tide (Feet)[1]	18	18
Total Depth (Feet)[2]	78	78
Wave Height (Feet)	12	20
Wave Period (Second)	7	10
Wave Length (Feet)	243	397
Wave Crest Elevation (Feet)[2]	24	29
Wave Trough Elevation (Feet)[2]	12	18

1/Datum is MLLW.

2/Assumes a Water Depth of 60 Feet Below MLLW.

TABLE 8.3-4

COMPARISION OF AVERAGE WIND FREQUENCY WITH AVERAGE WIND SPEED FROM VARIOUS DIRECTIONS AT HAWKINS ISLAND

	N	NE	E	SE	S	SW	W	NW
Frequency (%)	7	20	17	6	3	15	9	5
Speed (mph)	8	9	8	10	8	9	10	8

Storm winds at the site may exceed a velocity of 100 miles per hour for storms with large recurrence intervals.

No information is available concerning the occurrence of periods of reduced visibility at the site; however, data has been obtained for the Cordova area, and is presented in Table 8.3-5. The occurrence of reduced visibility may be less at the marine terminal site.

TABLE 8.3-5

PERCENTAGE OCCURRENCES OF PERIODS OF REDUCED VISIBILITY AT CORDOVA 1/

Visibility Less Than	DURATION PERIODS					
	< 1 Hr.	1-3 Hrs.	3-6 Hrs.	6-12 Hrs.	12-24 Hrs.	> 24 Hr.
5 Miles	39	29	17	9	5	1
1 Mile	64	22	10	4		
1/2 Mile	80	14	6			

1/ Based on year 1972 hourly observations

Extensive data concerning the formation of ice at the potential site is not available, but reports by local mariners indicate that ice very rarely forms in Orca Bay. Ice has been reported where fresh water flows into the bay, and also along the less shallow water near the shore line. However, the site is considered to be generally ice free.

8.3.3.1.3 Navigable Waterway Approach Description

Access to the potential marine terminal site is via Hinchinbrook Entrance and the southern region of Orca Bay. Hinchinbrook Entrance, which passes between Montague Island to the west and Hinchinbrook Island to the east, is about six miles wide and has very deep water extending close to shore. Sufficient maneuvering room is available for two-way traffic. (Figure 8.3-6).

With the exception of some shoal areas along the coast, the southern section of Orca Bay has water depths in excess of 400 feet and affords a wide, safe channel for the passage of deep-draft ships.

Aids to Navigation

The only aids to navigation present in the southern region of Orca Bay are a light at Johnstone Point (on the southwestern end of the bay) and the buoy marking Middle Ground Shoal.

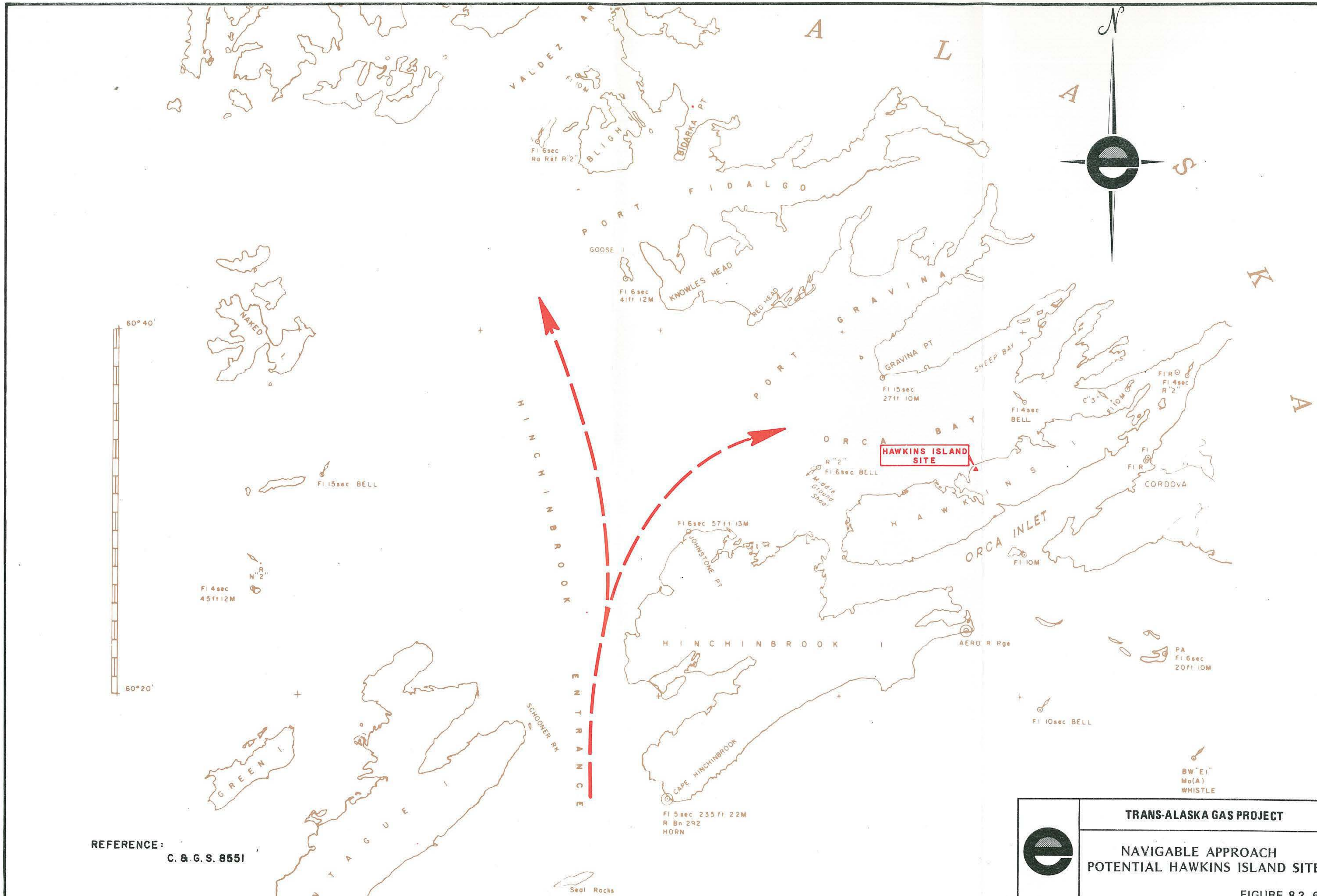
A light located on the northern shore of Orca Bay at Gravina Point can be used when navigating the middle reaches of the bay. However, lighted aids to navigation are presently unavailable in the vicinity of the site.

The U.S. Coast Guard has proposed to establish some additional aids and to upgrade existing aids in various areas of Prince William Sound. However, with the exception of Johnstone Point Light, which will be upgraded, no new aids are proposed for the southern region of Orca Bay.

Vessel Traffic Patterns and Safety Systems

The predominant traffic pattern consists of ships traveling in a north/south direction between Valdez and the Gulf of Alaska via Hinchinbrook Entrance. The amount of traffic utilizing this route will increase substantially in the future. Traffic in Orca Bay mainly consists of ships heading for, or departing from Cordova. All deep-draft vessels which call at Cordova must use the bay, since other available approach routes are too shallow. This traffic will operate primarily in the south central region of the bay and will move in an east-west direction. Traffic is not heavy.

At present, no traffic safety systems exist in Prince William Sound, and no safety lanes have been proposed for Orca Bay.



TRANS-ALASKA GAS PROJECT

NAVIGABLE APPROACH
POTENTIAL HAWKINS ISLAND SITE

FIGURE 8.3–6

Ship Anchorage Areas

Areas suitable for anchoring are not readily available in the southern region of Orca Bay. To the east of the site, deep water extends very close to shore and areas with satisfactory water depths would have a limited amount of maneuvering room. In the vicinity of Middle Ground Shoal (west of the site) deep water is located further from shore, and there is about one mile between the 60-foot and 300-foot contours. Consequently, this area has more maneuvering room available. This location is exposed to the west, north, and east, and bottom conditions are unknown.

An anchorage area has been proposed on the west side of Middle Ground Shoal as part of the proposed U.S. Coast Guard traffic safety system for Prince William Sound. This area has an average depth of 150 feet and is exposed to the west, north and east, and has adequate maneuvering room.

8.3.3.1.4 Site Assessment

The potential Hawkins Island site has a sufficient amount of land which is suitable for the construction of an LNG plant and related facilities. In addition, the marine aspects of the site appear favorable to LNG carrier operation. However, because of the following disadvantages of the site, and based upon the present conception of the Project, the Hawkins Island site was not considered a realistic and reasonable possibility:

(1) A submarine pipeline to connect the LNG plant with the mainland would need to be constructed through depths of water averaging 240 feet. Such an installation would require the mobilization of additional equipment and would substantially increase the overall cost of the pipeline.

(2) Anchorage conditions near the potential site are poor because suitable water depths are located a substantial distance from land or shoals. As a result, LNG carriers would have to anchor several miles from the site.

8.3.3.2 Bidarka

A site could be located at Bidarka in the eastern part of Prince William Sound on the Copper Mountain Peninsula at approximately 60°50'N., 146°37'W. The peninsula is within the domain of the Chugach National Forest and is accessible only by boat, helicopter or seaplane. No roads, railroads or airfields exist in the area.

The peninsula is a point of land approximately one mile in width and three miles long (Figure 8.3-7). It lies generally in a north-south direction. A hill on the southern end of the peninsula has a maximum elevation of approximately 750 feet above mean sea level. In the central

REFERENCES:
U.S.G.S. Map - Cordova (D-7)(D-8)

PLANT SITE
GREEN BELT AREA

SCALE 1:63360

½ 0 1 2 miles

TRANS-ALASKA GAS PROJECT

POTENTIAL BIDARKA SITE

FIGURE 8.3–7

region of the peninsula the land has a very moderate slope, with a maximum elevation of less than 300 feet. To the north the land becomes steeper, with elevations in excess of 1000 feet. Copper Mountain, the base of which borders the peninsula on the north, has an elevation in excess of 3800 feet. The mainland to the north and east of the peninsula is very rugged with numerous mountains, glaciers and small lakes. Vegetation consists of thick grasses and stands of spruce and fir trees.

No commercial or residential development has taken place on Copper Mountain Peninsula. At one time, a mining enterprise was in operation on the northeastern side of the peninsula.

The average air temperature for the region in which the site is located ranges between 23°F. and 53°F. The average rainfall is expected to exceed fifty-five inches, and the snowfall exceeds one hundred forty inches.

8.3.3.2.1 Potential Plant Site Description

The potential Bidarka plant site and its associated greenbelt occupy the entire width of the peninsula from its southern tip to a point 2.5 miles to the north (see Figure 8.3-8). The plant site, which consists of 500 acres, is located approximately 2,300 feet from the shores of Landlocked Bay. The greenbelt consists of an additional 700 acres.

Topography

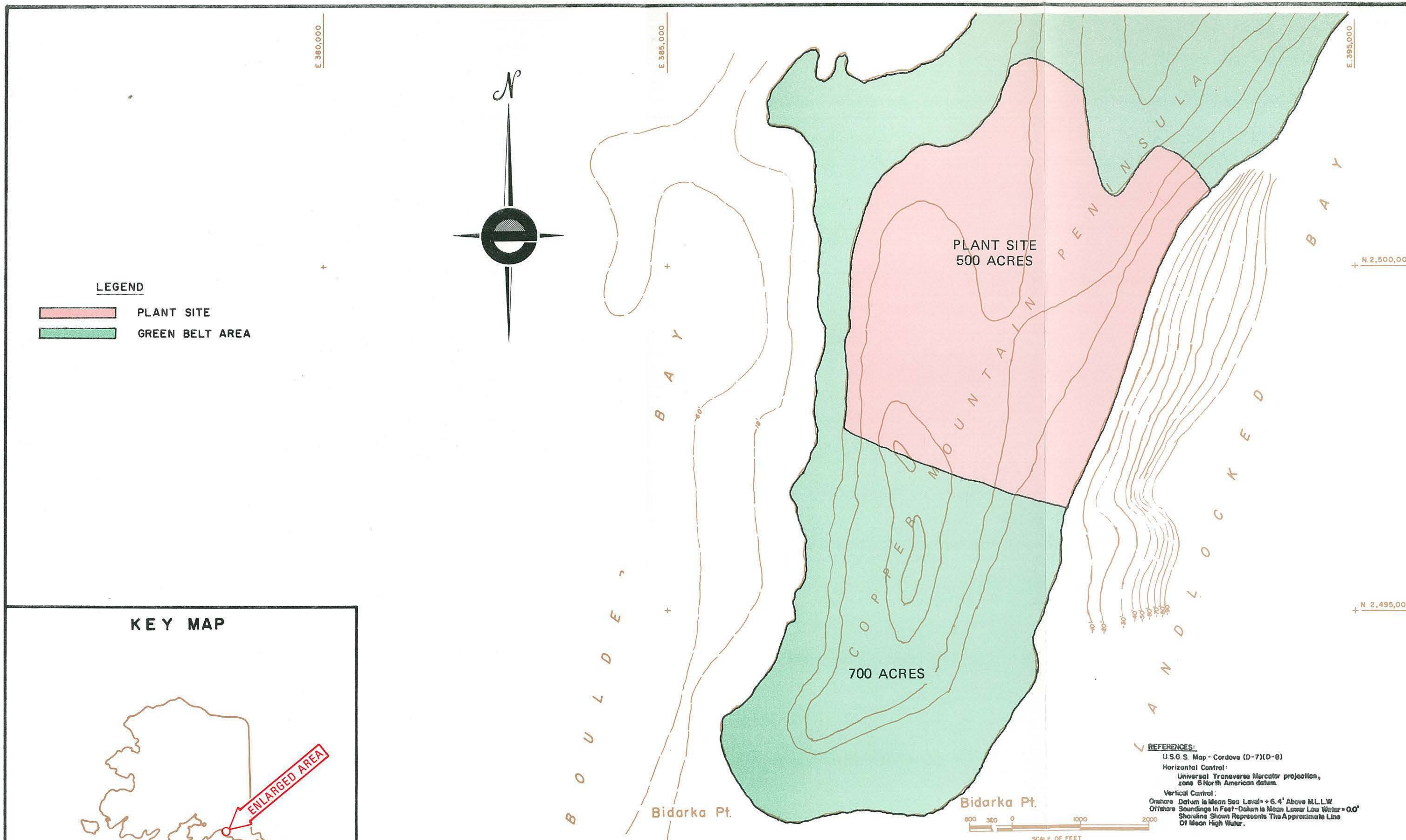
The area in which the potential plant site is located consists of a topographic saddle positioned between Copper Mountain to the north and a hill on the southern tip of the peninsula. The central portion of the plant site has a moderate slope which is modified to the north and south by the topographic highs. The overall slope of the site is 10 percent.

The elevation of the potential site ranges from 100 feet near the shore of Landlocked Bay to approximately 500 feet along the northern edge of the plant site. The average elevation of the plant site is less than 300 feet. The site appears to be adequately drained.

Soil Characteristics and Geology

Soil cover at the potential site consists of local patches of organic silt and a layer of granular soils overlain by a vegetative cover one to two feet thick. The patches of organic silt may range from five to ten feet in thickness. The granular soil material probably consists of subangular to round pebbles and cobbles in a sandy matrix. It is estimated that the soil cover is 20 to 30 feet thick near shore, but diminishes in thickness on the higher slopes.

No bedrock is exposed at the Bidarka site. Outcrops of shale, volcanic rocks, and metamorphosed sandstone are exposed about one mile



TRANS-ALASKA GAS PROJECT

POTENTIAL BIDARKA PLANT SITE

FIGURE 8.3–8

northeast of the site along the shoreline at the head of Landlocked Bay. Bedrock in that area is steeply dipping and moderately fractured, and it is likely that similar bedrock conditions also exist beneath the site.

No rockfalls were observed at the site; however, the topographic saddle between Copper Mountain and the southern tip of the peninsula suggests that a relatively weak zone may be present, hidden beneath vegetation and soil. No landslides or slumps were observed on the site, but numerous landslides have occurred on the steeper slopes along the east side of Copper Mountain Peninsula.

A preliminary investigation indicates that soils at the Bidarka plant site are not subject to liquefaction.

No active fault zones are known to be located in the vicinity of the potential plant site. There is a possibility of the occurrence of landslides as a result of earthquake-induced ground motion.

The Copper Mountain Peninsula may be subjected to tsunami run-up as a result of earthquakes. Initial indications are that possible run-ups as high as 150 feet may occur.

Proximity of Nearest Community

The nearest community to the site is the Indian Village of Tatitlek, which is located three miles northwest on the mainland. Tatitlek is a small community with a Bureau of Indian Affairs school, a small store and several dwellings.

The closest major center of population is the City of Valdez, 22 miles northeast of the site.

Accessibility of Pipeline

The general topography north of the potential plant site is characterized by steep mountain slopes and narrow valleys. Because of this rugged terrain, installation of the pipeline which would supply natural gas to the liquefaction plant would be extremely difficult.

8.3.3.2.2 Potential Marine Terminal Site Description

The potential marine terminal site is located approximately 1,000 feet off the eastern shore of Copper Mountain Peninsula in Landlocked Bay. The minimum water depth at the proposed location is 60 feet at mean lower low water.

Though the majority of Landlocked Bay has a water depth in excess of 60 feet, ship movements are restricted to a certain extent by the configuration of the bay. The widest section of the bay having a depth in excess of 50 to 60 feet, measures approximately 1.5 miles on an east-west axis, by 0.5 miles on a north-south axis. The marine terminal site is located adjacent to this area, so that vessel traffic may utilize this additional expanse as a turning basin if necessary. Though the narrowest section of the bay is only 0.8 miles wide, it is sufficient for two-way traffic. In all sections of the bay, adequate maneuvering room is available, and dredging to obtain additional room is not required.

Bathymetry

The distance of the 50- to 60-foot water depth contour from shore varies slightly along the eastern shore of Copper Mountain Peninsula. Near the southern end of the peninsula, a water depth of 50 to 60 feet is located about 1100 feet offshore. This distance decreases gradually to the north. In some areas near the head of the bay, 50- to 60-foot water depths are only 600 feet offshore.

At the potential marine terminal site, the floor of the bay slopes at about 5 percent from the beach to a depth of 20 feet. From this point to the 50 to 60-foot water depth contour, the average slope is 10 percent. The slope is fairly uniform with no evidence of any underwater obstructions.

Soil Characteristics and Geology

The seafloor at a water depth of 60 feet consists of a sandy silt mixed with shell fragments and pebbles. These materials extend towards shore to a water depth of 30 feet. From 20 to 30 feet, the seafloor is comprised of sand and scattered shell fragments with cobbles. Inside the 20-foot water depth contour, the bottom composition is almost entirely rounded cobbles and boulders with a sand-pebble matrix. This condition extends to the beach of Copper Mountain Peninsula.

The thickness of the seafloor sediments is unknown; however, it is estimated that the depth to bedrock at the 50 to 60-foot water depth contour is approximately 30 feet. The character of the bedrock is unknown.

The potential marine terminal site is located in a region which underwent uplift during the 1964 earthquake. A comparison of bathymetric contours from topographic maps developed before the earthquake with the results of a preliminary bathymetric survey undertaken in 1973 indicates a small decrease in water depths at the site.

The seafloor sediments at the terminal site appear to be stable, and there is no indication of soil liquefaction.

No known active fault zones are located in the vicinity of the site. Also, there are no off-shore bathymetric features which would amplify a tsunami wave.

Climatology

No meteorological data gathering equipment is located on or near the Bidarka site. All climatological characteristics of the site have been derived from data recorded at Cordova Airport and Middleton Island.

At the potential site, prevailing winds with the highest speed originate in the southern quadrant, due to a lack of topographical protection and a long fetch in this direction. The site is well sheltered from winds from the west, north, and east by surrounding land masses.

The maximum speed of prevailing winds from the south is 19 to 24 miles per hour. Winds of this speed occur only about one percent of the time. The average speed of prevailing winds from any direction at the site is eight miles per hour. Approximately 24 percent of the time, only variable breezes occur at the site.

The anticipated wind speeds for storms of various recurrence intervals are given in Table 8.3-6.

The speeds listed in Table 8.3-6 describe winds generated by storms in the vicinity of the site. In addition, the Bidarka site may be subjected to "williwaws" which originate in the interior and are intensified by a channeling effect through mountain passes and a steep gradient flow. Available data concerning these winds indicate that the site may be subjected to gusts of up to 75 miles per hour.

TABLE 8.3-6

STORM WINDS FOR BIDARKA POINT, ALASKA

Recurrence Interval	Maximum Gust (MPH)	Wind Duration			
		1 Minute (MPH)	1 Hour (MPH)	3 Hour (MPH)	6 Hour (MPH)
1	45	34	26	24	22
2	47	36	28	25	23
10	58	44	34	31	29
25	64	49	38	34	32
50	69	53	41	37	35
100	75	58	44	40	37

No specific data are available for Bidarka Point concerning the reduction of visibility, but data extrapolated from other areas indicates that, on an annual basis, visibility of less than 1/2 mile seldom persists for longer than one hour. Table 8.3-7 presents the percentage occurrences of periods of reduced visibility at Cordova. The occurrence of reduced visibility may be less at the marine terminal site.

TABLE 8.3-7

PERCENTAGE OCCURRENCES OF PERIODS OF REDUCED VISIBILITY AT CORDOVA, ALASKA[1/]

Visibility Less Than	DURATION PERIODS 1 Hour	1-3 Hours	3-6 Hours	6-12 Hours	12 Hours
5 Miles	39	29	17	9	6
1 Mile	64	22	10	4	
1/2 Mile	80	14	6		

1/Based on year 1972 hourly observations

Oceanography

The potential marine terminal site is exposed to waves originating in the southern quadrant only, since the site is not exposed to open water to the west, north and east. Significant waves originating in the southern quadrant are not expected to exceed four feet in height, and are expected to occur only four percent of the time. Approximately 96 percent of the time, calm conditions are expected to prevail at the site.

Due to the sheltered conditions of the site, storm wave heights are expected to be moderate. Storm waves would probably be most severe with south winds because of the large fetch and deep bathymetric conditions in this direction. Table 8.3-8 lists the anticipated storm wave conditions which will occur at the marine terminal site. It is expected that these conditions will persist for less than one hour for a storm with a 100-year recurrence interval.

TABLE 8.3-8

STORM WAVE AND TIDE CONDITIONS AT BIDARKA POINT, ALASKA

	Significant Wave	Maximum Wave
Recurrence Interval (years)	100	100
Wind Speed (Ft/Sec)	65	65
Storm Tide (Feet)1/	17	17
Total Depth (Feet)2/	77	77
Wave Height (Feet)	5	8
Wave Period (Seconds)	4	6
Wave Length (Feet)	90	170
Wave Crest Elevation (Feet)2/	20	21
Wave Trough Elevation (Feet)2/	15	13

1/Datum is MLLW.

2/Assumes a Water Depth of 60 Feet Below MLLW.

Tidal information for the marine terminal site is based primarily on records from a tide station within Landlocked Bay. Predicted tidal planes at the site are listed in Table 8.3-9 below.

TABLE 8.3.-9

TIDAL CHARACTERISTICS OF THE POTENTIAL BIDARKA SITE

Tidal Plane	Elevation
Highest Astronomical Tide	15.1 Feet
Mean Higher High Water	11.9
Mean High Water	10.9
Mean Tide Level	6.2
Mean Low Water	1.4
Mean Lower Low Water (Datum)	0.0
Lowest Astronomical Tide	-3.7

The above data pertain to tides which occur under normal conditions. However, the extreme tidal range may increase during the occurrence of a storm. At the marine terminal site, storm tides would be most severe when storm winds originate in the southern quadrant.

