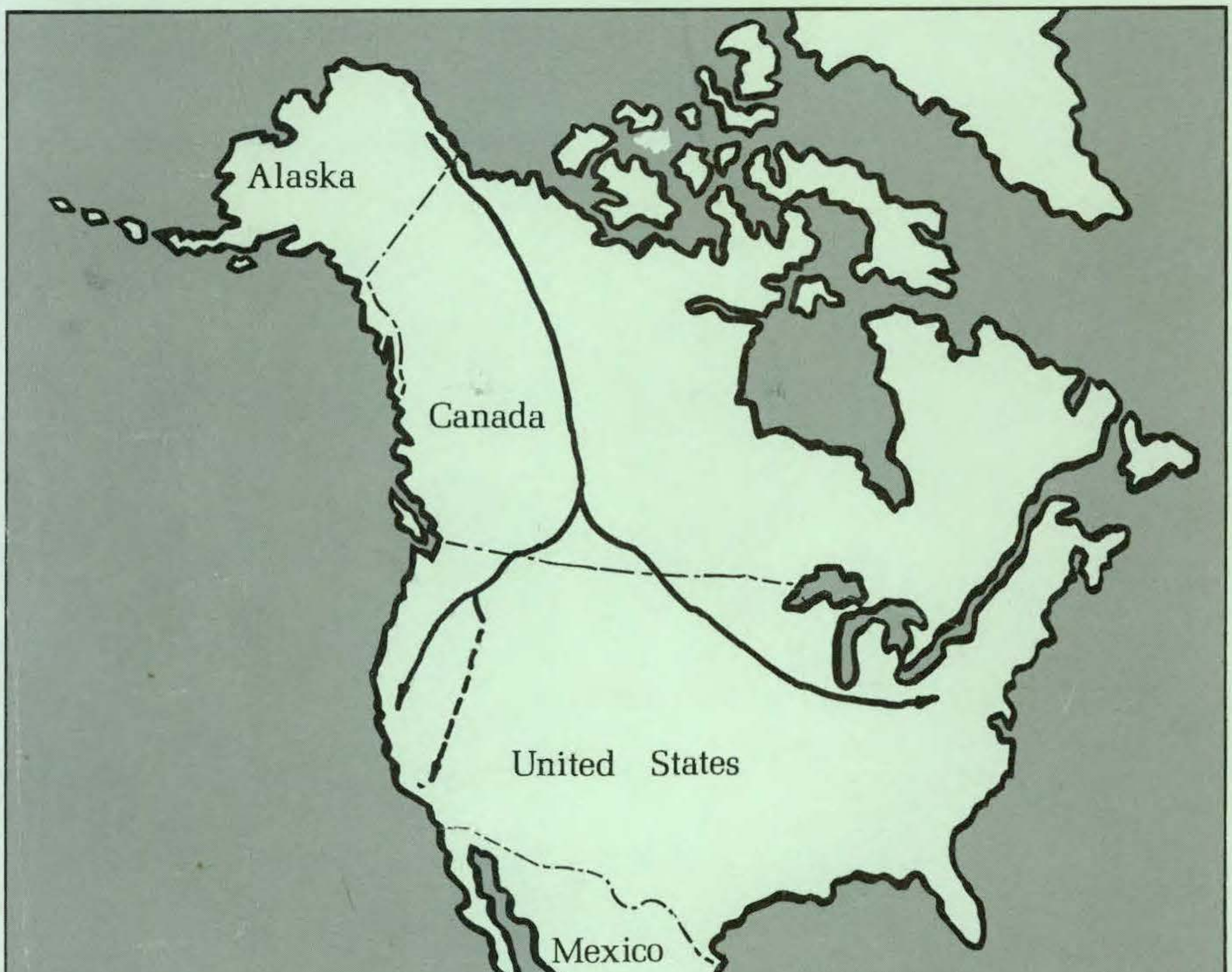
ALASKA NATURAL GAS TRANSPORTATION SYSTEM
Final Environmental Impact Statement