Currents of 0.3 knots have been reported near the entrance of Port Fidalgo. Currents at the site are not expected to exceed this value.

No ice is reported to form on Port Fidalgo or on Landlocked Bay. Thin ice may occur on the beach area at the head of the bay.

8.3.3.2.3 Navigable Waterway Approach Description

Access to the potential marine terminal site is via the central region of Prince William Sound, Port Fidalgo, and Landlocked Bay (Figure 8.3-9). The section of Prince William Sound adjacent to the entrance to Port Fidalgo is a large unobstructed body of water with an average depth in excess of 1200 feet.

The entrance to Port Fidalgo lies between Bligh Island to the north and Goose Island to the south, and is approximately five miles wide. No underwater obstructions are indicated on navigational charts of this area; consequently, a marked channel is not required.

The narrowest section of the approach route is the southern section of Landlocked Bay, north of its entrance, where the bay narrows to 0.8 miles. This section of the bay is straight, deep, and free of obstructions.

Aids to Navigation

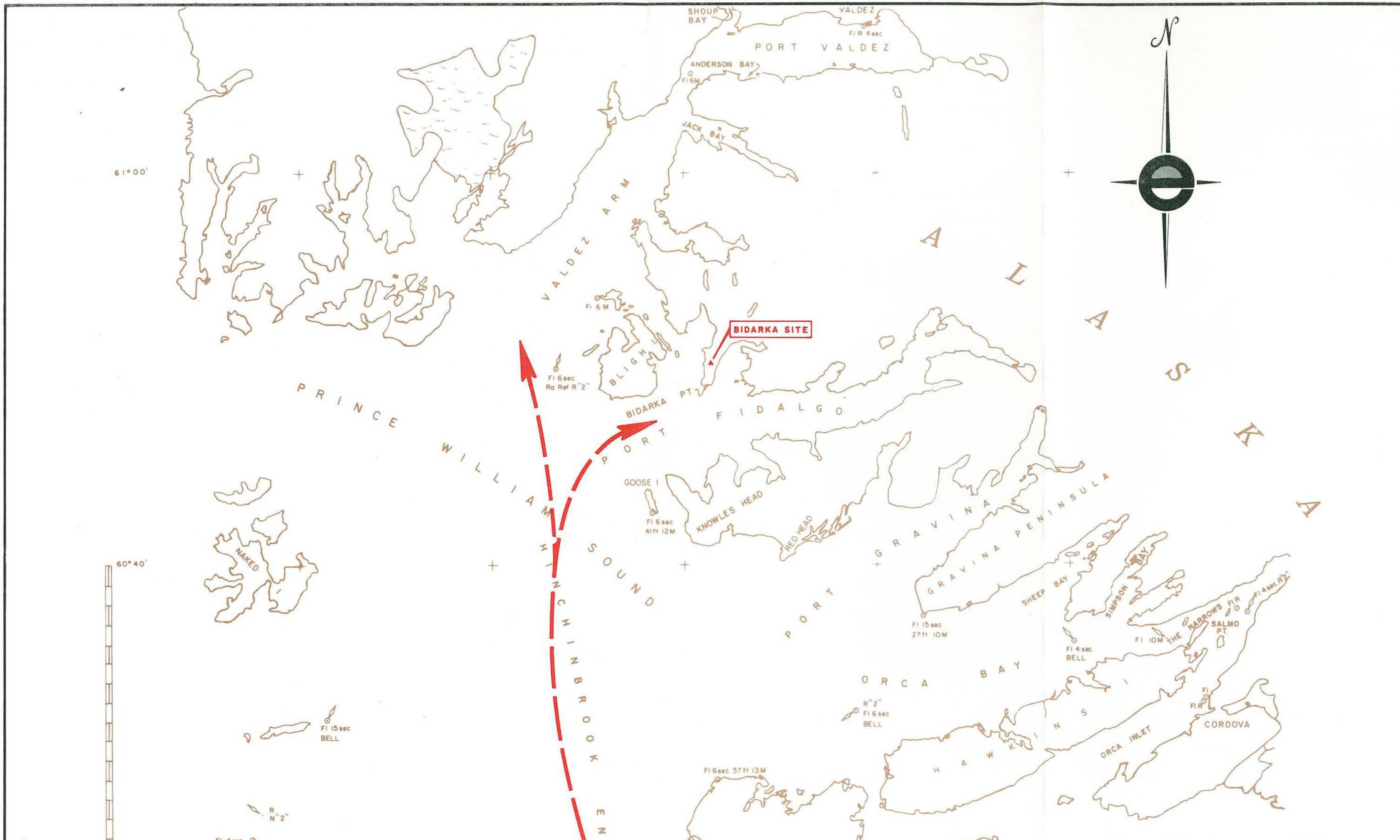
The central region of Prince William Sound presently has only three lighted aids to navigation: a lighted buoy is located on the western side of the sound near Smith Island; a lighthouse is located on the southwestern shore of Goose Island; and a lighted buoy marks Bligh Reef on the western shore of Bligh Island.

No aids to navigation exist in Port Fidalgo or Landlocked Bay. Although the lighthouse on Goose Island is located adjacent to the entrance of Port Fidalgo, the light is obscured in Port Fidalgo.

The U. S. Coast Guard is proposing to upgrade the aids already available and to establish additional aids in this area. However, none will be installed in Port Fidalgo.

Vessel Traffic Patterns and Safety Systems

The predominant vessel traffic in this area is comprised of ships traveling between the southern section of Prince William Sound and Valdez. This traffic moves primarily in a north-south direction. The numbers of vessels utilizing this route will increase substantially upon completion of the crude oil terminal in Valdez.



TRANS-ALASKA GAS PROJECT

NAVIGABLE APPROACH
POTENTIAL BIDARKA SITE

FIGURE 8.3–9

There is minimal amount of traffic in Port Fidalgo which is comprised of fishing boats and recreational craft. Traffic in Landlocked Bay is rare.

At present, no traffic safety systems exist in the Prince William Sound area. However, the U. S. Coast Guard has proposed the establishment of a traffic safety system in Prince William Sound to accomodate vessel traffic between the Gulf of Alaska and Valdez. The traffic safety system would consist of one northbound and one southbound safety lane. These lanes lead from Hinchinbrook Entrance to Valdez Arm, where they merge into one lane. Each individual lane is approximately one mile wide.

The northbound lane will be located about five miles west of the entrance to Port Fidalgo. The southbound lane will be located further to the west. No safety lanes have been proposed for Port Fidalgo.

Ship Anchorage Areas

There are few areas suitable for anchoring in the vicinity of the marine terminal site due to the deep water present. Water with a depth of less than 200 feet is located so close to shore that maneuvering room is severely limited.

The nearest area which may be used for anchoring is located off the southwestern coast of Port Fidalgo. For a distance of one mile off-shore, water depths range between 60 and 300 feet and the bottom conditions vary from soft to hard. The area is open to the west, north and east, and is partially sheltered on the south by the mainland. Due to the relatively close proximity of the anchorage area to land, the available maneuvering room is somewhat limited.

As part of the proposed traffic safety system, the U. S. Coast Guard has designated an anchorage area in the northern section of Orca Bay. By sea, this anchorage area is located 16 miles from the Bidarka site. While this area is also exposed to winds and waves, a larger maneuvering area is available.

8.3.3.2.4 Site Assessment

Evaluation of the potential Bidarka site indicates that it is a suitable location for a liquefaction plant. Approximately 500 acres of land are available for the plant site, and an additional 700 acres are available for use as a greenbelt. In addition, the marine aspects appear to be favorable for LNG carrier operation. However, because of the following disadvantages, the site, based upon the present conception of the project, is not considered to be a realistic and reasonable alternative to the proposed site:

(1) Installation of the natural gas pipeline to the potential plant site would be extremely difficult and costly, since the terrain north and west of the plant site is very rugged,

(2) The area in which the potential marine terminal site would be located could create certain limitations on the maneuvering room available for the LNG carriers. To the south of the site the maximum width of the bay is 0.8 miles. To the north and east of the site only an area measuring 1.5 miles by 0.5 miles is available for maneuvering,

(3) Because of the depth of the water, few suitable anchorage areas are available near the potential marine terminal site. Water with a satisfactory depth is found only near the shoreline, and the available maneuvering room is limited. The closest area which could be utilized is located on the southwestern side of Port Fidalgo. Though this area has relatively shallow water and suitable bottom conditions, it is located in open waters and provides little shelter from winds and seas, and

(4) A community, Tatitlek, is located three miles northwest of the potential plant site, and there are no high elevation points between the plant site and the village.

8.3.3.3 Valdez

A potential site is located at Valdez, on the southern shore of Port Valdez at approximately 61° 05' N., 146° 31' W. It is bordered by Anderson Bay to the west and Jackson Point to the east. The area in which the site is located is within the Chugach National Forest.

Adjacent to the proposed site is the Alyeska marine terminal. Roads will probably be constructed in conjunction with the Alyeska project along the oil pipeline right-of-way, which might provide access to the plant site.

Port Valdez, the northeastern terminus of Prince William Sound, is a glacial-cut fjord which is oriented along an east-west axis. The fjord is approximately twelve miles long and three miles wide. The shoreline of Port Valdez is very rugged and indented by numerous small bays and coves. Passage in or out of Port Valdez is via the Valdez Narrows, which is located in the southwestern end of the fjord.

Port Valdez has an average water depth in excess of 600 feet. Deep water extends very close to the southwestern shore. Towards the eastern end of the fjord, areas of very shallow water project further offshore. Port Valdez terminates in a tidal mud flat which extends about one mile off the mouths of the Robe and Lowe Rivers. The average water depth in this area is less than 18 feet.

The northern shore of the fjord has three major indentations in which shallow water occurs. The City of Valdez is located adjacent to one of these areas in the northeastern corner of the fjord. The second area occurs about midway between the eastern and western ends of the fjord, while the last major indentation is located in the northwestern corner of Port Valdez.

With the exception of the areas described above, the northern coast has deep water very close to shore. Some sections of the coast have water in excess of 300 feet deep within 100 feet of land.

The land bordering Port Valdez is extremely rugged with several mountains exceeding 4,000 feet above mean sea level. Numerous glaciers of various sizes are located in the higher elevations.

The only extensive area of relatively flat land is a glacial valley located at the eastern end of the bay, where two rivers and numerous creeks discharge into the fjord. The abandoned community of Old Valdez is located on this land. The valley extends inland to the east and north and ends at the foot of a glacier.

Average air temperatures for the Port Valdez area range between a low of 18^{o}F. and a high of 53^{o}F. Annual rainfall averages 59 inches, while total snowfall is approximately 244 inches.

8.3.3.3.1 Potential Plant Site Description (see Figure 8.3-10).

The potential plant site is located approximately 1200 feet from the southern shore of Port Valdez. Only 200 acres of land are readily available for the location of an LNG plant and related shoreside facilities. A 500-acre site may be obtained, but such land would require extensive site preparation work. A 700-acre greenbelt is also available (Figure 8.3-11).

Topography

The potential 200-acre plant site is located on relatively steep land which has an average slope of 11 percent and an elevation of 100 to 300 feet above mean sea level. The lower elevations are covered by a thick growth of hemlock, Sitka spruce and associated vegetation.

To obtain 500 acres of land, it is necessary to either incorporate land between the 300 and 500-foot contours, or extend the site parallel to shore between the 100 and 300-foot contours.

The additional land between the 300 and 500-foot contours is very steep. This results in an overall slope for the 500-acre plant site of 17 percent. Although the entire plant site would require substantial site preparation, the majority of this work would be necessary to modify the terrain which exceeds an elevation of 300 feet.

Drainage at the potential site is good. In addition to the steep terrain, two streams run through the site and drain into Port

PLANT SITE
GREEN BELT AREA

SCALE 1:63360

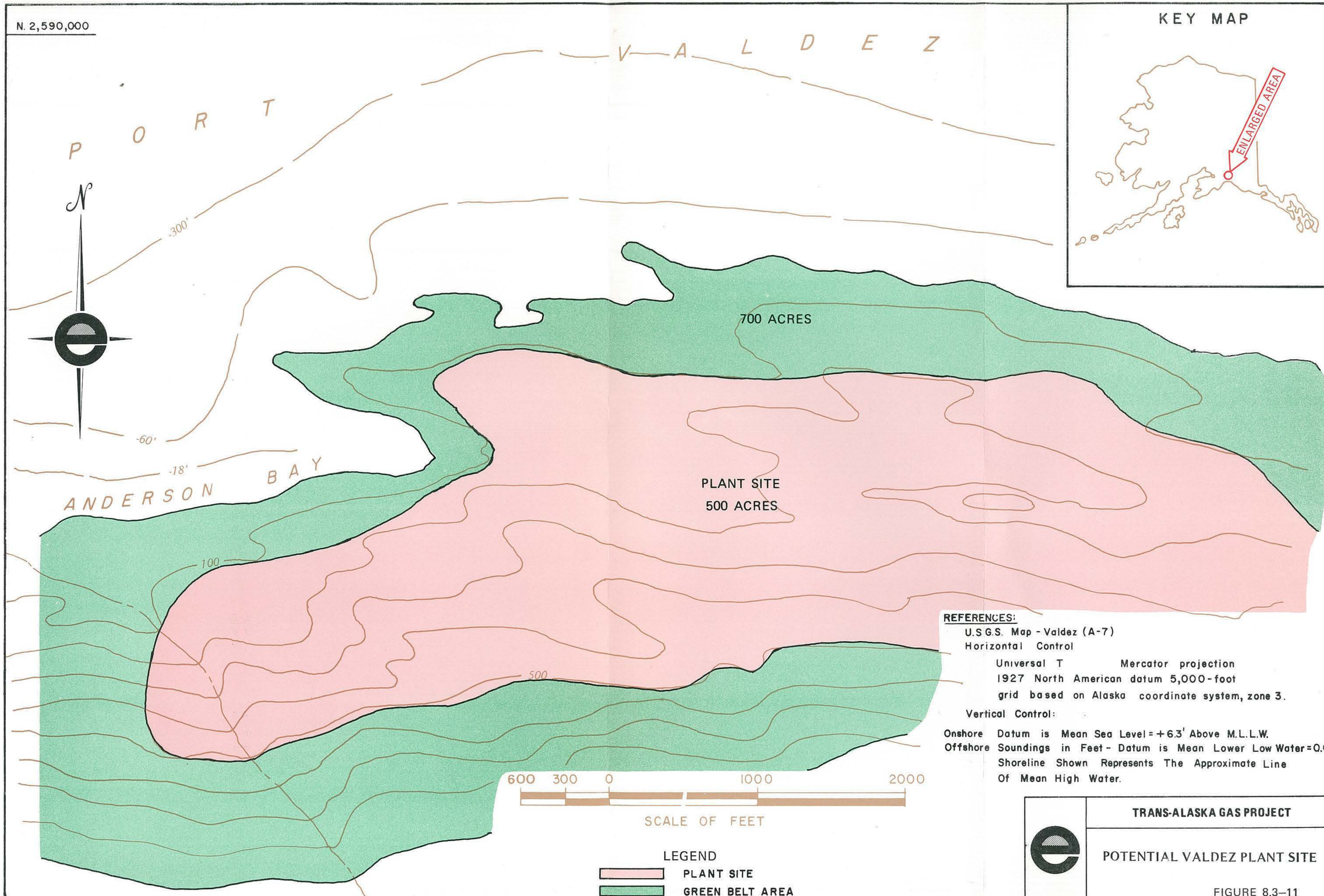
1 ½ 0 1 2 miles

REFERENCE U.S.G.S. Map - Valdez (A-7)

TRANS-ALASKA GAS PROJECT

POTENTIAL VALDEZ SITE

FIGURE 8.3–10



TRANS-ALASKA GAS PROJECT

POTENTIAL VALDEZ PLANT SITE

FIGURE 8.3–11

Valdez. These streams have formed small, incised valleys which provide a channel for run-off.

Soil Characteristics and Geology

Soil covers at the site are believed to be relatively thin and composed of organic peat and silt.

It is anticipated that the bedrock which underlies the site is comprised of thick bedded, well foliated slate and graywacke with lesser agrillite, arkosic sandstone and conglomerate of the Valdez group.

No active fault zones are known to exist in the vicinity. Also, there is no evidence of the occurrence of ground rupturing, subsidence or uplift at the site.

A preliminary evaluation indicates that unstable soils are not present at the site.

Proximity of Nearest Community

The nearest community is the City of Valdez, located six miles northeast of the plant site. In Valdez, transportation and port facilities, as well as various public services and utilities, are available.

Valdez has a 4300-foot long gravel runway which is utilized by several different airline companies. The Richardson Highway provides a connection to various points in the Alaskan interior. No railroad facilities are presently located in the city.

Waterfront facilities consist of a city pier, a fuel pier for large vessels and a small boat harbor (United States Coast Pilot, 1964). Available data indicate that deep-draft vessels can utilize the city pier, as the water depth adjacent to the pier ranges from 27 to 48 feet.

Accessibility of Pipeline

The terrain in the vicinity of the site is very rugged in areas, but installation of the natural gas pipeline would not be overly difficult. The land adjacent to the southern shore of Port Valdez is moderate enough to allow construction of the pipeline.

8.3.3.3.2 Potential Marine Terminal Site Description

The potential marine terminal site is located about 400 feet off the southern shore of Port Valdez, at a point approximately 2.5 miles east of the entrance to the fjord. The waters at the site range from a minimum depth of 60 feet, to over 600 feet, and no underwater obstructions are located in the area.

Due to the deep water and ample room available at the site, a marked channel or a turning basin would not be required. Dredging would also not be required.

Bathymetry

In the vicinity of the potential marine terminal site, the 50 to 60-foot water depth contour is located at a relatively constant distance offshore. The slope of the seafloor may be precipitous in some areas, with other areas less steep. The average slope is approximately 14 percent.

Soil Characteristics and Geology

It is estimated that the depth to bedrock at the site is less than 20 feet. Bedrock offshore is believed to be an extension of the onshore formations. Bedrock at the site appears to consist of metamorphosed slates and graywackes. The contact between the slate and graywacke is depositional, and fault contacts have not been observed. The rocks are fractured with joint sets in numerous directions and spacings

The 1964 Alaskan earthquake caused major changes in the bathymetry in certain parts of Port Valdez, especially in unconsolidated offshore deposits. As a result of the earthquake, Old Valdez was almost totally destroyed by the inundation of water from Port Valdez.

Preliminary investigation showed no bathymetrical feature offshore that would amplify a tsunami wave. In fact, evidence shows that water receded from Port Valdez rather than entering it during the 1964 earthquake. Although few investigations have been made, the very shape of the Port Valdez basin suggests that it is susceptible to seiching action. This is exemplified by the fact that wave debris was deposited at elevations in excess of 100 feet in portions of Port Valdez.

There is no indication that the site has been subjected to subsidence or uplift. Is not known if the seafloor sediments at the site are subject to liquefaction or landsliding.

Climatology

The mountains surrounding Port Valdez would shelter the potential marine terminal site from the more severe winds encountered in the Gulf of Alaska and in Prince William Sound. The site has a limited fetch to the east toward the head of the bay, and is relatively well sheltered in the remaining directions.

Available data indicate that prevailing winds occur primarily from the east or west, and seldom exceed a speed of eighteen miles per hour. The average speed of the wind is approximately six miles per hour. About nine percent of the time, light variable breezes are expected to occur at the site.

Though prevailing winds generally have a relatively low speed, the configuration of Port Valdez and the nature of the surrounding topography can channel and intensify winds when certain conditions exist. Wind speeds have reportedly reached 100 miles per hour in the past as a result of this channelling effect. Table 8.3-10 below lists information pertaining to storm winds and their persistence.

TABLE 8.3-10

STORM WINDS FOR PORT VALDEZ, ALASKA

Recurrence Interval (Yr)	Maximum Gust (MPH)	1 Minute (MPH)	1 Hour (MPH)	3 Hours (MPH)	6 Hours (MPH)
1	65	40	31	28	26
2	67	42	32	29	27
10	83	52	40	36	34
25	93	58	45	41	38
50	99	62	48	43	40
100	107	67	52	47	44

The frequency of reduced visibility in the Valdez area has two maxima during the year, with one occurring in February and one occurring in August. Table 8.3-11 indicates the percentage occurrence of periods of reduced visibility at Port Valdez based on observations conducted during 1972. For all periods when visibility was reduced one-half mile, 62 percent of these occurrences lasted less than three hours and no occurrences lasted longer than twelve hours.

TABLE 8.3-11

PERCENTAGE OCCURRENCE OF PERIODS OF REDUCED VISIBILITY AT VALDEZ, ALASKA

Visibility Less Than	0-3 Hr.	3-6 Hr.	6-12 Hr.	12-24 Hr.	24 Hr.
5 Miles	38	22	32	6	2
1 Mile	53	31	13	2	2
1/2 Mile	62	19	19		

Oceanography

Since the potential marine terminal site is exposed to only limited fetches of open water, wave activity at the site is expected to be slight.

An annual summary of significant waves indicates that waves from one to three feet in height occur only 10 percent of the time, while wave heights of less than one foot are present 90 percent of the time. The month of January exhibits the highest and most frequent waves, while normal wave action during the month of July is at a minimum.

Though high storm winds may be encountered at the site, storm waves are not expected to be substantial in height because of the limited amount of open water. Table 8.3-12 presents the anticipated storm wave characteristics at the site for a storm with a 100-year recurrence interval.

TABLE 8.3-12

STORM WAVE AND TIDE CONDITIONS AT THE POTENTIAL VALDEZ SITE

	Significant Wave	Maximum Wave
Recurrence Interval (Years)	100	100
Wind Speed (Ft/Sec)	76	76
Storm Tide (Feet)1/	17	17
Total Depth (Feet)2/	77	77
Wave Height (Feet)	5	9
Wave Period (Seconds)	5	6
Wave Length (Feet)	104	195
Wave Trough Elevation (Feet)2/	15	13
Wave Crest Elevation (Feet)2/	20	22

1/Datum is MLLW.

2/Assumes a water depth of 60 feet below MLLW.

Tides at Port Valdez are characterized by two unequal low waters and two unequal high waters, occurring over a period of slightly more than 24 hours, as shown in Table 8.3-13 below.

TABLE 8.3-13

TIDE CHARACTERISTICS OF THE POTENTIAL VALDEZ SITE

Tidal Plane	Elevation (Ft.)
Highest Astronomical Tide	15.3
Mean Higher High Water	11.8
Mean High Water	10.9
Mean Tide Level	6.2
Mean Low Water	1.5
Mean Lower Low Water (Datum)	0.0
Lowest Astronomical Tide	-3.7

In the absence of meteorological effects, it appears that a tidal current of approximately 1.2 knots could occur at the Port Valdez Site. Average speeds would probably be less than this and would gradually decrease with depth.

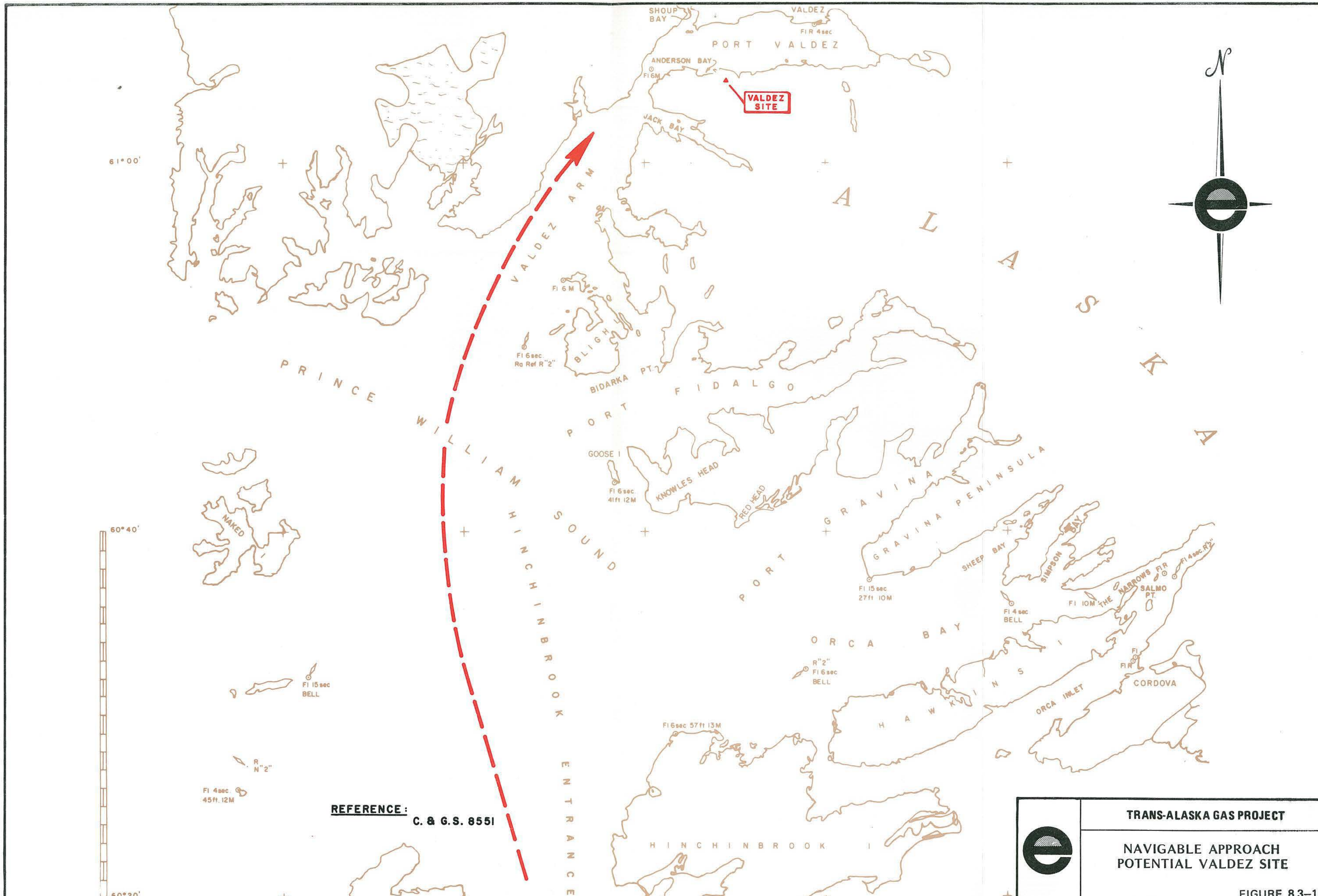
Port Valdez is generally assumed to be ice free during the entire year. On one occasion ice is reported to have attained a thickness of three inches in the Valdez boat harbor; however, ice rarely occurs as a continuous sheet. Some shore ice could develop in the intertidal zone within Port Valdez, but no serious problems are expected to arise from this condition. It is possible that Shoup Glacier could calve into Shoup Bay and Port Valdez under favorable wind and tide conditions. However, these occurrences are infrequent, especially since the entrance to Shoup Bay is blocked by a sand bar which has only three feet of water over it.

8.3.3.3.3 Navigable Waterway Approach Description

Access to the potential marine terminal site is via the north central region of Prince William Sound, Valdez Narrows, and the western end of Port Valdez (Figure 8.3-12). The northern section of Prince William Sound is very wide and water depths in this area average in excess of 1,200 feet.

Valdez Arm extends to the northeast from the central region of Prince William Sound. The entrance to Valdez Arm lies between Glacier Island to the west and Bligh Reef to the east and is about six miles wide. Water depths in Valdez Arm range from 1,200 feet by Glacier Island to 60 feet in the vicinity of the reef.

Northeast of the entrance, Valdez Arm narrows gradually for a distance of 13 miles. At the northeastern end, there is an abrupt constriction in the width of the channel. This area, known as Valdez Narrows, comprises the entrance to Port Valdez.



TRANS-ALASKA GAS PROJECT

NAVIGABLE APPROACH
POTENTIAL VALDEZ SITE

FIGURE 8.3–12

The western end of Port Valdez is very deep and allows ample maneuvering room. No submerged obstructions exist between the entrance to Port Valdez and the marine terminal site.

Aids to Navigation

There are only two lighted aids to navigation presently available in the southern end of Valdez Arm. A lighted buoy marks the location of Bligh Reef on the eastern side of the entrance. A lighthouse, located about four miles northeast of the buoy, marks the position of Busby Island on the eastern shore of Valdez Arm.

No aids to navigation are located in the central region of Valdez Arm. The only additional aid available is located on the rock which divides the Valdez Narrows.

Only one aid is located in Port Valdez. This light is located adjacent to Valdez in the northeastern end of the fjord. No aids are available near the site.

The U. S. Coast Guard has proposed to install additional aids on the approach route to Valdez. Lights will be installed at the western side of the entrance to Valdez Arm, the central region of Valdez Arm, and on each side of the entrance to Valdez Narrows. A light will also be installed in the southwestern corner of Port Valdez about 2.5 miles west of the marine terminal site.

Vessel Traffic Patterns and Safety Systems

All traffic in this region is travelling between the central region of Prince William Sound and the city of Valdez, as no other port facilities are presently located in the area. Traffic at the present time is light to moderate. However, upon completion of the Alyeska crude oil terminal in Port Valdez, the number of ships utilizing this route will increase substantially.

While no traffic safety system is presently available in Prince William Sound, a system has been proposed by the U. S. Coast Guard to accommodate the anticipated increase in traffic. The major area of concern is the upper reaches of Valdez Arm and Valdez Narrows.

Most of the system will consist of a northbound safety lane. These lanes originate in the Gulf of Alaska, pass through the central region of Prince William, and terminate in the entrance to Valdez Arm. These lanes will be separated by a minimum distance of one mile.

Due to the narrow constriction in the upper reaches of Valdez Arm, only one safety lane has been proposed for this area. Traffic in this lane will be one way, alternating between northbound and southbound ships. The lane will end at the northern end of Valdez Arm. No lanes have been proposed for Port Valdez.

Ship Anchorage Areas

There are no areas in the vicinity of the marine terminal site which are suitable for use as an anchorage area because of the great water depths which prevail in Port Valdez. Water of a suitable depth is located so close to shore that maneuvering room would be severely limited.

8.3.3.3.4 Site Assessment

A major disadvantage associated with the potential Valdez plant site is the rugged topography of the only land which could be utilized for the LNG plant and related facilities. Only 200 acres at the site would not require extensive site preparation prior to construction. The remaining 300 acres of the site are located between the 300 and 500-foot contours on land which is very steep. While the marine conditions appear, for the most part, to be favorable to LNG carrier operations, the topographic disadvantages and the following other disadvantages caused this site, at this time to be eliminated as a realistic and reasonable alternative to the proposed site:

(1) There will be substantial vessel traffic utilizing the route to the potential site upon completion of the crude oil terminal in Port Valdez,

(2) In the vicinity of the potential site, all vessel traffic will be heading for, or departing from the entrance to Port Valdez. Since the entrance is located about 2.5 miles west of the potential marine terminal site in the southwestern corner of the bay, much of the traffic may be moving relatively close to shore in the vicinity of the site. Consequently, the area available for maneuvering in the vicinity of the site may be periodically limited due to vessel traffic,

(3) Because of deep water, suitable areas for anchoring are not available near the site. LNG carriers might be required to anchor several miles outside of Port Valdez, and

(4) The nearest community is six miles away from the potential plant site, and no prominent land masses intervene between the site and the populated area.

Section 8.4
Alternate Pipeline Routes

8.4 ALTERNATE PIPELINE ROUTES

As indicated in Section 8.3.2 of this Report, alternate pipeline routes to western Alaskan ports (Norton Sound and Bristol Bay), Lynn Canal, and to the Cook Inlet/West Prince William Sound area have been rejected by the Applicant because suitable LNG Plant and marine terminal sites that meet the Project requirements could not be found. A pipeline route to east Prince William Sound, generally parallel to the Alyeska crude oil line has been chosen.

The Applicant has concluded that the proposed route between Prudhoe Bay and Gravina is best in terms of environmental, economic, and engineering factors. This conclusion is based upon an evaluation of other possible pipeline routes and route segments between Prudhoe Bay and Gravina (Figure 8.4-1), the results of which are summarized below.

8.4.1 Anaktuvuk Alternate Route, MP A-0 to MP A-312

Alternate MP A-0 to Alternate MP A-50

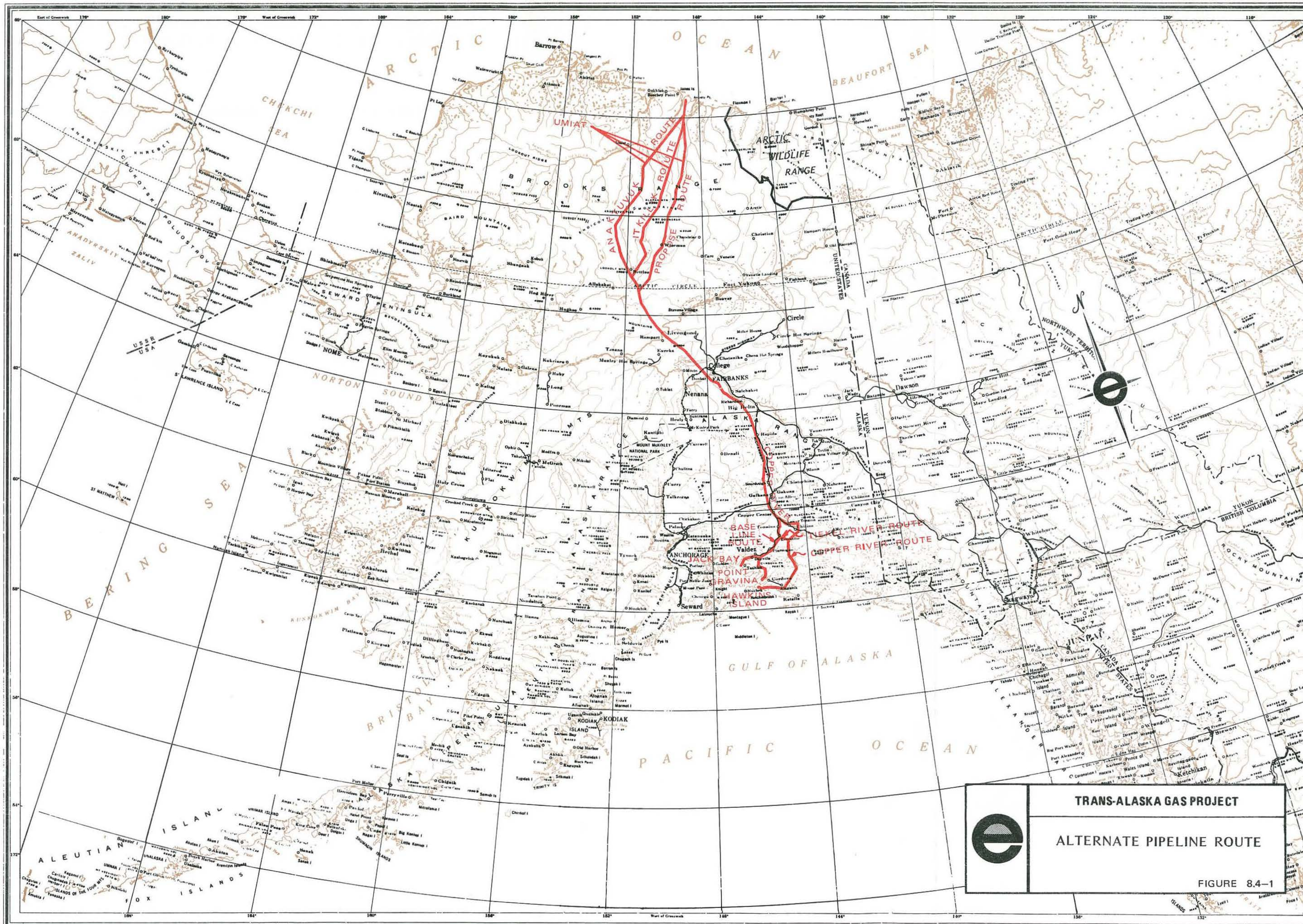
This segment is the North Slope portion of the route, from Prudhoe Bay to the north side of the White Hills.

Departing the vicinity of the Prudhoe Bay origin point, the Anaktuvuk gas line alternate route follows closely the proposed route for the first 25 miles, then turns slightly to the southwest. The route crosses the Toolik River, and roughly parallels the Kuparuk River to the White Hills. This whole segment is across the Arctic Coastal Plain, (North Slope) a featureless plain, imperceptibly rising to the south, and dotted with thousands of shallow lakes. The plain is underlain by permafrost, much of it high in ice content, fine-grained material, overlying frozen gravels. There are no trees, only grasses and moss, with a few dwarf willows along the water courses.

Alternate MP A-50 to Alternate MP A-163

This 113-mile segment is across the foothills of the Brooks Range, from the White Hills to Nasaurak Mountain.

The route skirts the north side of the White Hills, continues southwest, crossing the Kuparuk, Itkillik, and Nanushuk Rivers before entering the Anaktuvuk Valley near Rooftop Ridge. At MP A-148 the route continues southward about 45 miles before entering the Brooks Range.



TRANS-ALASKA GAS PROJECT

ALTERNATE PIPELINE ROUTE

FIGURE 8.4–1

Permafrost is continuous, except in the immediate vicinity of the water courses. The route is underlain by high ice content silts with occasional bedrock outcrops and till deposits in the areas between water courses, while sand and gravel are found along the streams, and older river terraces. The topography is flat to gently rolling, and consists entirely of tundra, or bare ground in river floodplains.

Alternate MP A-163 to Alternate MP A-255

This 92-mile segment is across the Brooks Range, from Nasaurak Mountain on the north to Button Mountain on the south. From Nasaurak Mountain the route follows the Anaktuvuk River Valley southward for about 16 miles to Anaktuvuk Pass at the Continental Divide, then down the south side of the Brooks Range via the John River Valley.

Soils in both the Anaktuvuk and John River Valleys consist of sand and gravel in the streams and river terraces, and talus, alluvial fans, and till along the valley edges, with a veneer of colluvial silt on top. Permafrost is continuous, except in the immediate vicinity of streams. Segregated underground ice may be expected almost anywhere. Aufeis is a common annual occurrence, especially on the Anaktuvuk River. Both valleys are wide, due to glacier modification, and have large flat bottom sections. The route utilizes both valley bottoms and slopes at the valley edges; whichever is the most convenient. The last 14 miles of this segment diverges at Crevice Creek, following an old winter trail, which parallels the John River about 2 miles on the east. Most vegetation along the route is brush and small trees, both spruce and deciduous; but with larger spruce trees along thawed river floodplains.

Alternate MP A-255 to Alternate MP A-312

From Button Mountain the route proceeds southeastward through low hills, and along the northeast edge of Kanuti Flats, rejoining the proposed route at milepost 290.

From Button Mountain the route crosses the Ninemile Hills through Ninemile Creek Valley, crossing the Koyukuk River about 2 miles upstream of Bettles Field. The route skirts the edge of Kanuti Flats, along the toe of low hills, thereby avoiding swamp construction. The route crosses two more ridges of low hills, the South Fork Koyukuk River, Jim Creek, Bonanza Creek, then follows Fish Creek Valley for about 6 miles before tying into the Base Line Route at milepost 290. Frozen eolian and colluvial silt is expected in valley bottoms, and along lower hill slopes. Some bedrock outcrops along the higher hillsides, and gravels along the river floodplains are expected. Vegetation in general, consists of brush and small trees, with large spruce trees along the thawed areas of river floodplains. Major crossings for the Koyukuk, South Fork Koyukuk, and Jim Rivers are required, although no unusual problems are expected.

Route Evaluation

Because the Anaktuvuk alternative is 22 miles longer than the proposed route, and because it lies outside of the designated Utility Corridor, it was not considered a reasonable alternative to the proposed route.

8.4.2 Itkillik Alternate Route, MP I-0 to MP I-299

Alternate MP I-0 to Alternate MP I-47

This segment covers the North Slope portion of the route, from Prudhoe Bay to the north side of the White Hills.

Beginning at the Prudhoe Bay origin point, the route proceeds southward across the Arctic Coastal Plain (North Slope), a featureless plain, imperceptibly rising to the south, dotted with thousands of shallow lakes. The whole segment is underlain by continuous permafrost, much of it high ice content, fine-grained material, overlying frozen gravels. There are no trees, only grasses and moss with a few dwarf willows along the water courses. Crossings of the Putuligayuk and Toolik Rivers are required, but few problems are expected.

Alternate MP I-47 to Alternate MP I-140

This 93-mile segment is across the foothills of the Brooks Range, from the White Hills to Itkillik Lake.

The route crosses the White Hills at their eastern edge, and proceeds almost due south, paralleling the Toolik River across hills forming the western edge of the Toolik basin. The route leaves the Toolik River near Kakukturat Mountain, crossing into the headwaters of the Kuparuk River. The route crosses the Kuparuk River, at a narrow crossing, just north of Imnaviat Mountain and Itigaknit Mountain. Crossing a low divide the route enters the drainage basin of Itkillik River, following low hills and small valleys to Itkillik Lake.

This whole segment is gently to moderately rolling country, underlain by continuous permafrost. High ice content, fine grained materials mantling the hills, and gravels in the streams and floodplains are expected. There are no trees, only grasses and moss, with a few dwarf willows along the water courses.

Alternate MP I-140 to Alternate MP I-167

From Itkillik Lake the route crosses the Itkillik River and follows the western edge of Itkillik Valley to the Continental Divide at Snowheel Mountain. The Itkillik Valley is a wide glacier modified valley with talus and alluvial cones extending into the flat bottomed valley from the rugged mountainsides. The pipeline route utilizes both the flat alluvial valley bottom and the encroaching talus and alluvial slopes, whichever offers the best route. Permafrost is continuous, except areas near the water courses which are not underlain by permafrost. There are no trees, only grasses and moss in the lower slopes and valley bottoms, and bare rock slopes elsewhere.

Alternate MP I-167 to Alternate MP I-241

This 74-mile segment, from the Continental Divide to the southern edge of the Brooks Range, follows the North Fork of the Koyukuk River. The valley is wide, glacier modified with talus and alluvial slopes encroaching onto the flat valley bottom. Mountains, forming both sides of the valley, are rugged, especially near the Continental Divide. The valley gradually widens southward until at MP I-241 the valley opens to the Koyukuk Valley and the foothills of the Brooks Range. Continuous permafrost is expected, except for thawed gravels in and near the water courses. The route is forested by large white spruce near the rivers, stunted spruce in wet areas, and birch in dry areas. The pipeline route utilizes both slope areas and valley bottom areas, whichever is most convenient.

Alternate MP I-241 to Alternate MP I-299

From alternate milepost I-241, near Florence Creek Lake, the route proceeds southwest then turns southeast along the edge of the Kanuti Flats, rejoining the proposed route at milepost 290.

From Florence Creek Lake the route proceeds southwest along the western edge of the Koyukuk River Valley, then turns southward. After crossing the Koyukuk River about 8 miles upstream from Bettles Field, the route skirts the western edge of the Jack White Range, to the Kanuti Flats. Following the northeast edge of the Kanuti Flats to avoid swamp construction, the route crosses the South Fork of the Koyukuk River and Jim River. Continuing southeastward, the route crosses a range of low hills, then Bonanza Creek before entering Fish Creek Valley. The route proceeds about 6 miles up Fish Creek Valley before rejoining the Base Line route at milepost 290. There are three major river crossings in this segment, although no unusual problems are expected. Vegetation, in general, consists of brush and small trees, with large spruce trees along the thawed areas of river floodplains. Soils along this section consist of silts with alluvial sands and gravels in the vicinity of the streams. Permafrost is discontinuous, usually present in the silty areas between drainages and absent along the streams.

Route Evaluation

Because the Itkillik Alternative is 9 miles longer than the proposed route, and because it lies outside of the designated Utility Corridor, it was not considered a reasonable alternative to the proposed route.

8.4.3 Copper River Alternate Route, MP CR-0 to MP CR-195

This alternate was considered only as a possible route to Hawkins Island. MP CR-0 is equivalent to Base Line MP 674.

Alternate MP CR-0 to Alternate MP CR-56

The gas pipeline route in this Section, after leaving the proposed route at milepost 674, just south of the Tazlina River crossing, continues within the Copper Basin. The route generally parallels the proposed trans-Alaska oil pipeline route for about 12 miles; crossing it two times. The route crosses the Klutina River about 1 mile upstream of the proposed oil pipeline crossing, continues in a southeasterly direction for about 4 miles, before diverging from the proposed oil pipeline route. After crossing the Richardson Highway, the route, for about 27 miles to milepost 39, roughly parallels both the Richardson Highway and the Copper River, about equidistant from each. The route, over these 27 miles, traverses rather flat terrain composed of fine sands, silts, and clays. The route crosses the Copper River about one mile upstream of the Tonsina River's confluence with the Copper. Since the Copper River is deeply incised within lacustrine sediments, both the approach and exit routes to the crossing are over steep bluffs, which may be frozen and contain varying amounts of ice. The Copper River drains an area of about 15,000 square miles at the pipeline crossing and, therefore, must be considered a major river. Unlike most major rivers, the Copper River has a steep gradient, producing a very swift current. Due to the swift current and alluvial bottom, deep stream bed scour may be expected. From the Copper River Crossing to milepost 56, a distance of about 16 miles, the route has gentle to moderately sloping terrain, underlain by lacustrine sediments. These 16 miles, although generally fairly flat, are interspersed with deep gullies and canyons eroded by the streams crossing the area. There are about one dozen of these gullies and canyons, the most notable of which are the Kotsina and Chitina Rivers whose canyons are in excess of 100 feet deep. A major pipeline crossing will be required for the Chitina River, an east-west basin draining about 4,000 square miles.

Most of this 56-mile segment is covered with stands of white spruce, birch, and aspen forests interspersed by areas of willow and alder brush. There are also clear areas where the muskeg soil conditions will not support vegetation other than moss and grass.

Alternate MP CR-56 to Alternate MP CR-135

After crossing the Chitina River, the gas pipeline route proceeds through the Chugach Mountains via the canyon of the Copper River. Beginning this portion of the route, the pipeline would skirt, for about 1 mile, along the foot of bedrock bluffs forming the left side of the Chitina River canyon. For the next 2 miles the route is along the base of the mountains about 0.25 mile from the Copper River. After crossing Taral Creek the gas pipeline must negotiate a steep bedrock slope to gain access to a bedrock shelf along which the route proceeds for the next 4 miles. The route in this segment is interrupted by a very deep, steep walled canyon cut into bedrock by Tenas Creek. Descending a steep bedrock slope, the route crosses the 0.25 mile wide Canyon Creek alluvial fan. Again, a steep bedrock slope must be ascended to gain access to a bedrock bench with only moderate side hill slopes for the next 2 miles. Descending from the bench over a bedrock ridge, the left bank approach to the Copper River crossing is made.