ALASKA



MARCH 1976

U.S. DEPARTMENT OF THE INTERIOR

WASHINGTON, D.C. 20240

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TRANSPORTATION SYSTEM

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This final Environmental Impact Statement has been prepared under the provisions of Section 102(2)(C) of the National Environmental Policy Act of 1969 (P.L. 91-190). Contact regarding the document should be addressed to:

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SUMMARY

( ) Draft (x) Final Environmental Statement
United States Department of the Interior, Alaska Natural Gas Transportation System EIS Task Force

1. Type of action: (x) Administrative ( ) Legislative

2. Brief description of action: Action pending is granting rights-of-way permits for crossing Federal lands. A 5,580-mile buried pipeline has been proposed to transport natural gas from Prudhoe Bay (Alaska) to markets in the lower United States. The pipeline, as proposed, would cross all, or portions of, Alaska; Yukon Territory, Northwest Territories, British Columbia, Alberta, and Saskatchewan (Canada); and Idaho, Washington, Oregon, California, Montana, North Dakota, South Dakota, Minnesota, Iowa, Illinois, Indiana, Ohio, West Virginia, and Pennsylvania. As proposed, all activities necessary for pipeline construction and operation will be phased over a seven-year period. Of all lands traversed by the proposal, 406 miles will involve lands under the jurisdiction of five Federal agencies, all of whom have permitting authority. Other permits or licenses also must be issued before construction may begin or the project becomes operational.

3. Environmental impact and adverse environmental effects: Because of the linear nature of the proposal, a wide spectrum of environmental impacts will occur if the pipeline is built. Impacts, which are detailed in the Overview and geographically-oriented volumes, will occur on climate, topography, geology, soils, water resources, vegetation, fish and wildlife, social and economic environments, land use and productivity, cultural resources, recreation and esthetics, and air quality (including noise). All impacts will not be adverse.

4. Alternatives considered: Alternatives covered include the courses of action open to the Secretary of the Interior to approve, deny, postpone, or accept and delay or deny part of the proposal; effects of gas deregulation and conservation; other natural gas sources; alternative energy sources and modes of transportation; and one major alternative transportation system involving an all-Alaska gas pipeline, liquefaction plants, and LNG tanker transport to the conterminous United States.

5. Comments have been received from the following: Comments were received from 23 Federal agencies, 35 State and local governments, Canada, 17 companies representing industry, 16 private organizations, 100 individual citizens, and three members of Congress. Comments from Federal agencies, State and local governments, Canada, private organizations, and members of Congress are reproduced in the Consultation and Coordination volume. Other comments will be reproduced and filed as a supplement to this statement at selected repository sites.

6. Date made available to CEQ and the public:

Draft statement: July 28, 1975
Final statement: MAR 1976

Note for Readers

This environmental impact statement was prepared in response to applications made to the Secretary of the Interior for permits to cross Federal lands with a natural gas pipeline. It identifies and evaluates environmental impacts that could be expected from construction and operation of the "Alaska Natural Gas Transportation System" as proposed by the consortium of companies listed in the Consultation and Coordination volume. It was prepared by an interdisciplinary team, most of whom are employees of the United States Department of the Interior.

Detailed construction designs and detailed plans for site restoration and system operation are not complete at this (proposal) stage of the project. For this reason, some of the impacts and mitigating measures are expressed in ranges of magnitude or qualified to reflect alternative situations.

The Secretary of the Interior considers a number of factors in reaching his decision regarding issuance or denial of right-of-way permits. The environmental impact analysis presented in this statement is an important but not necessarily the deciding factor. Alternative gas transportation systems proposals, United States-Canada diplomatic relations, national economic and risk analyses, national defense implications, energy efficiency analyses, and other factors must also be considered.

This statement is presented in nine volumes as follows:

- Overview Volume
- Alaska Volume
- Canada Volume
- San Francisco Volume
- Los Angeles Volume
- North Border Volume
- Alternatives Volume
- Consultation and Coordination Volume
- Glossary Volume

Alaska, Canada, San Francisco, Los Angeles and North Border Volumes are geographically oriented. The Overview Volume, Alternatives Volume, and Consultation and Coordination Volume are not geographically oriented in their coverage.

The following subject groupings are covered sequentially in each of the geographically oriented volumes and Overview:

1. Description of the proposal.
2. Description of the environment.
3. The environmental impact of the proposed action.
4. Mitigating measures proposed and additional measures considered.
5. Adverse effects which cannot be avoided should the proposal be implemented.

6. The relationship between local short-term uses of (man's resources) and the maintenance and enhancement of long-term productivity.
7. Irreversible and irretrievable commitments of resources associated with the proposed action.
8. Alternatives to the proposed route.

The reader can review particular segments of the proposed project selectively. For example, a reader interested only in impacts on North Dakota, could use the Overview Volume for the system "big picture," and the North Border Volume for coverage of his particular State. Similarly, a person interested primarily in ways of transporting natural gas could refer to the Alternatives Volume and satisfy his needs.

Following is a brief description of the coverage of each part:

Overview Volume - The Overview covers the Arctic Gas System proposal in its entirety. It will be most useful to those readers who want a system view and a broad concept of anticipated environmental impacts of the entire pipeline project.

Alaska Volume - This volume covers the 195-mile proposal of the Alaskan Gas Arctic Pipeline Company originating at Prudhoe Bay and terminating at the Alaska-Yukon Border and alternative routes.

Canada Volume - This portion of the environmental impact statement analyzes the 2,435-mile pipeline proposal of Canadian Arctic Gas Pipeline, Ltd., beginning at the Yukon-Alaska Border and proceeding generally southward to Caroline Junction in Alberta where it forks, one leg entering Idaho, near Kingsgate, British Columbia, and the other entering Montana, near Monchy, Saskatchewan. Discussions of route alternatives are also presented.

San Francisco Volume - This volume analyzes the 917-mile portion proposed by the Pacific Gas Transmission Company which passes through Idaho, Washington, and Oregon to Antioch, California. Discussions of route alternatives are presented.

Los Angeles Volume - This volume relates to the 414-mile portion proposed by Interstate Transmission Associates (Arctic) extending from the point of United States entry in Idaho to Rye Valley, Oregon. It also involves modifications to existing compressor stations in Oregon, Idaho, and Colorado. Discussions of route alternatives are presented. This volume also contains a discussion of the applicant's future proposal for an additional 760-mile pipeline passing through Idaho, Oregon, Nevada, and terminating at Cajon, California.

North Border Volume - This volume is an analysis of the 1,619-mile pipeline proposed by the Northern Border Pipeline Company. It covers the area from the United States-Canada border, crossing Montana, North and South Dakota, Minnesota, Iowa, Illinois, Indiana, Ohio, and West Virginia, to a termination near Delmont, Pennsylvania. Discussions of route alternatives are presented.

Alternatives Volume - This volume covers courses of action open to the Secretary of the Interior to approve, deny, postpone, or accept and delay or deny part of the proposal; effects of gas deregulation and conservation; other natural gas sources; alternative energy sources and modes of transportation; and one major alternative gas transportation system involving an all-Alaska gas pipeline, liquefication plants and tanker transport to the conterminous United States.

Consultation and Coordination - This volume describes and discusses the efforts made by the Department of the Interior to consult with and coordinate its work in the development of this statement. It includes the gathering of basic information for analysis, public meetings, public hearings, and efforts which have and will be made to assure that environmental impacts are adequately treated.

Glossary - This volume provides the reader with definitions of technical words or phrases used in the environmental impact statement.