This crossing of the Copper River will be exceedingly difficult. As mentioned above, the Copper is a major river, has a very steep slope, alluvial streambed, and, at this crossing, has very little area for over-bank flow. Therefore, during floods the river stage and velocity increase dramatically, with consequent deep scour of the streambed. A stream gauge at Taral, operated for 19 years, shows the flood of record to be 265,000 cfs. The average streamflow during the period of record is 36,600 cfs, with an average summer discharge of 50,000 to 100,000 cfs. Winter discharge decreases drastically, varying from about 4,000 to 8,000 cfs. Although streamflow is low, winter working conditions are poor; it is cold and the wind blows with near hurricane force.

After gaining the right bank of the Copper River, the route for 6 miles continues through a bedrock area sculptured by glaciers. This area is composed of bedrock knobs, ridges, and rock ribs with swampy muskeg areas between. The muskeg areas were formed by vegetation filling glacier-scoured depressions. The route, beginning at Uranatina River, in order to avoid two additional crossings of the Copper River, stays on the west side of the river for the next 68 miles.

Steep mountain slopes, terminating at cliffs with the Copper River flowing at their base, dictate the route utilized by the railbed of the abandoned Copper River and Northwestern Railroad (CRNWRR). From Uranatina River to Tiekel River, a distance of about 12 miles, the route follows the CRNWRR right-of-way which is benched into very steep bedrock slopes and cliffs. This right-of-way needs to be widened to accomodate the pipeline and laying equipment. Entering the Tiekel River Valley at about MP 84, the route crosses for about 1 mile the Tiekel River's alluvial outwash fan, composed of gravels with sands and silts. After crossing the alluvial outwash fan and the Tiekel River, the route must again utilize the old railroad right-of-way. For about 7 miles, the route hugs the old railbed bench in the rock slopes or utilizes river terraces to traverse the segment from Tiekel River to Cleve Creek. In some places the Copper River has eroded the stream terraces, destroying the old railbed; therefore, a new bench must be made in the rock slope and/or the river must be moved off the right-of-way using control structures. After crossing Cleve Creek, the route follows relatively flat, heavily forested ground for about 1.5 miles, before turning off the old railbed and proceeding directly upslope.

After rising about 1,200 feet in elevation, the route gains access to a modest bench in the mountainside. Proceeding southward along this bench, the route crosses Jackson Creek and follows a pass from

Jackson Creek to an unnamed creek about 1 mile to the south. The route follows the unnamed creek valley for about 1 mile, then goes over a broad ridge and enters another pass area. This pass area is a glaciated valley occupied by a small stream and lake formed between the main mountain and an elongated hill, forming the Copper River's right bank. The route follows a sidehill area at the head of the pass then follows along the base of the mountain until emerging in the Tasnuna River Valley. For about the next 7 miles, the route crosses the Tasnuna River Valley, going over old moraine and outwash deposits. Most of this area is low swampy ground formed by infilling or morainal lakes. Leaving the Tasnuna River Valley after crossing the Tasnuna River, the route parallels the Copper River on abandoned river terraces, between the river and mountain's base.

The next 3 miles cross the Allen Glacier outwash fan. This portion of the route is flat and composed of bare gravel with patches of alder brush. Five miles of the route lie between the Copper River and Allen Glacier. This 5-mile segment is a problem area, because there are only four potential routings, all of which pose difficulties. One route goes on the west through the active terminus of Allen Glacier. This area is composed of ice with enclosed detritus, all of which is in motion (glacier flow). A second possible route follows through a morainal lake and swamp, between the active glacier terminus and the older glacier moraine. A third route goes through the older terminal moraine, which has massive inclusions of relict ice buried within the mass. These areas of ground ice are continuously thawing with consequent subsidence of the ground surface. These masses are too large to prethaw, and also too large to refrigerate. The fourth possibility follows the Copper River. The Copper River is too large and too wild a river in which to lay several miles of pipe. The only feasible route through this area is through the morainal lake and swamp. This area has the best chance of being free of buried ground ice as the warming effect of the lake may have prethawed it. However, this route would be quite susceptible to adverse effects of even small glacier surges experienced by Allen Glacier. The pipeline need not be over-run by encroaching glacier ice to experience distress. Any surge of a few hundred feet or more would set forth ground compression waves ahead of the advancing ice face. Even though this route may not be completely free of buried ice and may experience distress from glacier surges, it is the best of several poor choices.

During construction of the Copper River and Northwestern Railroad, Miles Glacier occupied an area several miles ahead of its present terminus. This earlier position forced the Copper River against the western wall of the Valley where it flowed through the former site of the Abercrombie Rapids. Due to the subsequent retreat of Miles Glacier, the Copper River now flows against the eastern edge of the valley behind the old terminal moraine, and into Miles Lake. From Allen Glacier to the Copper River crossing at Miles Lake, a distance of about 7 miles, the proposed pipeline route would occupy the now abandoned river channel of the Copper River. This area is flat and composed of bare sand and gravel. Of any crossing of the Copper River, the pipeline crossing at the outlet of Miles Lake is the best. This is due to the outlet of the lake acting as a broad crested weir, with consequent lower approach velocities of the water at the crossing site. The crossing must be buried rather deeply; however, as the larger icebergs calved from the face of Miles Glacier, which comprises the eastern 3 miles of Miles Lake, become grounded in this area. Miles Glacier impounds Van Cleve Lake, a 7 square mile glacier-dammed lake, and two others of much smaller size. Periodically, when those lakes "fill up," water forces its way under the ice mass, forming a conduit and the lake completely drains. Gauge height records obtained by Copper River and Northwestern Railway Co. personnel show that a midwinter release of Van Cleve Lake produced a flood of about 200,000 cfs in 1909. Coupling a glacier-dammed lake release with 50,000 to 100,000 average summertime flow of the Copper River, as measured at Taral, plus the inflow of the Bremmer, Tiekel, and Tasnuna Rivers, a flood exceeding 300,000 cfs could be expected at this crossing site each time Van Cleve Lake releases during summer.

Alternate MP CR-135 to Alternate MP CR-146

This 11-mile segment, between the Miles Lake crossing of the Copper River to the beginning of the Delta crossing of the Copper River, holds few problems for the pipeline route. The route utilizes the flat valley bottom, along the east side of the valley, that is no longer subject to inundation during periods of high water. The area is covered by stands of spruce timber and dense brush and is underlain by gravel and sand with a silt cap. The only potential problem is the effect of flooding from a lake impounded by McPherson Glacier. However, since the pipeline is located on the flat areas away from the alluvial fan outwash of McPherson Glacier, the problem is minimal.

Alternate MP CR-146 to Alternate MP CR-157

The next 11 miles of the gas pipeline are across the Copper River Delta. The river in this segment is composed of myriads of distributary channels each carrying a varying portion of the total flow. By paralleling the existing Copper River Highway, the channel locations are fixed by bridges constructed by the Alaska Department of Highways. The total length will have a wet ditch requiring flotation anchors and/or concrete coating on the pipe, although only a small portion can be considered as river crossing. The largest of the channels is located at the western edge of the delta and probably carries 50 percent of the total flow. Floods of 300,000 cfs or more can be expected every few years, depending on the frequency of release of Van Cleve Lake during summer high flow periods. Average summer flows are large, probably near 100,000 cfs; but winter flows are small, estimated at about 10,000 cfs.

The material comprising the delta is fine gravel, sand, and silt. Coupling the high velocity of the river with the fine grained bed material, river bed scour may be expected. Except for a small segment at the eastern edge of the Delta and on Long Island (which have dense stands of poplar, alder, and willow) bare sand and gravel bars may be expected.

Alternate MP CR-157 to Alternate MP CR-178

This segment of the gas pipeline route crosses flat plains formed by abandoned delta deposits of the Copper River and coalescing outwash fans from several large glaciers. The area is covered by large stands of Sitka spruce and hemlock interrupted by wide braided streams whose floodplains are bare gravel or moderate stands of willow and alder brush. Alaganik Slough, Glacier River, an unnamed river flowing from Scott Glacier, and Eyak River must be crossed. Only Glacier River and the unnamed river present any problems. These two rivers are abundantly supplied with sediments by their respective glaciers. For this reason they do not have well defined stable channels, but rather the channels meander over a very wide area. However, by paralleling the Copper River Highway, the Alaska Department of Highways bridges and training structures may be utilized for a reasonably stable channel location. Material composing this area is gravels and sands, with a silt cap in the forested areas. The groundwater table is high and the whole segment will require anti-flotation measures for the pipeline.

Alternate MP CR-178 to Alternate MP CR-188

This segment crosses the Heney Range, utilizing a small unnamed creek valley on the east, through a pass about a mile north of Heney Peak, and down the Heney Creek Valley on the west. After following Heney Creek Valley for about 2 miles, the pipeline route turns to the southwest paralleling the Heney Range on either rock benches (where available), or benches cut into the sidehill. The pipeline route turns to the northwest for the last mile to the approach of the Orca Inlet crossing. The material composing this 10 mile segment is bedrock covered by thick spruce and hemlock forest, except for about 2 miles of the route which is above 1,500 feet elevation, where thick brush predominates.

Alternate MP CR-188 to Alternate MP CR-191

The Orca Inlet crossing is over tidal mud flats composed of fine sand and silt, most of which is bared at low tide. There are three channels which do not go dry at low tide. Total width of these channels is about one mile, or one-third of the total crossing. The depth of the channels varies from only a few feet to about 20 feet at mean lower low water, and they shift location with time. The entire three-mile crossing would be buried at sufficient depth to accommodate such shifting without uncovering the pipeline.

Alternate MP CR-191 to Alternate MP CR-195 (END)

This 4-mile segment, beginning at the end of the Orca Inlet crossing, traverses Hawkins Island. The route, after leaving the beach at Orca Inlet, crosses several hills comprising the backbone of the island, utilizing a pass and glaciated valleys wherever possible. The route is covered by dense spruce and hemlock forests, interspersed with open brushy patches in the higher elevations or where conditions do not permit forest growth. The route is primarily underlain by bedrock, although short sections may be stream gravels or muskeg.

Route Elevation

This route would present extremely difficult pipeline construction requirements along the environmentally sensitive Copper River Valley, particularly the area between the Copper River and Allen Glacier. In addition, the route would require a submarine pipeline to Hawkins Island. LNG Carrier anchorage conditions at potential sites on Hawkins Island are poor. For these reasons, and because much of the Copper River alternative route is outside the designated Utility Corridor, this route was not considered a realistic and reasonable alternative to the proposed route.

8.5 ALTERNATE DESIGNS, PROCESSES, AND OPERATIONS

8.5.1 Alternatives Within the Pipeline Corridor

The proposed gas pipeline route extends from Prudhoe Bay to Prince William Sound, utilizing wherever possible the designated Utility Corridor. This section describes the nine segments of Applicant's route that are separated by more than 3,000 feet from the oil pipeline route, and outlines the reasons for each divergence.

MP 12-24 - North Slope (Figure 8.5-1)

(1) The Alyeska alignment turns and enters the floodplain of the Sagavanirktok River in order to locate the hot oil line in as much drained gravels as possible. The gas line is designed to be chilled and therefore does not require drained gravels, but can take the more direct and shorter route across the frozen silts in the higher ground. The gas line route requires fewer bends and considerably less erosion control structures than the oil line. These advantages reduce the cost of construction and operations,

(2) The Sagavanirktok River will be spared the impact of a second large diameter line with the accompanying dikes and structures for erosion control. In addition, the impact on fish is lessened, and

(3) The gas line traverses flat areas with little drainage, and therefore requires fewer erosion control measures.

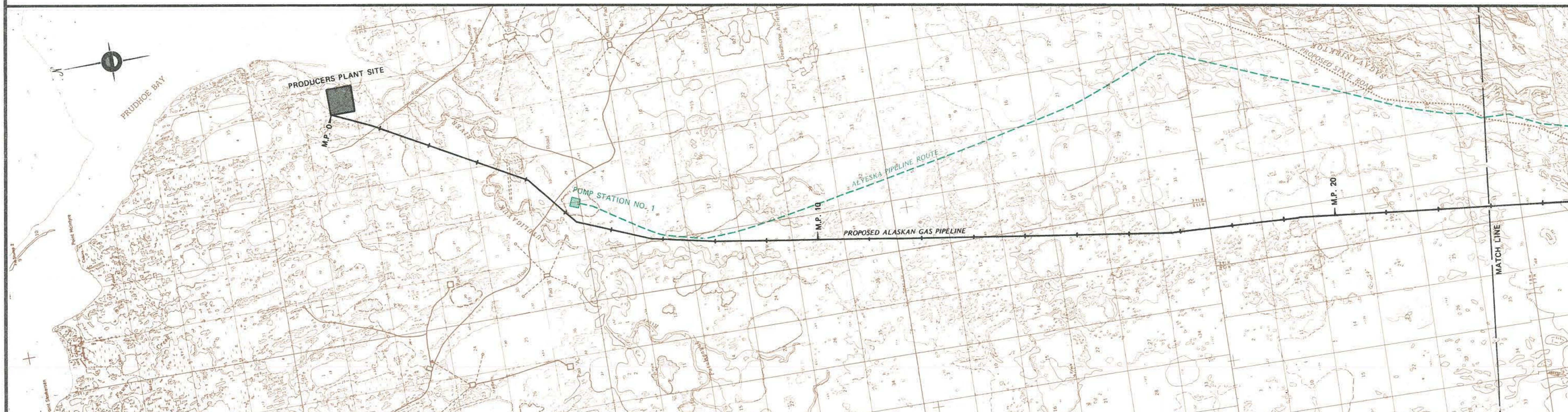
MP 51-68 - North Slope (Figure 8.5-2)

The same general comments as MP 12-24 above apply, except that the terrain is not as flat and drainage is intermittent.

MP 77-79 - North Slope (Figure 8.5-3)

The same general comments as in MP 51-68 above apply.

OWNERSHIP		U.S.A. (STATE OF ALASKA SELECTION)	
TERRAIN		FLAT	
VEGETATION		TUNDRA	
SPECIAL CONDITIONS	M.P. 0.00	PIPELINE CROSSING; PUTULIGAYUK RIVER CROSSING; ROAD CROSSING; NUMEROUS SWAMPS	M.P. 23.05
GEO–MORPHOLOGY		ARCTIC COASTAL PLAIN. A MONOTONOUS, RELATIVELY FLAT SURFACE CONTAINING NUMEROUS DRAINED AND UN-DRAINED THAW–LAKE BASINS. MINOR FEATURES INCLUDE POLYGONAL GROUND PATTERNS AND OCCASIONAL PINGO DEVELOPMENT	
SOILS & BEDROCK	MATCH LINE	LOOSE TO MODERATELY COMPACT, SATURATED SILT RANGING IN THICKNESS FROM 0–10 FEET (AVERAGE THICKNESS 6 FEET) OVERLYING LOOSE, MEDIUM TO COARSE, WELL ROUNDED SAND AND GRAVEL.	MATCH LINE
PERMAFROST		CONTINUOUS. ACTIVE LAYER 0–2 FEET (±)	
SEGREGATED ICE		CONSIDERABLE. OCCURS AS CRYSTALS, COATING, INCLUSIONS, WEDGES, LENSES, AND SEAMS	



PIPELINE SCHEMATIC

PRODUCERS PLANT SITE (M) — M.P. 0.00 — PRUDHOE BAY METER STATION

M.P. 3.40

42" O.D. x 0.750" W.T. X–65 PIPE

M.P. 19.60

MATCH LINE M.P. 23.05

M.P. 0.0 TO M.P. 19.3
3 FT. GRANULAR BACKFILL REQ'D. OR ANCHORS

CONSTRUCTION DETAIL

SPECIAL CONSTRUCTION
PUTULIGAYUK RIVER CROSSING
LENGTH: 600 FT.
PIPE DEPTH: 8 FT.
1.25 S.G. CONCRETE 520 FT.

CONSTRUCTION SECTION NO. 1
(2 YEARS)

SITE PREPARATIONS–SUMMER PRIOR TO CONSTRUCTION: PREPARE SOURCES OF MATERIALS, BUILD 5' GRAVEL PAD ON WORK SITES, BUILD ROADS.
RIGHT-OF-WAY–OCT. TO APR.: CLEAR SNOW, BUILD 2' COMPACTED SNOW WORK PAD, STRIP ORGANICS AND STOCK PILE, LEVEL WORK AREA.
LAYING–NOV. THRU MAY: BLAST DITCH LINE, WELD PIPE, EXCAVATE DITCH WITH BACKHOES, PAD DITCH, LOWER-IN, BACKFILL WITH SELECT CONDITIONED MATERIALS, SET VALVES, MAKE TIE-INS.
CLEAN-UP–APR. THRU MAY: RETURN ORGANICS TO DITCH LINE, INSTALL EROSION PROTECTION, REMOVE DEBRIS.

⊕MATERIAL SITES

0 1 2 3
SCALE IN MILES

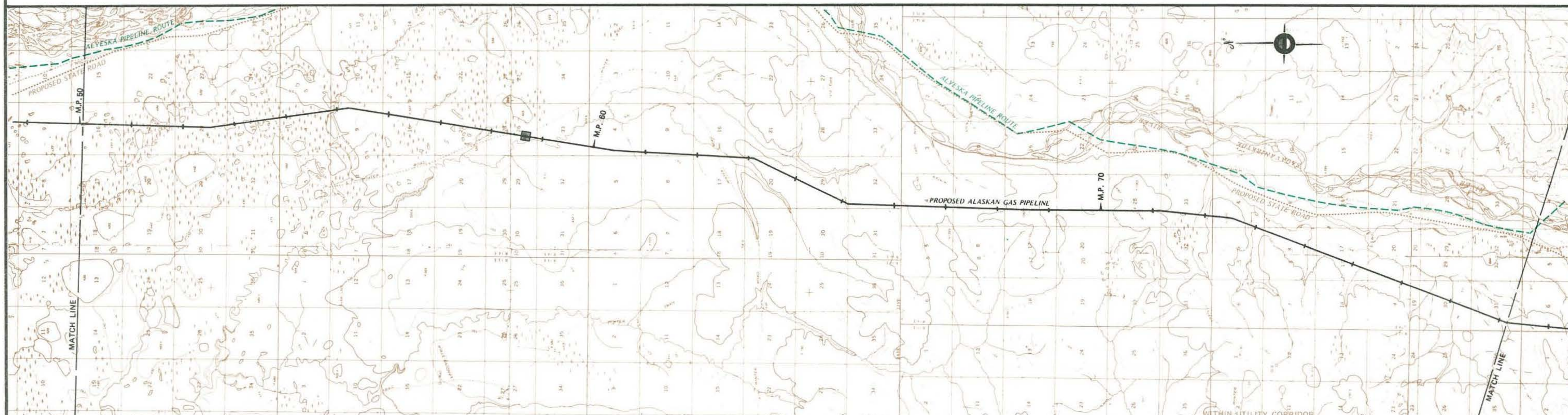
TRANS-ALASKA GAS PROJECT

PROPOSED
ALASKAN GAS PIPELINE

M.P. 0.00 TO M.P. 23.05

FIGURE 8.5–1

OWNERSHIP	U.S.A			
TERRAIN	FLAT TO GENTLY ROLLING			
VEGETATION	TUNDRA			
SPECIAL CONDITIONS	M.P. 50.10 NUMEROUS SWAMPS		SWAMP	M.P. 78.20
GEO-MORPHOLOGY	RELATIVELY FLAT PLAIN, DOTTED BY DRAINED AND UNDRAINED THAW-LAKE BASINS.	UNDULATING RIDGES MODIFIED BY BEADED STREAMS AND OCCASIONAL THAW-LAKE BASINS.		
SOILS & BEDROCK	MATCH LINE LOOSE TO MODERATELY COMPACT SATURATED SILT RANGING IN THICKNESS FROM 5–10 FEET (±) (AVERAGE THICKNESS 6 FEET) OVERLYING LOOSE, MEDIUM TO COARSE SAND AND GRAVEL.	LOOSE, MOIST SILT WITH SOME GRAVEL AND SAND, OVERLYING BEDROCK TO DEPTHS VARYING FROM 0–15 FEET (+). BEDROCK CONSISTS OF SOFT SILTSTONES AND WEAKLY CEMENTED CONGLOMERATES.	LOOSE, MOIST SILT WITH SOME GRAVEL AND SAND, OVERLYING BEDROCK TO DEPTH VARYING FROM 5–15 FEET (+). BEDROCK CONSISTS OF DURABLE SANDSTONES AND CONGLOMERATES.	MATCH LINE
PERMAFROST	CONTINUOUS. ACTIVE LAYER 0–2 FEET IN SOILS, VARIABLE IN BEDROCK.			
SEGREGATED ICE	CONSIDERABLE. OCCURS AS CRYSTALS, COATING, INCLUSIONS, WEDGES AND LENSES.			



PIPELINE SCHEMATIC

MATCH LINE M.P. 50.10

M.P. 50.1 – M.P. 59.2
3' GRANULAR BACKFILL REQ'D. OR ANCHORS

CS M.P. 58.73 M.P. 59.20

COMPRESSOR STATION NO. 1

42" O.D. x 0.750" W.T. X-65 PIPE

M.P. 74.73

MATCH LINE M.P. 78.20

CONSTRUCTION DETAIL

CONSTRUCTION SECTION NO. 1
(2 YEARS)

⊕MATERIAL SITES

0 1 2 3
SCALE IN MILES

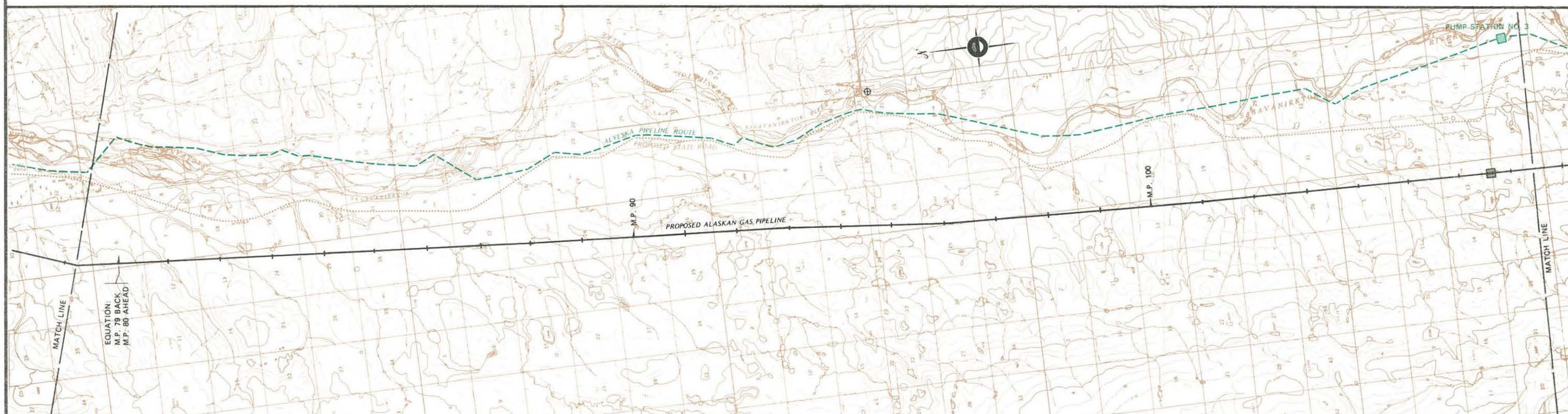
TRANS-ALASKA GAS PROJECT

PROPOSED
ALASKAN GAS PIPELINE

M.P. 50.10 TO M.P. 78.20

FIGURE 8.5–2

OWNERSHIP	U.S.A.
TERRAIN	ROLLING
VEGETATION	TUNDRA
SPECIAL CONDITIONS	M.P. 78.20 — SWAMP — SWAMPS & SMALL STREAM CROSSINGS — M.P. 107.40
GEO-MORPHOLOGY	UNDULATING RIDGES MODIFIED BY BEADED STREAMS AND OCCASIONAL THAW-LAKE BASINS. / GENTLY SLOPING GLACIAL MORAINE MODIFIED BY NUMEROUS PARALLEL STREAMS.
SOILS & BEDROCK	MATCH LINE — LOOSE, MOIST SILT WITH SOME GRAVEL AND SAND. OVERLYING BEDROCK TO DEPTHS VARYING FROM 5-15 FEET (±). BEDROCK CONSISTS OF DURABLE SANDSTONES AND CONGLOMERATES. / LOOSE TO MODERATELY COMPACT, NON-SORTED SILTS, SANDS AND GRAVEL. OCCASIONAL CONCENTRATIONS OF SAND AND/OR ANGULAR GRAVEL. RANDOM BOULDERS COMMON. — MATCH LINE
PERMAFROST	CONTINUOUS, ACTIVE LAYER 0-2 FEET.
SEGREGATED ICE	CONSIDERABLE. OCCURS AS CRYSTALS, COATING, INCLUSIONS, WEDGES, LENSES, AND SEAMS.