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1.OV Description of the Proposed Action

Introduction

A major oil field on the North Slope of Alaska was discovered in 1968 by the Atlantic Richfield Company. This 200-square-mile area known as the Prudhoe Bay Field contains, in addition to the oil reserves, an estimated 22.5 trillion cubic feet of recoverable natural gas reserves. Following this discovery three companies formed a study group to plan and design a pipeline system for transporting the oil. Subsequently, more companies joined this group and in 1970 the Alyeska Pipeline Service Company was formed to construct and operate an oil pipeline. This company applied to the Federal Government for the necessary permits and rights-of-way to construct a line from the Prudhoe Bay Field to Valdez, an ice-free deepwater port in southern Alaska on the Valdez Arm of Prince William Sound. With the passage of the Mineral Leasing Act of 1920 amendments and trans-Alaska oil pipeline authorization in November 1973, Congress authorized and directed the Federal agencies involved to issue the necessary permits and rights-of-way to the Alyeska Company so that construction of the trans-Alaska Pipeline System (TAPS) could begin. As a result, actual pipeline construction began in the winter of 1974-75. If TAPS construction is completed as scheduled, transport of oil through the line could begin by mid-1977.

A consortium of 16 companies, making up the Arctic Gas Northwest Study Group, has proposed that an approximately 5,557-mile pipeline be constructed for the transportation of gas from Prudhoe Bay to markets in the United States. These companies are listed in Table 1.OV-1. The oil producers have entered into preliminary negotiation agreements with some member companies of the consortium for the gas.

Before construction can begin on a gas pipeline, appropriate agencies of the Federal Government must grant a series of permits, authorizations, and approvals. Among the agencies with major involvement are the Federal Power Commission which must grant certificates for interstate gas sales and for the construction and operation of interstate pipelines, and the Department of the Interior which is responsible for granting rights-of-way across Federal lands. Since these are major Federal actions that will have a significant impact on the environment, this environmental impact statement has been prepared for compliance with Section 102 of the National Environmental Policy Act. Although the impact statement addresses itself to a route and right-of-way alignment, the project is a corridor concept at this point. By following a corridor concept, adjustments in alignment of up to several miles on either side of the route discussed in this environmental impact statement can be made without the necessity of treating all route adjustments as alternatives to the proposal.

The gas pipeline, in terms of dollars, is reported to be the largest privately financed project in the world. Based on late 1975 estimates the cost of construction would be $8.5 billion. Terminal points of the proposed pipeline will be Antioch, California; Rye Valley, Oregon; and Delmont, Pennsylvania.

Six companies have made application to the appropriate agencies of the United States and Canadian Governments for authorization to construct a pipeline from Prudhoe Bay and the Mackenzie Delta to southern terminal points. These companies, Alaskan Arctic Gas Pipeline Company, Canadian Arctic Pipeline Company Limited, Northern Border Pipeline Company, Pacific Gas Transmission Company (PGT), Pacific Gas and Electric Company (PG & E), and Interstate Transmission Associates (Arctic) (ITAA), propose to construct approximately 5,557 miles of pipeline (see Table 1.OV-1).

Table 1.0V-1 Participants in Arctic gas project

<u>Majority-owned Canadian Companies:</u>

Alberta Natural Gas Company Limited
Canada Development Corporation
The Consumer's Gas Company
Northern and Central Gas Corporation Limited
TransCanada Pipelines Limited
Union Gas Limited

<u>Minority-owned Canadian companies:</u>

Gulf Oil Canada Limited
Imperial Oil Limited
Shell Canada Limited

<u>Non-Canadian owned companies:</u>

Columbia Gas Transmission Corporation
Michigan Wisconsin Pipe Line Company
Natural Gas Pipeline Company of America
Northern Natural Gas Company
Pacific Lighting Gas Development Company
Panhandle Eastern Pipe Line Company
Texas Eastern Transmission Corporation

Producing Companies	(Estimated Reserves)
Sohio - BP	7.1 Trillion cf
Exxon	8.0 " cf
Arco	8.0 " cf
Others	0.9 " cf
	24.0 Trillion cf 1/

1/ On 1000 BTU basis which is equivalent to 22.5 trillion cubic feet at 60°F and 14.73 psia.

1.OV.1 Purpose

Function of the Pipeline

Total Reserves

The principal hydrocarbon-bearing reservoir in the Prudhoe Bay Field is in the Sadlerochit formation and has estimated producible gas reserves of 22.5 tcf (trillion cubic feet) (DeGolyer and MacNaughton, December, 1974). The State of Alaska has a 12.5-percent royalty interest in the 22.5-tcf gas reserves and is studying available options as to use of such possible share. If the State of Alaska does not commit these reserves to the Applicants' proposed gas pipeline, the gas reserves available to AAGPC for transport would be reduced accordingly. The known hydrocarbon-bearing reservoirs in the Prudhoe Bay Field are, in order of depth: the Kuparuk River Oil Pool, Prudhoe Bay (Sadlerochit) Oil Pool, and Lisburne Oil Pool. Natural gas reserves quoted are restricted to the Prudhoe Bay Oil Pool which contains by far the majority of the discovered reserves of the Prudhoe Bay Field. Gas reserves that may become available from the Kuparuk and Lisburne pools will be additional to the 22.5 tcf quoted above (DeGolyer and MacNaughton, December, 1974).

The Prudhoe Oil Pool of the Prudhoe Bay field is currently defined by more than 80 wells. The wells' status is not pertinent at this time because there are no crude oil and natural gas pipelines to transport the hydrocarbons to market. Currently, there are two producing oil wells that supply hydrocarbon products for field operations. The majority of the remaining wells are awaiting perforation for completion and production.

Additional natural gas accumulations have been discovered on the North Slope, but available information indicates these accumulations are too small in themselves to be marketed profitably. The very presence of the proposed gas pipeline will enhance the probability of such gas reserves being profitably tied-in to the proposed line.

Several studies have been published concerning the estimated ultimate recovery of gas from the North Slope. These studies predict that the amount of gas found in the future will be larger than that found to date. A report which provides an estimate of the speculative recoverable oil and natural gas in Alaska was issued by the Division of Geological and Geophysical Surveys (DGGS) of the State of Alaska in June 1974. The DGGS report states that "Speculative recoverable petroleum resources are here defined as those petroleum resources which are completely undiscovered, and which after discovery can reasonably be expected to be produced using present technology and economic conditions." The DGGS report estimates the speculative recoverable resource (gas) for the onshore area of the North Slope to be 41.8 trillion cubic feet (tcf). Adding the American Petroleum Institute's proved reserve to this speculative value provides an ultimate gas potential of 67.8 tcf. This estimate seems reasonable if not conservative for the onshore area. The DGGS report also estimates offshore gas potential in the adjacent Beaufort and Chukchi Sea Provinces to be an additional 46.5 tcf. By combining these figures, potential gas reserves for the onshore and offshore areas of the North Slope is estimated to total 114.3 tcf.

An initial determination of presently known gas reserves in the Mackenzie Delta area, Canada has been calculated. Further exploration in the delta area is expected to develop substantial reserves in addition to those already discovered.

Proved reserves for both fields are shown in Table 1.OV.1-1.

Table 1.OV.1-1 Proved reserves of natural gas at Prudhoe Bay and the Mackenzie Delta

(Millions of Cubic Feet at 14.73 psia and 60°F).-(adapted from DeGolyer and MacNaughton, 1974)

Zone (Prudhoe Bay)	Proved Reserves
Sag River Sandstone - Associated Gas	1,980,000
Sadlerochit Sandstone - Associated Gas	12,677,000
Sadlerochit Sandstone - Solution Gas	7,859,000
Total	22,516,000 1/

Field or Area (Mackenzie Delta)	Proved Reserves
Parsons Lake	740,248
Taglu	2,465,218
Various	351,700
Total	3,557,166 2/

1/ On 1000 BTU basis, Total = 23,867,000 MMcf.