PIPELINE SCHEMATIC

M.P. 78.20 MATCH LINE — M.P. 90.73 — 42" O.D. x 0.750" W.T. X-65 PIPE — CS M.P. 106.62 — MATCH LINE M.P. 107.40

CONSTRUCTION DETAIL

CONSTRUCTION SECTION NO. 1
(2 YEARS)

COMPRESSOR STATION NO. 2

⊕ MATERIAL SITES

SCALE IN MILES: 0 1 2 3

TRANS-ALASKA GAS PROJECT

PROPOSED ALASKAN GAS PIPELINE

M.P. 78.20 TO M.P. 107.40

FIGURE 8.5-3

MP 90-110 - North Slope (Figure 8.5-4)

The same general comments as in MP 51-68 apply.

MP 122-131 - North Slope Approach to Galbraith Lake (Figure 8.5-4)

The gas pipeline takes the shorter, more direct route into the Atigun drainage area in order to reduce costs.

MP 233-250 - Rosie Creek Pass (Figure 8.5-5)

(1) The gas line route is shorter and more direct than the Alyeska line to reduce costs,

(2) Rosie Creek Pass has an existing winter trail through it,

(3) The congestion and problems caused by the oil line, road, and the Koyukuk River going around Cathedral Mountain are obviated. A considerable amount of grading, road and pipeline crossing, river crossings, and the resulting impact on environment are avoided, and

(4) The chilled gas line does not require a location in the granular materials underlying the flood plain of the Koyukuk River.

MP 391-396 - Tolovana River to Slate Creek (Figure 8.5-6)

The gas line route was selected over more gentle terrain to avoid several steep slopes traversed by the oil pipeline.

MP 529-539 - Fort Greely By-Pass (Figure 8.5-7)

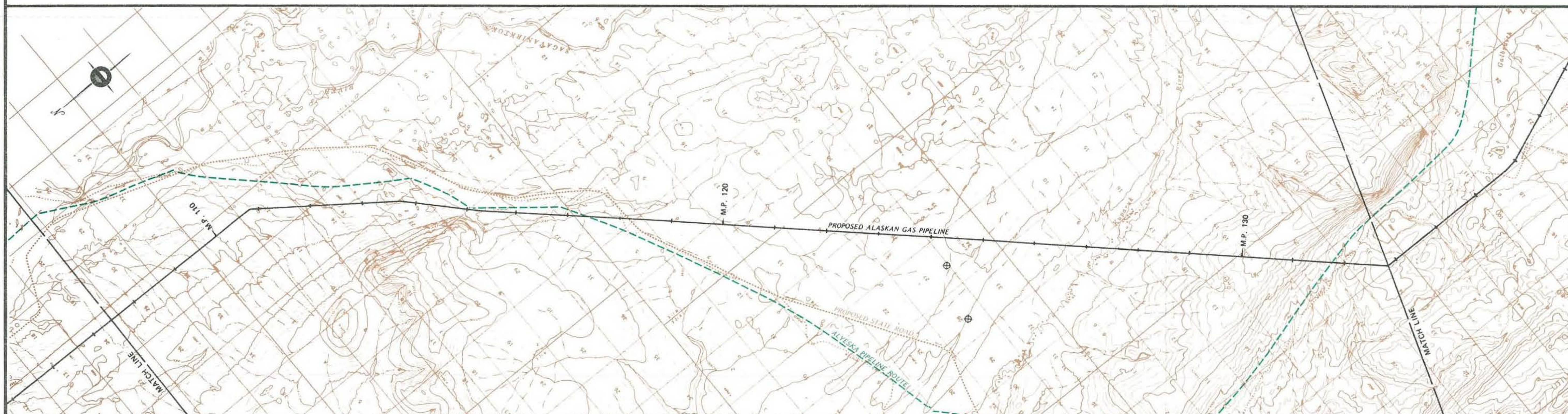
The gas line was routed around the town of Delta Junction, Big Delta Airport, and Fort Greely to avoid the congestion in that area and to eliminate several pipeline and highway crossings.

MP 677-700 - Stuck Mountain and Squirrel Creek By-Pass (Figures 8.5-8 and 8.5-9)

(1) The gas pipeline route traverses terrain that is generally flat and not as choppy as the Alyeska route, and

(2) The gas pipeline route by-passes the Willow Mountain - Willow Lake area where the highway, the oil pipeline, and transmission lines are congested on a steep side slope.

OWNERSHIP		U.S.A.			
TERRAIN		ROLLING			
VEGETATION		TUNDRA			
SPECIAL CONDITIONS	M.P. 107.40	PIPELINE (PROPOSED) CROSSING; ROAD (PROPOSED) CROSSING		MINOR STREAM CROSSING; PIPELINE (PROPOSED) CROSSING AND ROAD (PROPOSED) CROSSING	M.P. 132.80
GEO-MORPHOLOGY		GLACIAL MORAINE FIELD OF REPEATING, SUBDUED MOUNDS AND DEPRESSIONS.	BROAD GLACIAL MORAINE FIELD, MODIFIED BY SLOPE EROSION.	GENTLY RISING, BROAD, BEDROCK. CONTROLLED FOOTHILLS.	
SOILS & BEDROCK	MATCH LINE	LOOSE TO MODERATELY COMPACT, NON-SORTED SILTS, SANDS AND GRAVEL OCCASIONAL CONCENTRATIONS OF SAND AND/OR GRAVEL. RANDOM BOULDERS COMMON.		FROST SHATTERED BEDROCK. VENEERED WITH LOOSE SILTS AND SANDS IN DRAINAGES. BEDROCK CONSISTS OF DURABLE CONGLOMERATES AND SANDSTONE.	MATCH LINE
PERMAFROST		CONTINUOUS. ACTIVE LAYER 0–2 FEET (±).			
SEGREGATED ICE		CONSIDERABLE. OCCURS AS CRYSTALS, COATINGS, INCLUSIONS, WEDGES AND LENSES. WEDGES COMMON IN DEPRESSIONS.		CONSIDERABLE. OCCURS AS WEDGES AND LENSES.	



PIPELINE SCHEMATIC

M.P. 107.40 MATCH LINE

M.P. 122.52

42" O.D. x 0.750" W.T. X–65 PIPE

M.P. 131.8 TO M.P. 132.8

3' GRANULAR BACKFILL REQ. OR ANCHORS

MATCH LINE M.P. 132.80

CONSTRUCTION SECTION NO. 1
(2 YEARS)

CONSTRUCTION DETAIL

⊕ MATERIAL SITES

0 1 2 3
SCALE IN MILES

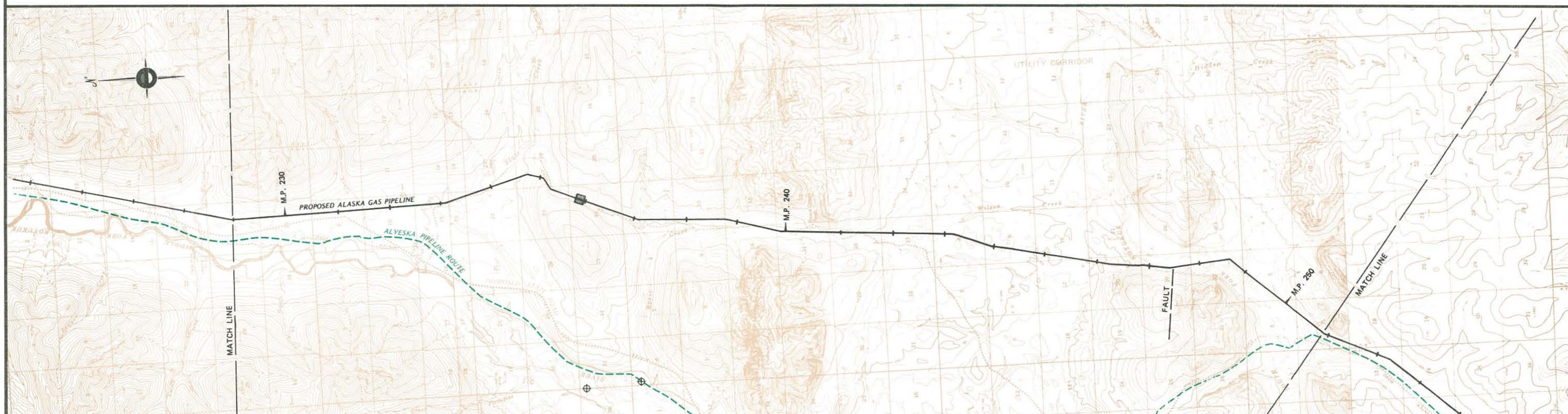
TRANS-ALASKA GAS PROJECT

PROPOSED
ALASKAN GAS PIPELINE

M.P. 107.40 TO M.P. 132.80

FIGURE 8.5–4

	M.P. 229.00 MATCH LINE						M.P. 250.90 MATCH LINE
OWNERSHIP		U.S.A.					
TERRAIN		SLIGHTLY ROLLING	ROLLING		SHARP CHOPPY	FLAT	
VEGETATION		MEDIUM BRUSH AND TREES TO 4" DIA.	MEDIUM LIGHT TIMBER 4" TO 12" DIA.		DENSE LIGHT TIMBER 4" TO 12" DIA.	TUNDRA	
SPECIAL CONDITIONS		SLATE CREEK CROSSING	POTENTIAL SNOW AVALANCHE AREA	RANDOM PEAT DEPOSITS. DEPTH OF PEAT VARIES 5–15 FEET (±).	SIDEHILL CONST. / SOUTH FK. KOYUKUK RIVER CROSSING	POTENTIAL SNOW AVALANCHE AREA	
GEO–MORPHOLOGY		BROAD COLLUVIAL APRON ALONG VALLEY FLANK.	NARROW DRAINAGE DIVIDE	GLACIAL MORAINE FIELD CONSISTING OF REPEATED SUBDUED MOUNDS AND WATER FILLED DEPRESSIONS.	BROAD RIVER VALLEY		
SOILS & BEDROCK		LOOSE SILTS WITH SOME ANGULAR GRAVEL.	LOOSE, WET SILTS WITH SOME ANGULAR GRAVEL. EXPOSED BEDROCK CONSISTS OF DURABLE GREYWACKE.	LOOSE, TO MODERATELY COMPACT, WET SILTS WITH SOME SAND OVERLYING SANDS AND GRAVELS TO DEPTHS 0–10 FEET (±).	LOOSE SILTS WITH SOME ANGULAR GRAVELS.		
PERMAFROST		CONTINUOUS. ACTIVE LAYER 0–2 FEET (±). WITHIN SLATE CK FLOODPLAIN ACTIVE LAYER VARIES 2–15 FEET (±).		CONTINUOUS. ACTIVE LAYER 0–2 FEET (±).			
SEGREGATED ICE		CONSIDERABLE. OCCURS AS MASSIVE ICE LOCALLY AND AS LENSES AND SEAMS COMMONLY.		LITTLE TO SOME. OCCURS AS LENSES & SEAMS.			



PIPELINE SCHEMATIC

M.P. 229.00 MATCH LINE — M.P. 232.80 — CS M.P. 235.91 — 42" O.D. x 0.750" W.T. X–65 PIPE — M.P. 248.00 — MATCH LINE M.P. 250.90

COMPRESSOR STATION NO. 4

CONSTRUCTION SECTION NO. 2 (2 YEARS)

SPECIAL CONSTRUCTION
SOUTH FORK KOYUKUK RIVER CROSSING
LENGTH: 1200 FT.
PIPE DEPTH: 8 FT.
1.25 S.G. CONCRETE 1120 FT.

CONSTRUCTION DETAIL

⊕ MATERIAL SITES

0 1 2 3 SCALE IN MILES

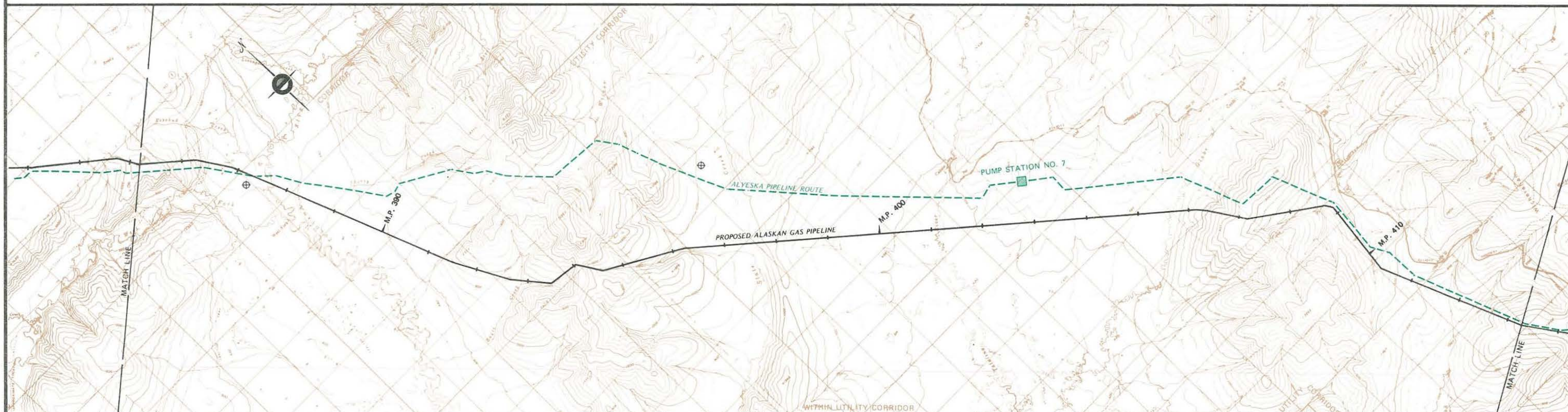
TRANS-ALASKA GAS PROJECT

PROPOSED ALASKAN GAS PIPELINE

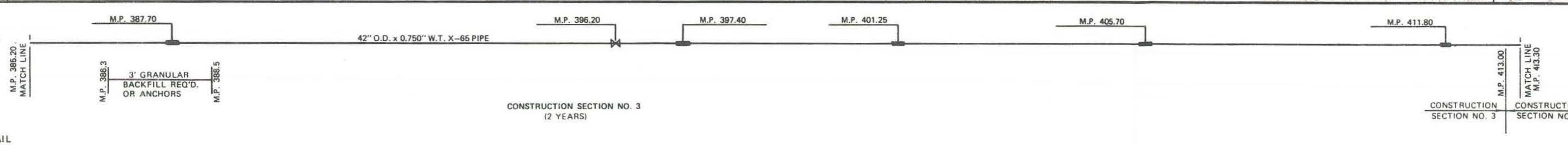
M.P. 229.00 TO M.P. 250.90

FIGURE 8.5–5

OWNERSHIP	U.S.A.					
TERRAIN	ROLLING	FLAT	ROLLING	SLIGHTLY ROLLING	ROLLING	
VEGETATION	DENSE BRUSH & TREES TO 4" DIAMETER	MEDIUM LIGHT TIMBER 4" TO 12" DIAMETER	DENSE BRUSH & TREES TO 4" DIAMETER	DENSE LIGHT TIMBER 4" TO 12" DIAMETER	MEDIUM BRUSH & TREES TO 4" DIAMETER	
SPECIAL CONDITIONS	M.P. 385.20	ROAD CROSSING; PIPELINE PROPOSED CROSSING (SWAMPS); TOLOVANA RIVER CROSSING (SWAMPS)	SLATE CREEK CROSSING	TATALINA RIVER CROSSING & SWAMPS	GLOBE CREEK CROSSING & SWAMPS	AGGIE CREEK CROSSING; M.P. 413.30
GEO-MORPHOLOGY	NORTHEAST–SOUTHWEST TRENDING RIDGES AND VALLEYS.					
SOILS & BEDROCK	MATCH LINE	MODERATELY DENSE ANGULAR SAND AND GRAVEL.	LOOSE, WET SILTS.	WEATHERED SLATE BEDROCK UNDER 2–15 FEET GRANULAR SOIL COVER.	LOOSE, MODERATELY DENSE SILT AND SAND.	MATCH LINE
PERMAFROST	DISCONTINUOUS. PERMAFROST TABLE DEPRESSED BELOW 20 FEET OVER 50% OF THIS SEGMENT. ACTIVE LAYER VARIES FROM 1–4 FEET (±) IN LEVEL, NON FORESTED AREAS.					
SEGREGATED ICE	LITTLE TO SOME. OCCURS AS LENSES AND SEAMS.	LITTLE TO SOME. OCCURS AS LENSES AND SEAMS. LOCAL MASSIVE ICE ON NORTH FACING SLOPES.				



PIPELINE SCHEMATIC



CONSTRUCTION DETAIL

⊕ MATERIAL SITES

SCALE IN MILES: 0 1 2 3

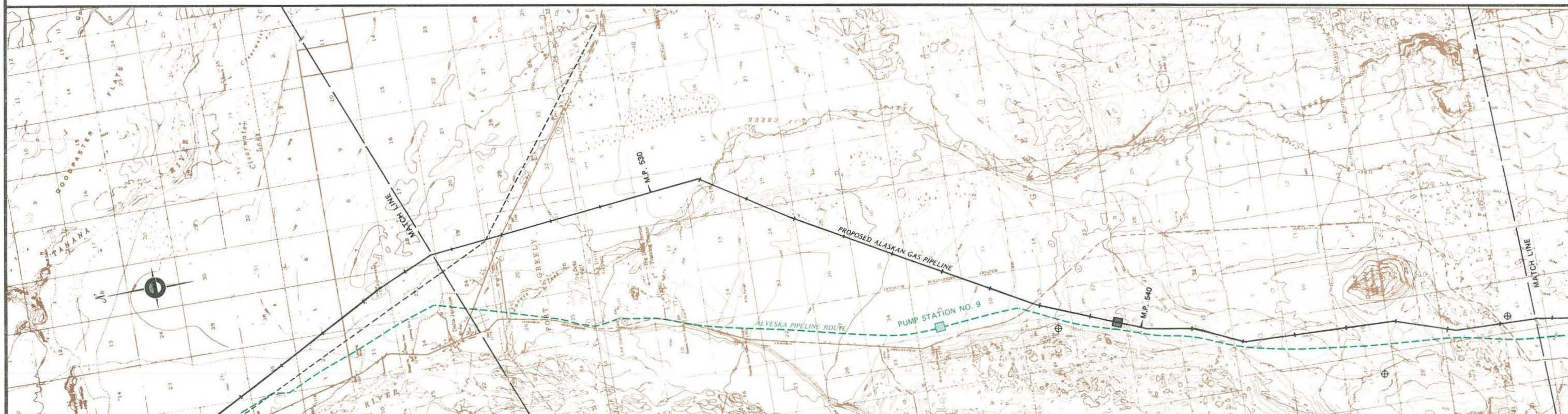
TRANS-ALASKA GAS PROJECT

PROPOSED ALASKAN GAS PIPELINE

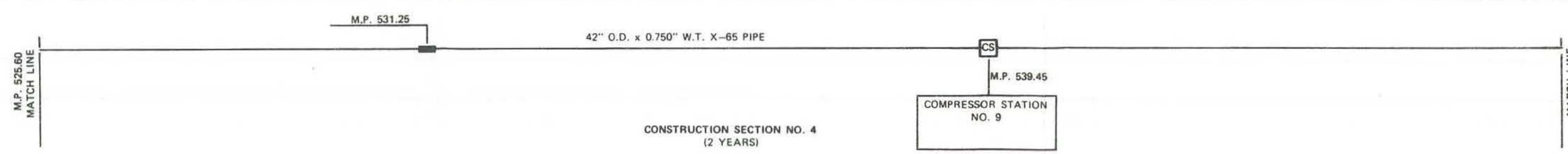
M.P. 385.20 TO M.P. 413.30

FIGURE 8.5–6

OWNERSHIP	STATE OF ALASKA; U.S.A. MILITARY RESERVATION; U.S.A.; U.S.A. MILITARY RESERVATION; U.S.A.
TERRAIN	SLIGHTLY ROLLING; FLAT; SLIGHTLY ROLLING; ROLLING
VEGETATION	DENSE BRUSH & TREES TO 4" DIA. DENSE LIGHT TIMBER 4" TO 12" DIA.; DENSE BRUSH & TREES TO 4" DIA.; MEDIUM BRUSH & TREES TO 4" DIA.; TUNDRA
SPECIAL CONDITIONS	M.P. 525.60; 8" PRODUCTS LINE CROSSING; ALASKA HWY. CROSSING; JARVIS CREEK CROSSING; RICHARDSON HWY. CROSSING; MINOR STREAM CROSSING; RICHARDSON HWY. CROSSING; M.P. 547.50
GEO-MORPHOLOGY	
SOILS & BEDROCK	MATCH LINE; MODERATELY DENSE SAND AND GRAVEL WITH NUMEROUS COBBLES AND BOULDERS.; MODERATELY DENSE SAND WITH SOME SILT AND GRAVEL. OCCASIONAL POCKETS OF LOOSE, WET ORGANIC SILT TO 8 FEET (±).; LOOSE, MOIST TO WET SILT WITH SOME SAND COVERING SAND AND GRAVEL TO DEPTHS OF 0–10 FEET (±).; MATCH LINE
PERMAFROST	DISCONTINUOUS, PERMAFROST SURFACE (IF PRESENT) 25 FEET (+). ACTIVE LAYER VARIES FROM 1–6 FEET.; DISCONTINUOUS, PERMAFROST SURFACE VARIES FROM 1–10 FEET. ACTIVE LAYER VARIES FROM 1–6 FEET.; PERMAFROST SURFACE VARIES FROM 1–2 FEET. ACTIVE LAYER VARIES FROM 1–2 FEET.; PERMAFROST SURFACE (IF PRESENT) 25 FEET (+).; SEE NEXT SHEET
SEGREGATED ICE	NONE; LITTLE TO NONE; SOME TO CONSIDERABLE. OCCURS AS CRYSTALS, LENSES, AND SEAMS; NONE