2/ With addition of probable and possible reserves, total = 6,352,727 MMcf.

Daily Volume to be Transported

Planned delivery from the Alaskan Arctic Gas Pipeline Company is scheduled to commence at approximately 2.0 billion cubic feet per day (Bcf/d), increasing to 2.25 Bcf/d within the first 3 to 4 years of operation. (The capacity of the pipeline in Alaska is restricted to 2.25 Bcf/d until compressor facilities are constructed.) The addition of four compressor stations in Alaska will bring the capacity of the Alaska Supply Lateral to 4.5 Bcf/d.

The Alaska Department of Natural Resources, Division of Oil and Gas, is responsible for establishing production rates for the field. The State has contracted the consulting firm of H.K. van Poollen and Associates, Inc., to provide comprehensive reservoir analysis, which is to include data for establishing initial production rates from the Prudhoe Bay (Sadlerochit) Oil Pool.

Based on a preliminary van Poollen report, the Alaska Department of Natural Resources informed the State Legislature's Joint Gas Pipeline Impact Committee at a public hearing on December 11, 1975 that the optimum rate of gas production is 2 billion cubic feet per day. Also, water injection into the aquifer of the reservoir would be required to justify the daily gas production rate of 2 Bcf. This preliminary conclusion by the State indicates that higher gas production rates and the lack of a water injection program would be detrimental to the ultimate oil recovery from the reservoir and would not constitute reasonable resource conservation objectives for either the State or the producers. The State's initial estimate of 2.0 Bcf/d is 0.25 Bcf/d less than the Applicant has proposed.

The capacity of the proposed trans-Canada segment of the pipeline to Caroline Junction, Alberta, where the pipeline branches, will be 4.5 Bcf/d. In addition to the estimated 2.25 Bcf/d projected from the Alaska Supply Lateral, the trans-Canada pipeline would have the capacity to transport 2.25 Bcf/d from fields at Richards Island and Parsons Lake in Canada to markets in eastern and western Canada. The 2.25 Bcf/d destined for Canadian markets would be taken off in the West Coast Transmission Limited tap at the 60th parallel and the Trans-Canada Limited System with a tap at Empress, Saskatchewan between Caroline Junction, Alberta and Monchy, Saskatchewan. As a result, the volume reaching the United States after 5 years would be 2.22 billion cubic feet per day plus whatever volume Canada might determine as being available for export. At present, there are no projections of Canadian exports, and there is little probability of any in the near future.

The Northern Border leg to Delmont, Pennsylvania will have an estimated capacity of 2.02 billion cubic feet per day; the Pacific Gas Transmission and Pacific Gas and Electric leg to Antioch, California and the Interstate Transmission Associates (Arctic) leg to Rye Valley, Oregon will have capacities of 1.2 and 0.6 billion cubic feet per day respectively. The capacity is greater than the 2.22 Bcf/d received from the Prudhoe Bay Field. This means that the lines proposed for construction in the contiguous United States would be built with an excess capacity of 1.6 Bcf/d. It is assumed that the excess capacity of the Northern Border and West Coast pipelines would be available to transport additional volumes of gas from new fields in the vicinity of the Prudhoe Bay Field or other fields that may be developed where a tap-in would be economical. The excess capacity could also be used to transport synthetic gas that may be produced from other sources, such as coal or organic waste.

On an annual basis the proposed volume to be transported after one year of operation is 226.6 Bcf and the annual volume after 5 years of operation is 1.6 trillion cubic feet. As proposed, the volume of gas to be transported after 5 years of operation would be divided between production from the Prudhoe Bay field in Alaska and the Richards Island and Parsons Lake Areas in Canada. Total daily delivery to the various pipeline companies for the first 5 operating years is shown in Table 1.OV.1-2.