PIPELINE SCHEMATIC



CONSTRUCTION DETAIL

⊕ MATERIAL SITES

0 1 2 3 SCALE IN MILES

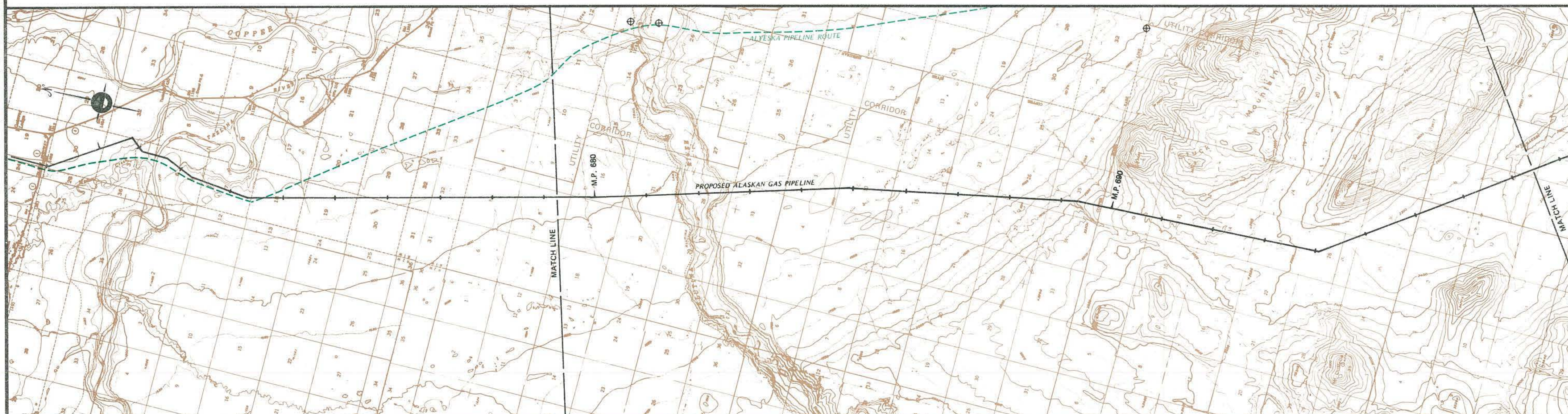
TRANS-ALASKA GAS PROJECT

PROPOSED ALASKAN GAS PIPELINE

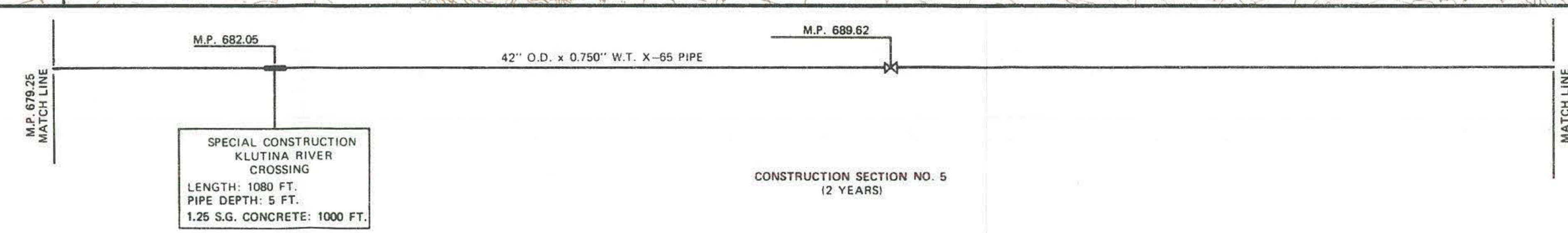
M.P. 525.60 TO M.P. 547.50

FIGURE 8.5–7

		M.P. 679.25 to M.P. 698.50	
OWNERSHIP		VARIED	
TERRAIN		FLAT	ROLLING
VEGETATION		MEDIUM BRUSH & TREES TO 4" DIA.	DENSE BRUSH & TREES TO 12" DIA.
SPECIAL CONDITIONS	M.P. 679.25	KLUTINA RIVER CROSSING	M.P. 698.50
GEO-MORPHOLOGY		INTERMONTANE BASIN AREA CONTAINING EXTENSIVE GLACIO FLUVIAL AND GLACIO-LACUSTRINE SEDIMENTS.	SADDLE IN BEDROCK RIDGE WITH COLLUVIAL APRONS ON APPROACHES.
SOILS & BEDROCK	MATCH LINE	SILTS WITH SOME CLAY TO CLAY WITH SILT LOCAL DEPSOITS OF SAND AND GRAVEL WITH SOME SILT.	LOOSE, ANGULAR GRAVEL, SAND AND SILT. CONSIDERABLE ANGULAR COBBLES AND SCATTERED BOULDERS LOCALLY. (MATCH LINE)
PERMAFROST	DISCONTINUOUS. PERMAFROST SURFACE VARIABLE. GENERALLY SURFACE IS AT 5 FEET(±). LOCALLY SURFACE EXTENDS TO 25 FEET(±). ACTIVE LAYER VARIES FROM 2–5 FEET IN LEVEL, NON-FORESTED AREAS. →	DISCONTINUOUS, PERMAFROST SURFACE VARIES FROM 5–25 FEET (+) INTERMITTENTLY. ACTIVE LAYER VARIES FROM 2–5 FEET IN FLAT, NON-FORESTED.	DISCONTINUOUS, PERMAFROST SURFACE AT 5 FEET GENERALLY.
SEGREGATED ICE	CONSIDERABLE LOCALLY. OCCURS AS CRYSTALS, LENSES, SEAMS, AND MASSES. →	CONSIDERABLE LOCALLY, OCCURS AS CRYSTALS, LENSES AND MASSES.	



PIPELINE SCHEMATIC



CONSTRUCTION DETAIL

⊕MATERIAL SITES

SCALE IN MILES: 0 1 2 3

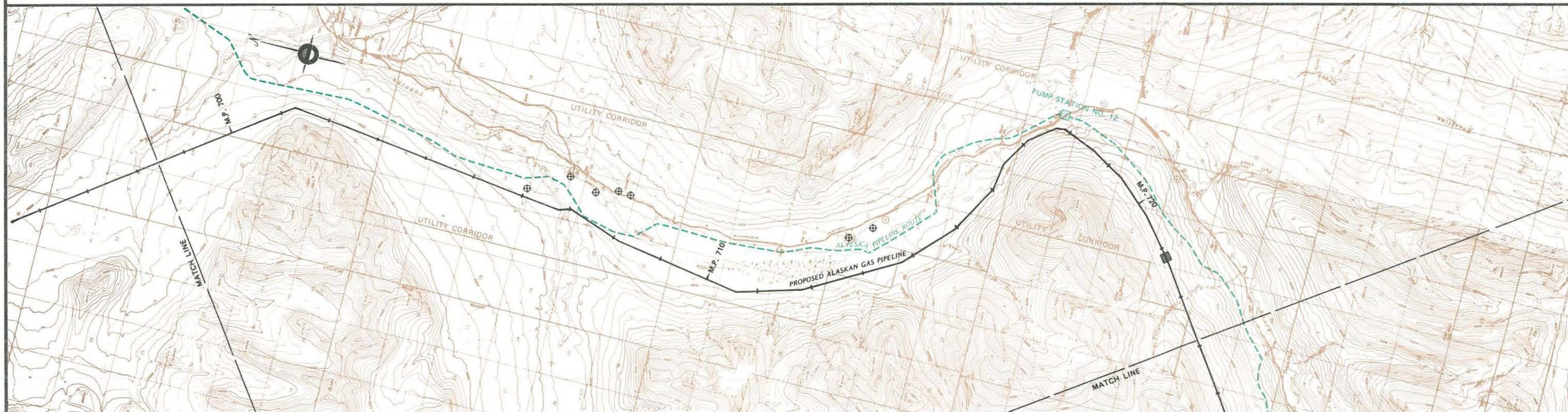
TRANS-ALASKA GAS PROJECT

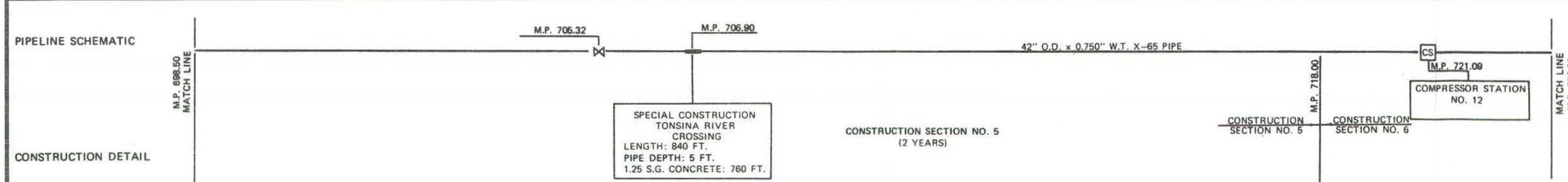
PROPOSED ALASKAN GAS PIPELINE

M.P. 679.25 TO M.P. 698.50

FIGURE 8.5–8

OWNERSHIP	U.S.A.	
TERRAIN	ROLLING	MOUNTAINOUS
VEGETATION	DENSE BRUSH & TREES TO 12" / DENSE BRUSH & TREES TO 4" DIA.	DENSE BRUSH & TREES TO 12" DIA.
SPECIAL CONDITIONS	M.P. 698.50 — TONSINA RIVER CROSSING / AREA OF POTENTIAL AVALANCHING. / AREA OF STRONG SOLIFLUCTION EVIDENCE.	AREA OF POTENTIAL AVALANCHE. — M.P. 722.90
GEO-MORPHOLOGY	GLACIATED RIVER VALLEY WITH COALESCING ALLUVIAL-COLLUVIAL FANS.	GLACIALLY SCOURED VALLEY UPLAND
SOILS & BEDROCK	MATCH LINE — LOOSE ANGULAR GRAVEL, SAND, AND SILT. CONSIDERABLE ANGULAR COBBLES AND SCATTERED BOULDERS.	DURABLE GRAYWACKE BEDROCK MANTLED BY 0–5 FEET OF SAND, SILT, GRAVEL AND COARSE ANGULAR TALUS. — MATCH LINE
PERMAFROST	DISCONTINUOUS, PERMAFROST SURFACE AT 5 FEET GENERALLY / SPORADIC, PERMAFROST SURFACE VARIABLE 5–50 FEET (±). ACTIVE LAYER 2–5 FEET IN LEVEL, NON-FORESTED AREAS	NON-PERMAFROST AREA.
SEGREGATED ICE	SOME TO CONSIDERABLE. OCCURS AS CRYSTALS, LENSES AND WEDGES. / LITTLE TO NONE.	NONE





⊕ MATERIAL SITES

0 1 2 3
SCALE IN MILES

TRANS-ALASKA GAS PROJECT

PROPOSED ALASKAN GAS PIPELINE

M.P. 698.50 TO M.P. 722.90

FIGURE 8.5–9

(3) The Klutina River crossing, and the gas line route in general avoid numerous private lands and dwellings,

(4) Unstable bluffs and landslide areas at the Squirrel Creek crossing are by-passed by the proposed gas line route, and

(5) The proposed route is shorter and more direct than Alyeska's.

These deviations from the Alyeska alignment reflect the routing advantages of a chilled gas pipeline. Because the gas is chilled, it can be buried in a permafrost environment. This situation allows the gas line to take advantage of routes both more accessible and shorter than the proposed Alyeska route.

8.5.1.1 Alaskan Gas Pipeline: Alternate Stream Crossing Methods

In selecting particular stream crossing modes, three general types were considered:

(1) Utilizing existing structure,

(2) Utilizing specific aerial pipeline crossing structures, and,

(3) Burial in the stream bed.

All but two crossings will be buried. Generally, a buried crossing will cost less than an aerial crossing, unless some special or unusual circumstances exist. Buried crossings also put the pipeline out of sight and therefore have less visual impact than aerial crossings. Furthermore, buried crossings require less maintenance, and, therefore, are less expensive to operate than aerial crossings.

The Yukon River crossing is planned on a bridge to be built in connection with the Alyeska oil pipeline.

The gas pipeline crossing of the Tazlina River will utilize a specially-designed aerial crossing structure. The estimated cost is lower than other methods and the excessive depth of burial needed would require excessive excavation.

8.5.2 LNG Plant

The LNG Plant process sections for which alternate designs have been considered are:

(1) Gas Treating for CO_2 removal,

(2) Dehydration, and

(3) Liquefaction,

(4) LNG product storage and handling, and

(5) Support facilities.

8.5.2.1 Alternates to the Proposed Diglycolamine (DGA) Gas Treating for CO_2 Removal

The objective of the gas treating process is to reduce the CO_2 concentration of the natural gas feed from about 1-2 mole percent to a residual concentration of 50-100 ppm to prevent solic CO_2 formation and resultant blockage in the cryogenic section of the plant. The carbon dioxide removed from the gas feed is released to the atmosphere. Several alternates to DGA gas treating were considered for the removal of carbon dioxide from the feed stream. The possible alternates include the following processes:

(1) Amine,

(2) Activated potassium carbonate,

(3) Physical solvent,

(4) Combining a physical solvent with a chemical treating agent, and

(5) Molecular sieve adsorption.

Each alternate will be discussed noting the reasons for its elimination.

8.5.2.1.1 Amine Processes

Amine processes are the most effective in treating gas streams with a relatively low inlet acid gas partial pressure. The most commonly used amines are diglycolamine (DGA), monoethanolamine (MEA), and diethanolamine (DEA), all of which remove CO_2 by chemical reaction. Amine processes absorb the acid gas at high pressure and the resulting rich solution is regenerated by steam stripping. These processes have circulation rates equal to, or less than, the other processes and can readily reduce product impurities to 50-100 ppm.

Amine solutions become contaminated by non-regenerable compounds formed by side reactions and by insoluble material such as pipe scale. These contaminants are removed by distillation in a reclaimer and by filtration. The contaminants are then disposed of by utilizing onsite land fill techniques. The environmental impact of solids disposal is essentially the same for all amine processes.

DGA has been selected over other amines in this application for the following reasons:

(1) Lowest amine solution circulation rate

(2) Lowest steam regeneration rate,

(3) No royalty payments,

(4) Higher potential for partial dehydration of the product gas stream,

(5) Corrosion rate equal to, or less than, that experienced with other processes,

(6) Solution degradation less severe than MEA or DEA,

(7) Low solution freezing point, and

(8) No relative environmental disadvantages.

8.5.2.1.2 Activated Potassium Carbonate Process

The activated potassium carbonate process is a possible alternate to DGA gas treating. This process is similar to the amine process because it is based on reacting CO_2 with a circulating solution in a contactor. The solution is then regenerated in a stripper at elevated temperature and reduced pressure. This process differs from the amine process in the type of circulating solution employed. The process employs an aqueous solution of potassium carbonate in combination with various activators such as alkanolamines, borates arsenic, and other compounds. Prior to processing, it is necessary that the gas be heated to 200°F or more, then cooled back to ambient temperature after processing.

The activated potassium carbonate process was eliminated as an alternate for the following reasons:

(1) It is not capable of achieving a residual CO_2 content of 50-100 ppm,

(2) Potential solution freezing problems, and

(3) Increased complexity required of gas heating and cooling systems.

8.5.2.1.3 Physical Solvent Processes

Physical solvents are normally utilized in the natural gas industry for treating gas streams where the partial pressure of the acid gas in the feed is 50 psi or higher, and when only bulk removal of the acid gas is desired. Physical solvent processes employed in the natural gas industry include the Rectisol process, the Fluor Solvent process, and the Selexol process. Of these only the Rectisol process has been applied for the purification of natural gas for LNG production. The Rectisol process uses methanol as a solvent. Because of the relatively high vapor pressure of methanol, and because of the solubility relationship between CO_2 and methanol, the process is normally applied at very low temperatures.

The Rectisol process was eliminated as an alternate because of the following disadvantages:

(1) The Rectisol process is normally applied only when the partial pressure of the acid gas in the feed is 50 psi or higher. The normal acid gas partial pressure in the Alaskan natural gas feed is about 6.5 psi,

(2) It has (as do the other physical solvent processes) the undesirable feature of a high affinity for heavy hydrocarbons,

(3) Operation at temperatures in the range of -70^{o}F requires implementation of a complex flow scheme, and

(4) The relatively high vapor pressure of methanol can result in elevated solvent losses.

The Fluor Solvent process and the Selexol process are also normally only effective in treating gas streams when the partial pressure of acid gas in the feed exceeds 50 psi. In addition, these processes are incapable of attaining a residual CO_2 concentration in the range of 50-100 ppm.

8.5.2.1.4 Combining a Physical Solvent With a Chemical Treating Agent

The Sulfinol process combines a physical solvent with a chemical treating agent to remove H_2S, CO_2, COS, and mercaptans from natural gas. The Sulfinol solvent is composed of an alkanolamine that is mixed with the organic chemical sulfolane.

The Sulfinol process is most advantageously applied at a ratio of H_2S to CO_2 of 1 or higher, and an acid gas partial pressure of at least 25 psi. Since the ratio of H_2S to CO_2 is much less than 1 and the normal CO_2 partial pressure in Alaskan natural gas feed is only about 6.5 psi, and the maximum is less than 15 psi, the Sulfinol process was eliminated as an acceptable gas treating process for this Project.

8.5.2.1.5 Molecular Sieve Adsorption Processes

Molecular sieves operate on the principle of physical adsorption by selectively trapping one or more constituents of a gas stream while allowing the remaining gas constituents to pass through. Certain molecular sieves have the capability of simultaneously sweetening and dehydrating a gas stream by adsorbing acid gases and water vapor. This process, under certain limiting operating conditions, can be advantageously applied to purifying a natural gas stream prior to LNG production. It was determined that the process is neither practical nor economical if applied to gas streams containing more than approximately 0.5 mole percent acid gas in the feed. Since the normal acid gas concentration in the feed gas varies from 1-2 mole percent, molecular sieves for CO_2 removal purposes were eliminated from consideration.

8.5.2.2 Alternates to Molecular Sieve Dehydration

Two alternates to molecular sieve dehydration were considered for the gas drying. The selected process and both alternate processes employ the technique of adsorption by using solid desiccants. Briefly, a description of each alternate and its limitations follow:

(1) Alumina - Activated alumina is a solid desiccant capable of producing dew points below -100°F. For equivalent dehydration performance, alumina desiccants tend to require more regeneration heat than other desiccants. Alumina desiccants also tend to absorb heavy hydrocarbons which are difficult to remove in regeneration, and

(2) Silica Gel - Silica gel is a solid desiccant capable of producing dry gas containing approximately 10 ppm water vapor. The maximum allowable water vapor content for the dehydrated gas entering the liquefaction plant is 1 ppm. A silica gel system was therefore not considered as a viable system for this Project.

Molecular sieves have a very narrow range of pore sizes and can effectively eliminate adsorption of heavy hydrocarbons. Molecular sieves, therefore, have an advantage over alumina and silica gel in both the degree of dehydration and in selectivity of material adsorbed. The relative environmental impacts of the selected molecular sieve dehydration scheme and both alternates are essentially similar.

8.5.2.3 Alternates to Liquefaction Process

Two alternates to the Phillip's Optimized Cassade liquefaction process were considered. These were the multi-component refrigerant (MCR) process and the turbo-expander process.

The multi-component refrigerant cycle is a modification of the cascade cycle in which the gas is liquefied by heat exchange with a multi-component refrigerant. The natural gas stream is heat exchanged in series with the refrigerant components arranged in order of increasing volatility. This process is less efficient than the cascade cycle and thus requires more horsepower. Environmentally, the net result is a larger fuel requirement and greater emissions.

Licensor engineering proposals were obtained for the proposed cascade process and a competing MCR process. These were then used to produce a comparative engineering-economic evaluation. On the basis of this evaluation, the cascade process was selected over the MCR process.

In the turbo-expander cycle, a portion of the natural gas is liquefied by permitting the gas to do work through the use of an expander. This process is known as the expander cycle, and utilizes the cooling effect obtained by expanding a stream of compressed gas through an expander.

The main disadvantage of this process is that it has not been commercially proven for large, baseload LNG plants, and therefore was rejected from any further evaluations.

8.5.2.4 Alternates to Aboveground Double Wall Metal LNG Storage Tanks

The following alternate LNG storage facilities have been considered:

(1) Below ground, metal tanks,

(2) Pre-stressed concrete tanks, and

(3) Frozen earth and mined cavern storage.

8.5.2.4.1 Below Ground Metal Tanks

These tanks are the same as the proposed aboveground metal storage tanks. The placement of these tanks below ground is an obvious higher cost facility. Since the aboveground installation, properly diked, provides acceptable environmental protection, they were selected based on overall economics.

8.5.2.4.2 Pre-Stressed Concrete Tanks

These tanks are constructed with an inner shell of pre-stressed concrete subject to the cryogenic temperatures and hydrostatic pressures. The outer shell is constructed of steel and serves as a vapor-tight container. A layer of insulation material is placed between the two shells. Various deviations of this design are offered with the actual operating experience of this design limited to a few installations. Compared to the double wall metal storage tank, which has been proven in LNG applications, the installed cost of the pre-stressed concrete tank is recognized as being substantially higher. Economic considerations and experience, therefore, led to the elimination of this type of storage tank for the proposed action.

8.5.2.4.3 Frozen Earth and Mined Cavern Storage

Frozen earth storage containers are simply pits which have been excavated below the earth's surface. The perimeter of the pit is frozen by a refrigerant that is circulated through a series of buried concentric pipes. The mined cavern type of atmospheric LNG storage utilizes a large, inclined entry to a room and a pillar cavern containing a polyurethane foam insulation around the perimeter. Storage at atmospheric pressure eliminates the necessity of mining a deep cavern with substantial overburden.

Environmentally, the underground storage may appear more attractive than the aboveground method, as it does not have the threat of a potential impact-type of accident with resulting rupture and spill. However, below ground storage has not been commercially proven for large, baseload LNG plants except in a few specialized areas. Below ground storage was therefore eliminated from further evaluation.

8.5.2.5 Alternate Heat Dissipation Systems

The heat dissipation system selected is a combination of once-through seawater and air cooling. The selection of this system was based on engineering judgment. It is planned to compare, in detail, the following alternates at a later date as part of the Project overall optimization:

(1) Cooling towers,

  (a) Fresh water
  (b) Seawater

(2) Cooling ponds, and

(3) All air cooling.

8.5.3 Alaskan Marine Terminal

The Alaskan Marine Terminal will be a T-head pier consisting of two LNG carrier berths as described in Section 1. The proposed location of the marine terminal is relatively well sheltered from winds and waves. Because multi-buoy moorings, breakwaters and single point moorings are more complicated, potentially more costly and potentially more difficult to operate, and because they are generally utilized only for use in locations exposed to wind and wave action, a T-head pier configuration was determined to be most suitable, and alternate types of berths were not evaluated.

Minor variations in design to accomodate the physical nature of the site and the character of the LNG tanker employed can be expected. Such changes are considered modifications of the proposed action not amounting to actual alternatives to the action.

Applicant has examined three alternate methods of loading LNG which could eliminate the need for a permanent terminal structure. Those alternates will be separately considered noting the reasons why they were not given further consideration.

8.5.3.1 Loading of LNG Carriers by Barge

Batch transfer of cargo from LNG storage to the LNG carrier (moored offshore) has been considered. This transfer could be accomplished by cryogenic barges, of relatively shallow draft. Although such a system may present advantages where nearshore water depth or other factors preclude a deep-water pier, Applicant concludes that a barge transfer system would be both unsuitable and unnecessary in the present case.

At the proposed terminal site at Gravina, water depths adequate for a deep-water pier are found within an acceptable distance offshore. Barge transfer of LNG would have no significant advantages over the proposed system, and would present several disadvantages -- higher capital and operating costs, lower reliability, higher LNG spill risk, and a greater degree of interference with other craft in the vicinity.

8.5.3.2 Loading of LNG Carriers Through Submarine Pipelines

Offshore mooring systems and submerged pipelines to shore are commonly used by crude oil supertankers. This cargo transfer system has not been used for LNG loading systems. However, a study is presently being conducted by the American Gas Association to determine the technical and economical feasibility of extended LNG transfer lines for loading service. Because submarine cryogenic pipelines have not been commercially proven, they were eliminated from further consideration for use on this Project.

8.5.4 LNG Carriers

The proposed LNG tanker scheme embodies two variables: (1) the cargo tank design to be employed; and (2) the construction site to be utilized.

8.5.4.1 Alternate Cargo Tank Design

At this time a definite selection of cargo containment systems has not been made for the LNG Carrier Fleet. This determination will not be made until active negotiations between the shipyards are underway. However, there are cargo containment systems offered by Conch, Technigaz, Gaz Transport, Moss, Chicago Bridge and Iron, and Crinavis. All of these designs can be made acceptable to Applicant and, in all probability, the ultimate fleet of proposed tankers would include one or more of these cargo containment designs.

8.5.4.2 Alternate Locations for Ship Construction

The construction site for LNG tankers will be determined by factors such as yard delivery schedules, contractual terms and conditions, yard space availability, Project time requirements, and general shipyard willingness to build LNG vessels.

American shipbuilding facilities have demonstrated potential capability to construct LNG tankers of this size. These potential shipbuilders include Avondale Shipyards, Inc., General Dynamics, Ingalls Shipyards, Newport News Shipbuilding and Dry Dock Company, Sun Shipbuilding and Dry Dock Company, and Todd. Presently only Avondale, General Dynamics, Newport News, and Sun Shipbuilding are actively engaged in LNG shipbuilding contracts.

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Section 8

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Section 9
Permits and Compliance

SECTION 9 - PERMITS AND COMPLIANCE WITH OTHER REGULATIONS AND CODES

TABLE OF CONTENTS

9 PERMITS AND COMPLIANCE WITH OTHER REGULATIONS AND CODES

9.1 PERMITS

This section identifies those permits, licenses, certificates and approvals which may be required for implementation of the proposed Alaskan Project. If requirements additional to those presented herein are determined subsequent to the filing of this Report, Applicant will, of course, take whatever action is necessary to secure such requisite authorizations.

In itemizing these permits, licenses, certificates and approvals, Applicant does not necessarily concede the jurisdiction of any agency or governmental unit, or the validity or applicability of any of the statutes, codes or regulations here enumerated.

Federal Permits

The Mineral Lands Leasing Act, 30 U.S.C. §181, *et seq.*, requires approval of the Department of the Interior for temporary use of and the grant of rights-of-way across most federal lands.

The Mineral Lands Leasing Act was amended in 1973 and regulations pursuant to these amendments have not been promulgated. Regulations under the prior act are found at 43 C.F.R., Part 2800.

The Rivers and Harbors Act of 1899 authorizes the Corps of Engineers to approve and issue permits for the construction of any improvement to a harbor or navigable river. 33 U.S.C. §417, §472. Regulations are found generally at 33 C.F.R. §209.120, *et seq.*

On December 23, 1970, the Chief Counsel, U. S. Coast Guard, concluded that a sufficient factual basis existed to require permits for bridges and pipeline crossings to be constructed over the following named waters of Alaska:

Lowe River	Tanana River
Tonsina River	Salcha River
Klutina River	Piledriver Slough
Copper River	Chena River and Tributaries
Tazlina River	Chatanika River
Gulkana River	Tolovana River

Hess Creek	Jim River
Fish Creek	South Fork Koyukuk River
Bonanza Creek (North and South Forks)	Middle Fork Koyukuk River
Prospect Creek	Sagavanirktok River

On January 28, 1974, based on additional information, the Chief Counsel further concluded that a sufficient factual basis existed to add the following named waters to the list of waters for which permits will be required:

Dietrich River	Slate Creek
Hammon River	Shaw Creek

The EPA, pursuant to §§402 and 405 of the Federal Water Pollution Control Act, 33 U.S.C. §§1342 and 1345 has authority to issue permits for wastewater discharges. Regulations are found at 33 C.F.R. §209.120.

Federal Licenses

The Federal Communications Act of 1934, 47 U.S.C. §301, et seq., requires licenses from the Federal Communications Commission, should the applicant's facility require extensive radio communications. Applicable regulations are found at 47 C.F.R. Chapter I.

The Vessel Bridge-to-Bridge Radiotelephone Act, 33 U.S.C. §§1201-1208 requires that all large vessels have radiotelephone equipment of a specified capability. Regulations are found at 33 C.F.R. Part 26. Radio licenses are issued by the Federal Communications Commission pursuant to 47 C.F.R. Parts 81 and 83.

46 U.S.C. §§541-713 contains extensive codification of the obligations and duties owed between merchant seamen and the officers and owners of a vessel. The captain, all licensed officers, and 75 percent of the crew of U. S. vessels must be U. S. citizens, 46 U.S.C. §221, 672 (a). Restrictions and qualifications relating to competence and physical condition, including license requirements, are imposed by numerous sections in Title 46 and by Coast Guard regulations promulgated pursuant thereto--46 C.F.R. Parts 10-16. For example, pursuant to 46 U.S.C. §391 (a), tankermen must be specifically certified as being qualified to handle LNG.

46 U.S.C. §§11-63, 252, 264 states that no vessel may transport merchandise between points in the United States embraced within the coastwise laws unless it is owned by citizens of the United States, was built in the United States and has been documented under the laws of the United States. Documentations of such vessel must be either by registration or by enrollment and license. Both forms of documentation are administered by the Coast Guard. Applicable regulations exist at 19 C.F.R. §4.80. Additional requirements for enrollment and license are set forth in 46 U.S.C. §§251-335 and 46 C.F.R. Part 67. In addition,

46 U.S.C. §§71-83(k) and 46 C.F.R. Part 69 concern the inspection, survey and measurement requirements for documentation.

Federal Certificates

Section 7(c) of the Natural Gas Act, 15 U.S.C. §717f(c), requires that a certificate of public convenience and necessity be issued by the Federal Power Commission prior to the construction or operation of any pipeline and related facility for the transportation of natural gas in interstate commerce. The regulations issued pursuant to the Natural Gas Act are found at 18 C.F.R. Chapter I.

The Coastal Zone Management Act, 16 U.S.C. §§1451-1464, encourages states to develop, in cooperation with federal and local governments, land and water use programs for coastal waters and adjacent shorelands. Pursuant to 33 C.F.R. §209.120(g)(17), applicants for federal licenses and permits are required to have certification from the state that the Applicant's activity is consistent with the state's plan.

The Coastwise Load Line Act, 46 U.S.C. §§88-88(i), requires each large merchant vessel to have hull markings indicating the maximum depth to which the vessel may safely be loaded, and to abide by the markings. Applicable Coast Guard regulations for assignment of load lines are found at 46 C.F.R. §2.85-1 and 46 C.F.R. Part 42. Load line certificates are issued by the American Bureau of Shipping. Additional certificates required include:

(a) Cargo Ship Safety Construction Certificates issued by the Coast Guard or the American Bureau of Shipping. 46 C.F.R. §31.40-5;

(b) Cargo Ship Safety Equipment Certificates issued by the Coast Guard, 46 C.F.R., §31.40-10;

(c) Cargo Ship Safety Radiotelephone Certificates issued by the Federal Communications Commission, 46 C.F.R. §31.40-20, and

(d) Federal Maritime Commission Certificates of Financial Responsibility, §311(p) of the Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. §1321(p) and 46 C.F.R. Part 542.

Alaska Permits

AS 16.10.010 requires a permit for interference with salmon spawning streams or areas.

AS 38.05.330 requires right-of-way easements or permits for secondary roads, ditches and pipelines not subject to AS 38.35.

AS 46.03.020 and 46.03.740 require a permit to apply surface oil for dust control or road compacting.

AS 46.03.100 requires a waste disposal permit for discharges into state waters.

AS 46.03.720 requires a permit for the construction or operation of sewage treatment facilities.

AS 46.03.730 requires a permit from Department of Environmental Conservation for use of certain pesticides.

AS 46.15.030 requires a permit from Department of Natural Resources if substantial state waters are appropriated.

11 Alaska Administrative Code (AAC) 12.190 requires a permit for use of explosives.

11 AAC 58.200 requires a permit for roads, trails, ditches, pipelines or similar uses.

11 AAC 58.210 requires special land use permits.

11 AAC 72.050 requires water appropriation permits.

11 AAC 76.540 requires special material use permits.

11 AAC 62.810 requires tidelands right-of-way easements permits.

18 AAC 50.030 requires open burning permits.

18 AAC 50.090 requires a permit for operations in areas involving potential ice fog.

18 AAC 50.120 requires an operations permit for industrial processes involving certain types of air quality emissions.

18 AAC 60.020 requires solid waste management permits.

18 AAC 72.020 requires subsurface waste water discharge permits.

18 AAC 72.040 requires sludge disposal permits.

18 AAC 75.010 requires surface oiling permits.

Alaska Certificates

AS 42.06.240 requires a certificate of public convenience and necessity from the Alaska Pipeline Commission, to the extent not preempted by the Natural Gas Act.

18 AAC 70.081 requires a certificate of reasonable assurance of compliance with Federal Water Pollution Act.

The Division of Marine and Coastal Zone Management requires a certificate of compliance with the Coastal Zone Management Act. (The regulations have not yet been promulgated.)

Local Permits

Fairbanks Ordinance 49.20.025 requires a special permit for construction in any flood plain area.

Fairbanks Ordinance 45.05.060 requires a burning permit for any burning connected with a construction project.

In addition, the zoning requirements of two burroughs will have to be complied with. Fairbanks Ordinance 49.15.010 governs zoning requirements for the Fairbanks area. The other burrough is North Slope. Presently, the North Slope Burrough ordinances are undergoing revision. When the new ordinances are enacted, it is expected there will be zoning restrictions, as well as other requirements, pertaining to pipelines.

9.1.1 Authorities Consulted

The required list of permits, licenses, and certificates was drawn up by internal research and consultation with others. The basic research material was composed of applicable federal and state statutes and regulations and consultation with outside counsel.

In addition to internal research and consultation, in order to finalize formal application to secure the necessary permits for a surficial reconnassiance it was necessary to contact and consult with several federal and state agencies. The federal agencies were:

United States Department of the Interior
Bureau of Land Management
United States Forest Service, Anchorage
Alaska Command, Military

The Alaskan state agencies were:

Department of Natural Resources
Department of Highways, Central District
Department of Fish and Game

At Valdez, contact was made with the State of Alaska Department of Highways, Valdez District, and at Cordova, contact was made with the U. S. Forest Service Office.

9.1.2 Permits and Authorizations Obtained to Date

On July 9, 1973, Applicant filed applications with several federal and state agencies seeking permits authorizing the surficial reconnaissance of the proposed Alaskan Gas Pipeline route. This surveillance was to consist of two El Paso Natural Gas Company representatives, a construction specialist, a geologist, an environmental specialist, support personnel, and a party chief.

On July 19, 1973, Applicant received from the U. S. Bureau of Land Management a special land use permit authorizing a route reconnaissance for a proposed natural gas pipeline in the utility corridor. The Company had to post a $25,000 bond. The permit was for one year expiring on July 18, 1974. On September 21, 1973, Applicant sent a letter to the Bureau of Land Management informing the appropriate officials that Applicant had completed its reconnaissance of the area, thereby terminating its need for the permit. On August 8, 1974, Applicant received a letter from the Bureau of Land Management informing them that the permit had expired.

On July 19, 1973, Applicant received letter authorization from the U. S. Bureau of Land Management to proceed with the requested study in the Copper River Valley. This letter was in response to Applicant's notice of request to study the surface geology in Section 17 D-2 lands.

On July 9, 1973, Applicant sent a letter to the United States Forest Service requesting permission to conduct aerial reconnaissance in the Chugach National Forest lands. On July 11, 1973, El Paso received letter authorization to conduct the requested route reconnaissance. This letter also authorized El Paso to land helicopters on the Chugach National Forest lands. The only restriction was that the pilots not disturb the wildlife. The letter contained no specific termination date, therefore, the authorization is still current.

On July 9, 1973, Applicant sent to the Alaska Department of Natural Resources, Division of Lands, a letter identical to the letter sent the U. S. National Forest Service. On July 11, 1973, Applicant received letter authorization to conduct an aerial reconnaissance over state lands. This authorization was good for one year, and terminated minating on July 11, 1974.

On July 9, 1973, Applicant sent an identical letter to the Alaska Department of Fish and Game. On July 12, 1973, Applicant received letter authorization to conduct aerial reconnaissance of the proposed gas pipeline route. This authorization contained no termination date; therefore, it is still current.

In addition, on July 9, 1973, Applicant sent letters to Mr. Max C. Brewer, Commissioner of the Department of Environmental Conservation, and Mr. Charles F. Herbert, Commissioner of the Department of Natural Resources. These letters advised them of the various agencies that Applicant had been contacting regarding the requested permits and authorizations to conduct the necessary route reconnaissance of the proposed natural gas pipeline.

9.2 COMPLIANCE WITH HEALTH AND SAFETY REGULATIONS AND CODES

This section includes a compilation of federal, regional, state, and local safety and health regulations and codes requiring compliance and pertaining to the construction, maintenance, and operation of the proposed Alaskan Project. Other health and safety standards and codes, such as underwriter codes and voluntary industry codes, are also included. Again, if additional requirements are determined subsequent to Applicant's filing, necessary measures to ensure compliance will be taken.

Federal Regulations and Codes

The Natural Gas Pipeline Safety Act of 1968, 49 U.S.C. §1671, et seq., administered by the Secretary of Transportation, permits the Secretary to establish federal safety standards for the construction and maintenance of natural gas pipelines. The actual administration of the Act has been delegated to the office of Pipeline Safety. Subsequent regulations issued pursuant thereto are found at 49 C.F.R. Parts 191-192. (Two of the applicable sections are listed below.) In addition, provisions of the Trans-Alaska Pipeline Authorization Act of 1973 may vest certain safety-related authorities in the Secretary of the Interior.

(a) Title 49, C.F.R. 192 provides applicable standards for the transportation of natural gas and other gas by pipeline, and is based upon the minimum federal safety standards (DOT).

(b) Title 49, C.F.R. 192, Amendment 192-10, Docket No. CPS-14, provides applicable standards for liquefied natural gas systems.

The Occupational Safety and Health Act of 1970, 29 U.S.C. §651, et seq., administered by the Secretary of Labor, provides for the establishement of certain minimum federal safety and health standards. The regulations issued thereunder are found at 29 C.F.R. Chapter XVII.

(a) Title 29, C.F.R. Part 1910 provides the basic occupational safety and health standards for pipelines. (OSHA)

(b) Title 29, C.F.R. Part 1926 provides the safety and health regulations for pipeline construction. (OSHA)

(c) Title 29, C.F.R. Part 1910.23 provides the health and safety regulations for liquefied natural gas systems. (OSHA)

The Federal Water Pollution Control Act of 1972, 33 U.S.C. §1251, et seq., controls the disposition of any liquid waste from construction, operation, or maintenance of the Applicant's facility which may reach the natural waters of a state. Regulations issued thereunder are found at 40 C.F.R. Part 125.

The Noise Control Act of 1972, 42 U.S.C. §4901, et seq., administered by the Environmental Protection Agency, requires that noise emission sources comply with certain standards. The applicable regulations are found in 29 C.F.R. §§1910.95, 1926.52.

46 U.S.C. §391(a) governs the transportation of flammable liquid cargoes in bulk. General requirements are found in 33 C.F.R. Parts 30-40. Each vessel subject to regulation under §391(a) must be inspected before service and at least every two years thereafter. Coast Guard inspection procedures are found at 46 C.F.R. Part 2.

Under the Ports and Waterways Safety Act, 33 U.S.C. §§1221-1227, the Coast Guard may restrict access to vessels and waterfront areas, and otherwise act to enhance their security, especially if dangerous cargoes are being loaded or unloaded. See 33 C.F.R. Parts 6 and 125 for pertinent regulations. The Coast Guard may require the use of electronic or other devices, may control and restrict vessel movement in almost any manner, may establish cargo handling procedures, and may prescribe safety standards for vessels and certain shore structures.

33 U.S.C. §471 authorizes the Coast Guard to establish anchorage grounds for vessels in U. S. harbors, rivers and bays and to issue regulations for safe navigation in the vicinity of these grounds. The appropriate regulations are found in 33 C.F.R. §110.

Title 33, C.F.R. §209.120(g)(7) provides that the Corps of Engineers is to regulate the construction of piers, docks, and other boat structures.

International Rules of the Road, 33 U.S.C. §§1051-1094, apply to vessel navigation on the high seas, and the Navigational Rules for Harbors, Rivers, and Inland Waters, 33 U.S.C. §§151-232, apply to vessel navigation within the inland waters of the U.S. The Coast Guard has jurisdiction to enforce both of these navigational rules, 14 U.S.C. §2, and to prescribe to a limited extent, regulations interpreting and implementing certain of their provisions. For additional relevant statutes, see 33 U.S.C. §§171-183, 191-192, 1062-1074, 1075, 1076, 1090.

Title 33, C.F.R. 239, provides U. S. Coast Guard's regulations covering the security of vessels and waterfront facilities.

The Federal Aviation Act of 1958, 49 U.S.C. §1350 requires consultation with the Administrator of the Federal Aviation Administration for the installation or improvement of airfields or landing areas along the Applicant's right-of-way. Pertinent regulations are found in the Federal Aviation Administration Advisory, Circular No. 70-2, July 23, 1973.

Alaska Regulations and Codes

AS 18.70.050 and regulations of the Department of Public Safety relate to fire prevention and control during construction.

7 Alaska Administrative Code 14.000 requires approval from the Department of Health and Social Services before entering into contracts for installation or operation of public water systems.

Other Industry and Underwriter Health and Safety Codes

In addition to the preceding federal and state health and safety regulations and codes, the following standards pertaining to pipelines may apply:

American National Standards Institute (ANSI) B31.8 Gas Transmission and Distribution Piping,

American Petroleum Institute (API),

American Society for Testing Materials (ASTM),

Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS), and

American Waterworks Association.

In addition to the above pipeline standards, the following industrial standards pertaining to LNG facilities will be adhered to:

ACI - 315, "Manual of Standard Practice for Detailing Reinforced Concrete Structures,"

AGA - Gas Engineers Handbook - Purging,

AISC - Code of Standard Practice,

American Association of State Highway Officials (AASHO) Specification M145-66 - Recommended Practice for Classification of Soils, Soil Aggregate Mixture for Highway Construction Purposes and Standard Specifications for Highway Bridges,

American Concrete Institute (ACI) - Concrete Construction Methods,

American Concrete Institute (ACI) - 318, "Building Code Requirements for Reinforced Concrete,"

American Institute of Steel Construction (AISC) - "Specification for Design Fabrication and Erection of Structural Steel for Buildings,"

American Institute of Timber Constructon - "Timber Construction Manual,"

American Welding Society - Standard D1.1 - "Structural Welding Code,"

ANSI B31.1 Code for Pressure Piping
B31.3 Petroleum Refining Piping
B31.5 Refrigeration Piping,

API - RP2A - "Planning, Designing and Construction of Fixed Offshore Platforms,"

API Standard No. RP-500A - Classification of Areas for Electrical Installations at Petroleum Refineries,

API - RP520 - "Design and Installation of Pressure Relieving Systems in Refineries,"

API Standard 2510A - "Design and Construction of LNG Installations at Petroleum Terminals, Natural Gas Processing Plants, Refineries, and Other Industrial Plants,"

ASCE, 1961 Transactions, Volume 126, Part 2, Paper No. 3269 - Wind Forces on Structures,

ASME, Section VIII, Div. 1 - Boiler and Pressure Vessel,

Diesel Engine Manufacturer's Association (DEMA),

Illumination Engineering Society (IES),

Institute of Electrical and Electronics Engineers (IEEE),

Insulated Power Cable Engineers Association (IPCEA),

"International Oil Tanker and Terminal Safety Guide" Published by Institute of Petroleum, London, England,

NBFU - National Board of Firefighting Underwriters,

NEC - National Electric Code NFPA, No. 70,

NEMA - National Electrical Manufacturer's Association,

NFPA No. 30 "Flammable and Combustible Liquids Code,"

NFPA 59A "Liquefied Natural Gas at Utility Plants,"

NFPA No. 68 "Explosion Venting Guide,"

NFPA No. 77 "Static Electricity,"

NFPA No. 78 "Lightning Protection Code,"

NFPA No. 87 "Piers and Wharves,"

NFPA No. 321 "Classification of Flammable Liquids,"

NFPA Code 325M "Properties of Flammable Liquids,"

The Metal Grating Institute - Standard MG-1 - "Metal Grating," and

Uniform Building Code - Zone 3.

9.2.1 Authorities Consulted

The federal, regional, and state safety and health regulations listed above were determined using applicable federal and state statutes and regulations, and consultation with outside counsel.

9.2.2 Procedures to be Followed

Steps will be taken to insure that all personnel associated with the Project will be educated as to the appropriate rules and regulations and the procedures necessary for compliance.

9.3 COMPLIANCE WITH OTHER REGULATIONS AND CODES

The following comprise all other federal, regional, state, and local regulations and codes requiring compliance in the construction, maintenance, and operation of the proposed Alaskan Project.

Federal Regulations and Codes

30 U.S.C. §601, *et seq.*, require, unless already covered by an express provision of a federal permit, a separate authorization from the Secretary of the Interior or Agriculture for the use of material from areas on or adjacent to rights-of-way. Regulations issued pursuant to this statute are found at 43 C.F.R., Part 3600.

The Fish and Wildlife Coordination Act, 15 U.S.C. §661, *et seq.*, 16 U.S.C. §472, 16 U.S.C. §551, and 42 U.S.C. §687 controls construction practices in U.S. Forest Service lands and National Forests.

The Rivers and Harbors Act of 1899, as amended, 33 U.S.C. §401 *et seq.*, requires permission from the U. S. Army Corps of Engineers for bridges, causeways, or other elevated structures over navigable waterways. In this regard, certain regulations are found at 33 C.F.R. Part 114. Similarly, the Transportation Act of 1966, 49 U.S.C §1665, *et seq.*, may vest some control over the location of bridges over navigable waterways in the Department of Transportation, exercised through the Commandant, U.S. Coast Guard.

33 U.S.C. §565 provides that Corps of Engineers' approval must be obtained before a private party may improve any of the navigable waters. For regulations, see 33 C.F.R, §209.120(b)(6), (g)(2), and (g)(8).

Permission for the temporary occupation or use of public works, such as sea walls, jetties, levees, or other works built for improvement of navigable waters or control of floods must be obtained from the Corps of Engineers pursuant to 33 U.S.C. §408. See 33 C.F.R. §209.120 (b)(5) for pertinent regulations.

46 U.S.C. §18 states that every vessel described in the preceding paragraph must have a "home port" in the U.S., the name of which must appear on the vessel's bow and stern, 46 U.S.C. §46; 46 C.F.R. §67.13-1, and in the vessel's document of enrollment and license, 46 U.S.C. §18; 46 C.F.R. §67.19.