Function of Related Facilities

Table 1.OV.1-3 summarizes the facilities of the entire Alaska Natural Gas Transportation System. To achieve maximum daily transmission volumes compressor stations and gas chilling facilities will have to be constructed along the line. In Alaska, gas collection facilities, including the initial compressor and chiller, would be constructed by the field producing companies. No additional facilities will be constructed on the gas transmission line in Alaska until the delivery volume is increased beyond the present estimate of 2.25 billion cubic feet per day.

By agreement, Atlantic Richfield Company operates the eastern half and BP Alaska, Inc., operates the western half of the Prudhoe Bay Field. Current activity is directed toward development of the field. Oil wells are being directionally drilled from several multiple-well gravel pads called drill sites. A pipeline system will deliver production from the drill sites to one of six strategically located separation facilities throughout the field. The oil will be transported by an oil gathering system from these six separation facilities to the trans-Alaska pipeline origin station. The gas from all six separation facilities will be transported by a gas gathering system to the Central Gas Facilities for further processing. The Central Gas Facilities will consist of the Central Compressor Plant, the Field Fuel Gas Unit, the injection-gas pipeline system and the gas-injection drill site pads and wells.

The Central Plant will handle produced gas from the entire field. The gas will be gathered at 600 psig (pounds per square inch gauge) and compressed through two stages to 4,500 psig. This high pressure gas then enters the injection-gas pipeline system, which transports the gas to the injection wells which will be completed in the Prudhoe Bay Field pool gas cap. The function of the Central Compressor Plant is to compress the natural gas produced from the entire field for injection into the Prudhoe Bay Field pool gas cap. It will later be expanded to include gas-chiller and quality processing facilities to permit the delivery of chilled, compressed gas to the Applicants' proposed gas transportation pipeline.

The function of the Field Fuel Gas Unit is to condition produced gas for use as fuel for the Prudhoe Bay Field operations. This includes fuel for the central powerplant operated by BP Alaska but does not include fuel used locally at the three oil-gas separation facilities operated by BP Alaska. It does include the fuel for the remaining three separation facilities operated by Atlantic Richfield. Insulated lines will transport the field fuel gas to all field users. In addition to the gas fuel used for the Prudhoe Bay Field Operations, another function of the Atlantic Richfield operated Field Fuel Gas Unit is to provide gas fuel for the Alyeska trans-Alaska pipeline pump stations 1, 2, 3, and 4. Atlantic Richfield estimates a total of 100 MMcf/d of fuel gas will be required to be processed by the Field Fuel Gas Unit (Atlantic Richfield Company, 1974).

The gas consumed as fuel for field operations represents significant volumes of produced gas, is part of the total gas reserves, and will not be available for transport in the Applicant's gas pipeline.

Changes in the gas injection compressors will be necessary before they can be used for gas transmission. The compressors having been used for well

Table 1.0V.1-2 Projected average-day gas volumes

(MMcfd at 60°F and 14.73 psia)