18 C.F.R., Ch. 1, Part 2, §2.69, Guidelines to be Followed by Natural Gas Pipeline Companies in the Planning, Locating, Designing, and Maintenance of Rights-of-Way and for the Construction of Aboveground Facilities, requires an Applicant and its contractors to comply with certain delineated procedures for environmental enhancement during design, construction, and operation and maintenance of facilities within the jurisdiction of the FPC.

Alaska Regulations and Codes

AS 16.05.870 requires approval from the Department of Fish and Game for crossing, using, obstructing or diverting any river, stream or lake.

AS 38.35.020 requires right-of-way leases across state lands, including tidelands and submerged lands.

11 AAC 58.810 requires permission to proceed (from the Department of Fish and Game or the Corps of Engineers) with activities on leased land which would use, divert, obstruct, pollute or change the natural flow of bed of any river, lake or stream, or affect the navigability of any stream.

9.3.1 Authorities Consulted

The above list of other federal, regional, state, and local codes and regulations was prepared using applicable federal and state statutes and regulations and consultation with outside counsel.

9.3.2 Procedures to be Followed

Appropriate measures will be instituted to ensure that all personnel associated with the Project will be educated as to the applicability of the above rules and regulations and the procedures necessary for compliance.

9.4 SPECIAL CASES

9.4.1 Liquefied Natural Gas Facilities

For the applicable standards and requirements governing liquefied natural gas transporting and processing, see the previously cited federal and state codes, regulations, and voluntary industry standards. For the required technical details illustrating the various design features of the LNG Plant, marine terminal and carrier fleet, see Section 1 of this Report. See also Section 11 of this Report for a description of potential hazards associated with LNG storage and transport.

Section 10
Sources of Information

SECTION 10 - SOURCES OF INFORMATION

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10 SOURCES OF INFORMATION

The following is a listing of sources of information utilized by Applicant in the preparation of this Environmental Report. Appropriate literature sources have been listed in the Bibliographies appearing at the end of each section of the Report, and they have not been duplicated here. The remaining sources -- public hearings, meetings, studies, consultants, and supportive reports -- are presented herein.

10.1 MEETINGS WITH GOVERNMENTAL AND OTHER ENTITIES

10.1.1 Federal Government

U. S. Army Corps of Engineers, Anchorage, Alaska

Applicant requested information from the Corps of Engineers respecting permit requirements for pipeline crossings of navigable waters. Applicant was advised that permits were required for streams classified as navigable; however, there is presently no such listing of navigable streams for the State of Alaska. (Note: Such list has subsequently been prepared -- see Section 9 of this Report).

U. S. Bureau of Land Management (BLM)

On July 26, 1973, Applicant met with personnel of the Anchorage District of BLM to discuss the status of D-2 Lands in the Copper River Valley. Applicant was informed that until the Secretary of the Interior makes his recommendations for the disposition of D-2 Lands, and until Congress acts upon these recommendations, any major applications for use of federal lands administered by the BLM would be carefully studied.

On March 30 and June 11, 1974, Applicant met with the staff of the BLM to acquaint it with its proposed Alaskan Project.

U. S. Coast Guard

On February 28, 1974, Applicant notified the U. S. Coast Guard of its proposed Project, in response to a request related to the draft environmental impact statement for the proposed Prince William Sound Vessel Traffic System.

Environmental Protection Agency

On July 23, 1973, a meeting was convened with the Director of the Environmental Protection Agency for Alaska. The purpose of the meeting was to identify applicable guidelines and regulations, and the depth of study required, in an environmental assessment of a Copper River Valley gas pipeline alignment. Applicant, as requested, used stipulations of the USDI permit for the Alyeska Project, and those of the EPA (Water Quality Standards, and Herbicides, Pesticides and LD_{50}) Handbooks as bases for its assessment.

Applicant subsequently requested additional information from the Director regarding regulations pertaining to its proposed Project, and on the requirements for a permit to monitor water quality; the former information was secured, and Applicant was informed that the latter was not required.

U. S. Forest Service

Applicant met with Regional Forest Service representatives in Anchorage on July 24, 1974, to obtain baseline data on wildlife habitats in the Chugach National Forest, and to acquaint the local Forest Advisory Group with the proposed Alaskan Project.

On July 27, 1973, Applicant met with the Director of Services to secure information for use in its baseline assessment respecting habitat improvement, management units, and soils and water quality. Applicant was advised that the USFS must, under current policy, write an environmental impact assessment on any proposed activity on Forest Service land which may change its natural appearance.

On July 30, 1973, Applicant met with the Chugach National Forest District Supervisor and the Chugach National Forest Land Specialist, to discuss the probable affects of ANCSA on national forest lands in Alaska, including those in the vicinity of Port Valdez.

Applicant was informed that two native villages (Tatitlek and Eyak) have rights to portions of these lands pursuant to ANSCA, but that this land withdrawal would not ultimately affect Applicant's proposed pipeline alignment from Thompson Pass to Gravina Point.

Applicant was further advised that the Forest Service can exclude from native land selection areas within designated national forest transportation corridors.

U. S. Geological Survey

Applicant requested and secured information on the location and frequency of occurrence of icings and glacial outburst floods, and 1972-73 surface water records, for ultimate use in its characterization of the baseline environment.

Joint Federal-State Land Use Planning Commission

On July 26, 1974, Applicant met with the Joint Federal-State Land Use Planning Commission to determine the current status of the federal lands within the Copper River Valley. Applicant was informed that the region of its concern, lying immediately east of the Copper River, is a portion of a larger area between the Richardson Highway and the Copper River which the Commission will recommend for preservation as a "scenic natural area." This classification would probably preclude Applicant's proposed use of a portion of the area as a natural gas pipeline route.

Applicant was further advised that there were some potentially serious land ownership and land control problems within the corridor which was specifically selected and withdrawn for transportation and utility purposes along the route of the Alyeska Pipeline.

National Climatic Center, Asheville, North Carolina

Applicant made a request to the Director for wind direction versus wind speed data for Bettles, Alaska. The desired information was received for ultimate use in the baseline compilation.

National Marine Fisheries Service

Applicant requested and secured information on fisheries in Prince William Sound.

Soil Conservation Service

On July 24, 1973, Applicant visited the Anchorage Regional SCS Field Office to obtain soil maps for baseline analyses of both the Copper River and Tiekel River portions of the proposed gas pipeline route.

On July 27, 1973, Applicant again met with the SCS to obtain soils information for the Copper River and Chugach Mountain route. Since final soil maps were then in print, Applicant secured preliminary information based on comparative analyses of sites that were mapped and lined in similar areas. Detailed SCS maps were later secured.

10.1.2 State of Alaska

Arctic Environmental Research Center

Applicant requested and received environmental data applicable to its Alaskan Project.

Alaska Department of Environmental Conservation

Applicant contacted the Regional Environmental Engineer July 25, 1973, to determine applicable air, water quality and conservation guidelines of the state.

Applicant was informed that the DEC was primarily concerned with the peripheral activity (*i.e.*, staging area constraints, living requirements, sanitary facilities and input to communities) which would result from an increased work force for pipeline construction.

Applicant requested and received available data on the following: federal, state and local environmental laws and regulations dealing with solid waste materials; air quality standards for south central Alaska; water supply data and waste disposal methods in the Copper River Drainage; and regulations and standards for maximum allowable thermal discharges in Prince William Sound. Applicant was advised that permits for water quality monitoring were not required.

Alaska Department of Fish and Game

On July 20, 1974, Applicant requested baseline data on sea mammals in Prince William Sound from the I&E and Marine Mammals Sections, Alaska Department of Fish and Game. Applicant was informed that records from the Department's 1958 Annual Report indicated that during 1958, 30,250 hair seals were killed in Copper River through control activities, and that normally, annual kills ranged between 1300 and 4500 seals.

The Department further indicated that there was a small population of sea otters on Hawkins Island, and another numbering about 350 on Hinchinbrook. The area was also said to harbor a small number of sea lions. Additionally, Applicant was informed that the introduced moose herd in the Copper River Delta numbered 250, following major winter losses in 1972, and that the Department was concerned with Applicant's proposed use of the Copper River pipeline route, in view of its importance as a waterfowl area.

On July 23, 1973, Applicant secured from the Fisheries Division baseline information respecting shellfish and herring harvests in Prince William Sound and potential salmon spawning areas in the Salmon River.

On August 1, 1973, Applicant met with Department representatives to discuss wildlife, special construction timing, route alterations, and hunting and fishing pressure on sensitive areas. Applicant was informed of particularly sensitive wildlife areas and species, and that peripheral impacts (i.e., hunting and fishing) were of prime concern to the agency.

Applicant requested information on all endangered species and ecosystems in Alaska, and received data on the Aleutian Canada goose, two species of peregrine falcons, the Eskimo curlew, and the short-tailed albatross.

Applicant requested information on existing legislation affecting development of natural resources, wildlife and anadromous fish streams, and data on fish studies of the Sag River. Applicant was advised of the required permit for any disturbance of anadromous fish stream; no other regulations were applicable. Publications were obtained respecting local aquatic biology, and Arctic char spawning and overwintering in the Sag River.

Applicant requested data on the importance of salmon in Jack Bay, and was advised that Jack Bay is a concentrated salmon area with schooling and migration, and also supports a sport fishery for halibut.

Alaska Forestry Department

On July 23, 1973, Applicant contacted the State Forester to determine the Department's jurisdictions relative to the proposed Alaskan Project.

Applicant was advised that the Forestry Department had no jurisdiction, but that the Bureau of Land Management would probably have some advice on resource management in the Copper River area.

Alaska Department of Health & Welfare, Division of Environmental Health

Applicant contacted the Department on July 23, 1973, for state health regulatory requirements or criteria applicable to gas pipeline facilities. Applicant was informed that the Division of Environmental Health had no jurisdiction over the construction of facilities, but did have responsibility for the peripheral effects of human land use, including the development of facilities and camps during both construction and operation.

Alaska Department of Highways

Applicant requested and received information on the Copper River Highway for use in the baseline assessment.

Alaska Department of Natural Resources

On June 12, 1974, a meeting was held with the Director of the Division of Lands for the Alaska State Department of Natural Resources to discuss criteria used to evaluate energy corridors and to determine ADNR'S ownership in the floodplains and tidelands in the vicinity of the Copper River (and elsewhere in the state) and in the estuarine and riparian lands to the three-mile limit.

Alaska State Pipeline Coordinator (Office of the Governor)

On June 13, 1974, Applicant met with the Coordinator to discuss the proposed gas pipeline route in Alaska.

10.1.3 University of Alaska

Arctic Environmental Information and Data Center

Applicant requested and secured baseline wind data for Hawkins Island.

Department of Biology

Applicant requested information on Alaskan fish (and current field studies), the Alaska botanical baseline, and background biological data in the vicinity of Cordova, Alaska. Available information was received and incorporated into the baseline environmental assessment.

Department of Geology

Information was requested on possible revegetation procedures.

Institute of Marine Sciences

Information was requested on the feasibility of aquaculture in Prince William Sound. Applicant was advised that Prince William Sound was ideally suited for aquaculture development. In addition, Applicant was also supplied baseline marine biological data for Prince William Sound.

10.1.4 Public Hearings

To date, Applicant has participated in four public hearings convened by federal and state governmental entities. They are:

(1) Special Committee on Energy, Joint Meetings with the House Resources Committee, Juneau, Alaska (February 18 and 19, 1974),

(2) Alaska House of Representatives, The Natural Gas Pipeline Committee (Special Interim Legislative Committee), Anchorage, Alaska (August 9, 1974),

(3) NARUC Ad Hoc Committee on U. S. - Canadian Energy Relations, Washington, D. C. (February 26, 1974), and

(4) The Role of the Trans-Alaska Gas Project in Achieving Project Independence, Anchorage, Alaska (September 10, 1974).

10.1.5 Informal Meetings

A number of informal meetings were held with various governmental, environmental and conservation entities, including The Federal Power Commission, The Department of the Interior, The Department of State, numerous Alaskan governmental agencies, The Sierra Club, The Wilderness Society, Natural Resources Defense Council, National Audubon Society, Friends of the Earth, and Canadian Arctic Reserves Committee.

The purpose of these meetings was to inform these organizations of the proposed Alaskan Project and to discuss its potential environmental ramifications. Pipeline routes, LNG utilization, and potential terminal sites were reviewed. No environmental conclusions were reached.

10.2 STUDIES CONDUCTED

Dames and Moore

Compiled the baseline data on abiotic, biotic, and socioeconomic factors for the Project Environmental Report and evaluated the environmental impact of the proposed facilities. Also provided support to other Project consultants during site and route selection. Work was based primarily on published data, supplemented by field reconnaissance.

Fluor Engineers and Constructors, Inc.

Detailed engineering feasibility studies leading to the preliminary design of the proposed LNG Plant. Also provided general Project management in terms of coordinating construction schedules, and the like. Results of studies are presented in Section 1 of this Report.

Fluor Ocean Services

Site selection studies in Alaska of potential LNG Plant Marine Terminal sites, and detailed engineering feasibility studies, culminating in the preliminary design of the Alaskan Marine Terminal. Results of studies appear in Sections 1 and 8 of this Report.

Methane Tanker Service Company

Detailed engineering feasibility studies leading to the preliminary design of the LNG Carrier Fleet. Also supervised studies of marine casualty risks and LNG vapor plume dispersion. Results of studies appear in Sections 1 and 11 of this Report.

Pipeline Technologists

Detailed engineering feasibility studies leading to preliminary design of the Alaskan Gas Pipeline. Also participated in pipeline route selection studies. Results of studies appear in Sections 1 and 8 of this Report.

10.3 CONSULTANTS

Dames and Moore

Dames and Moore is a partnership, founded in 1938, which provides consulting services in the environmental and applied earth sciences. Offices are located in 33 cities, including Los Angeles, Anchorage, and Fairbanks. Its staff of over 800 professional engineering and scientific employees has diversified backgrounds in, primarily, oceanography, meteorology, air and water quality, terrestrial and aquatic ecology, land planning, demography, socioeconomics, marine geology, engineering geology, rock mechanics, soil mechanics, geophysics, engineering seismology, surface and groundwater hydrology, and mineral exploration.

An approximate breakdown of its current professional staff is as follows:

Professional Specialty	Number
Geotechnical, Soils & Civil Engineering	250
Coastal Offshore Engineering, Marine Geology, Marine Biology	52
Meteorology, Climatology, Air Quality	50
Hydrology, Water Resources, Groundwater Geology	93
Biological Sciences	86
Soil Science, Agronomy, Botany	16
Systems Engineering	20
Geography, Demography, Land Planning	28
Engineering & Environmental Geology	120
Rock Mechanics & Mining Engineering	40
Economic & Mining Geology	30
Geophysics	18
Seismology	35
Chemistry & Physics	10
Total	848

Fluor Engineers and Constructors, Inc.

The Fluor Corporation has been engaged in engineering and construction for over seventy-five years. In 1922, Fluor engineered and constructed its first hydrocarbon processing plant. Since then, successful projects of increasing size and complexity have brought about a corresponding growth in personnel, facilities, and capabilities.

Principal industries served by Fluor Engineers and Constructors, Inc., are petroleum refining, natural gas, petrochemicals, chemicals, fertilizers, pharmaceuticals, rubber, plastics, synthetic fibers, atomic energy, thermal electric power, and water desalination.

Fluor Engineers and Constructors, Inc., is headquartered in Los Angeles, California, and has regional headquarters in Houston, Texas, London, England, and Haarlem, Netherlands.

The Company's principal customers include many of the major U. S. and foreign oil companies and manufacturers. To a lesser degree, Fluor performs engineering and construction services for various governmental agencies, such as the Atomic Energy Commission and the Office of Saline Water of the Department of the Interior.

Fluor Engineers and Constructors, Inc., operates directly through two divisions: (1) its Los Angeles Division engages in design, engineering and construction of plants for petroleum refining, petrochemicals, natural gas, power and allied industries. It is located at 2500 S. Atlantic Blvd., Los Angeles, and (2) its Houston Division furnishes the same services as the Los Angeles Division, and is located at 4620 N. Braeswood Blvd., Houston, Texas.

Fluor Ocean Services

Fluor Ocean Services, a subsidiary of Fluor Corporation, provides complete engineering and construction services to worldwide marine and offshore industries. Such services include feasibility studies, project planning, preliminary engineering, detailed design, procurement, project management and construction. The Company can serve its clients as an engineering consultant, as an engineering and construction manager, or as a total capability team charged with complete responsibility from project conception through start-up.

Fluor Ocean Services' project experience includes marine and offshore terminals, ports and harbor developments, offshore drilling and production platforms, offshore pipelines, and floating and subsea storage.

Its Houston, Texas, office is its corporate headquarters and the home of the Engineering and Construction Divisions. An active engineering office is maintained in London, England, with temporary field offices staffed as necessary for the performance of projects.

The project task force approach is commonly used by Fluor Ocean Services. In this approach, a team of specialists in all the required disciplines is organized under a Project Manager, who provides a single point of responsible contact for the client throughout the project. Support personnel are assigned to or removed from the team as the workload demands. The principal features of the task force concept are consolidation and close proximity of all members of the team, complete commitment of all personnel, improved individual and team motivation, rapid communications, simplified control of project activities, and efficient project execution.

Methane Tanker Service Company

Methane Tanker Service Company, a Delaware corporation, is a wholly-owned subsidiary of El Paso Natural Gas Company. The Company, formed in 1973, is comprised of a staff of executives, engineers, and supporting technicians. It serves as a service company for the ship-owning companies within the El Paso organization to provide assistance in contract negotiations, to carry out construction supervision and plan approval activities for ships now under construction, and to act as El Paso's marine transportation element for investigating the technical and economic feasibility of proposed and future LNG projects.

Robert O. Parker, Ph.D.

Dr. Robert O. Parker is an independent consultant, and is considered an authority in the field of LNG vapor dispersion and radiation effects.

Dr. Parker has a Bachelor of Science in Chemical Engineering from Carnegie-Mellon University, a Master of Science from Columbia University, and a Doctor of Engineering Science from New York University. He has been on the teaching staff of New York University School of Engineering for fifteen years, progressing from the position of Instructor to the position of Professor of Chemical and Nuclear Engineering. Prior to his teaching career, he held various engineering positions with the Griscom-Russell Company.

Dr. Parker is a professional member of the American Institute of Chemists, the American Institute of Chemical Engineers, American Chemical Society, American Nuclear Society, New York Academy of Sciences, National Fire Protection Association, and is a professional registered engineer. He has published approximately 17 papers and articles on heat transfer, process engineering, cryogenic liquids, and LNG behavior.

Pipeline Technologists, Inc.

Pipeline Technologists, Inc., is a consulting firm of professional pipeline engineers and supporting technicians. The company specializes exclusively in the feasibility, analysis, design, planning, coordination, inspection of construction, and general management of liquid petroleum, natural gas, and slurry pipeline projects. It also provides operation administration and training of personnel for completed systems, as well as marketing studies, financial planning, appraisals and tariff studies for new pipelines and terminals.

Originally formed in 1951 as a partnership, the firm was later incorporated under the laws of the State of Delaware, and is now a wholly-owned subsidiary of Kaneb Service, Inc., a publicly-owned company with interests in service, industry, and energy resources. Although a subsidiary, Pipeline Technologists, Inc. operates as a separate entity with its own board and corporate officers. The company has no association with manufacturers, suppliers, or construction contractors.

The home office and center of operations is located in Houston, Texas, in the Western National Bank Building. It houses engineering and drafting departments, computer services, and administrative services groups.

In addition, three permanent branch offices have been established in Calgary, Canada, The Hague, Netherlands, and Melbourne, Australia. The staff of these offices, besides being generally experienced, are particularly knowledgeable of local problems, as well as of special procedures, rules and regulations governing pipeline system design, construction, and operations in the areas they serve.

The Pipeline Technologists, Inc. staff consists of approximately 300 persons, principally Professional Engineers registered in most of the United States and many foreign countries around the world. In addition to the permanent staff, Pipeline Technologists, Inc. has ready access to a large reserve of experienced manpower to assist in such areas as specialty consulting and research, construction coordination and inspection, surveying, right-of-way and terminal site procurement, personnel training, operations and management.

Pipeline Technologists, Inc. has engineered and completed several hundred domestic and foreign pipeline projects in more than forty countries around the world. Pipeline Technologists, Inc. has specialized in pipeline design for unusual commodities such as ethylene, oxygen, and helium. Other special projects include marine and arctic work. One such special project was started in 1968 when Pipeline Technologists, Inc. was called upon to assist in the Alyeska pipeline project to transport crude oil from the North Slope of Alaska approximately 800 miles to the Port of Valdez.

Joseph D. Porricelli

Joseph D. Porricelli, a principal of Engineering Computer Optechnomics, Inc. ("ECO"), 505 Burning Tree Drive, Arnold, Maryland, is responsible for the ship casualty analysis supporting the Alaskan Project LNG safety studies.

He is currently the Project Engineer for ECO under their contract with the Council on Environmental Quality regarding the environmental impact of the proposed Outer Continental Shelf petroleum operations off the Atlantic and Alaskan coasts.

He served for twelve years with the U. S. Coast Guard, the last six of which he spent with the Office of Merchant Safety in its New York and Washington, D. C. offices. He was a member of the Interagency Task Force for the Council on Environmental Quality to develop the environmental impact of supertankers on ports of the United States, and was a member of the joint industry-government group which studied segregated ballast tankers for the United States delegation to the Conference for the Prevention of Pollution from Ships, 1973.

Mr. Porricelli has participated in a number of marine technical and safety forums, including the Ship Design and Equipment and Marine Pollution Subcommittees of the Intergovernmental Maritime Consultative Organization (IMCO) of the United Nations and the International Electrotechnical Commission (IEC).

Mr. Porricelli received his Bachelor of Science degree from the United States Coast Guard Academy and a Master of Science in Naval Architecture and Marine Engineering from the University of Michigan. He is a member of the Society of Naval Architects and Marine Engineers, the American Society of Naval Engineers, the Institute of Electrical and Electronic Engineers, and the American Boat and Yacht Council. Mr. Porricelli has published a number of technical papers dealing with the environmental safety and economic aspects of tankers.

David D. Smith, Ph.D.

Dr. David D. Smith is an authority on oil spills and waste disposal, marine operations, harbor development projects, and water quality. He has a broad range of experience in applied oceanography, water quality, and liquid and solid waste management studies.

An environmental scientist, with a Ph.D. in geology from Stanford University, Dr. Smith has directed or participated in a wide variety of multi-disciplinary projects involving biology, oceanography, and meteorology, geology, and marine, coastal, civil, sanitary, and chemical engineering, as well as economics and operations research.

He has extensive testimony experience, has published more than 35 technical articles, and is a member of more than 20 professional and technical societies. He is a Captain in the U. S. Naval Reserve.

11 LNG SAFETY

The objective of the LNG safety report is to present a comprehensive appraisal of the safety of the LNG Plant and the LNG Carrier Fleet for the Trans-Alaska Gas Project. There are to be three major sections in the report.

The first will describe the nature of LNG in general, and will compare it with certain other hazardous products.

The second section will deal with the LNG Plant, and will cover the plant site description, applicable codes and regulations, planned design safety measures, construction (quality control) safety measures, planned operational safety measures and a land spill analysis.

The third section will address the LNG Carrier Fleet, and will discuss the proposed trade route, applicable codes and regulations, planned design safety measures, planned construction (quality control) safety measures, planned operational safety measures, cargo release probabilities and a water spill analysis.

Both sections two and three will be concluded with assessments of safety measures taken for the LNG Plant and the LNG Carrier Fleet.

The report will also include a glossary of terms, a list of abbreviations, a list of references and vitae for principal consultants. The report is currently under preparation, and will be furnished upon its completion.