	Operating Year				
	1	2	3	4	5
Prudhoe Bay to Travaillant Lake					
Prudhoe Bay Supply	-	2,000.0	2,000.0	2,250.0	2,250.0
Fuel Used in Alaska	-	-	-	-	-
Delivery at Alaska-Yukon Border	-	2,000.0	2,000.0	2,250.0	2,250.0
Fuel Used in Yukon	-	5.4	5.4	6.3	5.7
Fuel Used in N.W.T.	-	4.8	4.8	5.4	5.7
Travaillant Lake Delivery	-	1,989.8	1,989.8	2,238.3	2,238.6
Richards Island to Travaillant Lake					
Richards Island Supply	875.0	875.0	1,050.0	1,225.0	1,575.0
Downstream Supply	375.0	375.0	450.0	525.0	675.0
Fuel Used in N.W.T.	-	-	-	-	-
Travaillant Lake Delivery	1,250.0	1,250.0	1,500.0	1,750.0	2,250.0
Total Delivery to Travaillant Lake	1,250.0	3,239.8	3,489.8	3,988.3	4,488.6
Travaillant Lake to Caroline					
Total Delivery to Travaillant Lake	1,250.0	3,239.8	3,489.8	3,988.3	4,488.6
Fuel Used in N.W.T.	4.3	50.3	57.4	91.2	111.1
Delivery to WCTL 1/ at 60th Parallel	239.4	248.9	287.8	319.2	355.5
Fuel Used in Alberta	14.4	33.0	49.9	62.2	93.6
Caroline Delivery	991.9	2,907.6	3,094.7	3,515.7	3,928.4
Caroline to Kingsgate					
Caroline Supply	-	619.6	618.4	689.7	687.5
Fuel Used in Alberta	-	-	-	-	-
Delivery to ANG 2/	-	209.9	209.5	233.8	233.1
Fuel Used in B.C.	-	-	-	-	-
Kingsgate Delivery	-	409.7	408.9	455.9	454.4
Caroline to Monchy					
Caroline Supply	991.9	2,288.0	2,476.3	2,826.0	3,240.9
Fuel Used in Alberta	-	3.7	4.5	8.5	13.9
Delivery to TCPL 3/	991.9	900.6	1,090.6	1,278.0	1,692.7
Fuel Used in Saskatchewan	-	2.3	2.5	3.0	3.0
Monchy Delivery	-	1,381.4	1,378.7	1,536.5	1,531.3
System Summary					
Total Supply	1,250.0	3,250.0	3,500.0	4,000.0	4,500.0
Total Fuel	18.7	99.5	124.5	176.6	233.0
Total Delivery	1,231.3	3,150.5	3,375.5	3,823.4	4,267.0

1/ WCTL is West Coast Transmission Limited.
2/ ANG - Alberta Natural Gas will make deliveries to PGT at Kingsgate.
3/ TCPL is TransCanada Pipelines Limited.

Source: Canadian Arctic Gas Pipeline Limited, 8b, Table 1, 1975.

Table 1.OV.1-3 Proposed and potential facility construction of pipeline

Facilities	AAGPC	CAGPC	N.B.	PGT	ITA(A)	Total
Compressor Stations	4[1]	36[2]	12[3]	4[4]	3	59
Refrigeration Chillers	4[1]	15	0	0	0	19
Air Exchange Chillers	0	16	0[5]	4[4]	?	20+
Stockpile Areas and/or Wharves	3	40	30[5]	?	5[5]	78+
Air Fields	6	21	0	0	0	27
Helipads	14	170	?	?	?	184+
Measuring Stations	1	9	13	4	3	30
Communication Sites	9	80[7]	87	0	0	176
Maintenacne Sites	4[8]	4	0	0	1	9
Block Valves	9	120-150[9]	100	33	30[9]	252-282
Permanent Road (miles)	2	67	52	1	2[9]	124
Borrow Areas	16	70	?	?	?	86++
Offi-line Delivery Taps	0	2	13	0	2	17

NOTE: ? -denotes that the number has yet to be determined or that the information was not provided by the applicant.

1. Potential future construction
2. Up to 14 additional may be constructed in the future
3. Up to 13 additional may be constructed in the future
4. Twelve existing stations with chillers will also be used
5. Optional equipment (may be added to selected compressor stations if needed)
6. From NB - EIS: "Alternative 42' Pipeline System"
7. Thirty will be located at compressor stations; remainder estimated
8. Will be located at future compressor station sites
9. Estimated

injection might be retuned or new compressors might be added. This decision will probably not be made until the production rate of the oil has been ascertained.

The gas has to be refrigerated after compression but before entering the pipeline so that its inlet temperature is 25°F. The refrigeration system will presumably be similar to that described for future compressor stations to be built when the pipeline flow rate exceeds 2.25 billion cubic feet per day. A gas-turbine driven refrigeration system using propane as a refrigerant will be installed for gas cooling.

The measuring station as described by Alaskan Arctic Gas Company will record the flow rate of the gas and will transfer the data to the gas pipeline control center.

The construction period for the total system is estimated to be seven years. During this period 63 compressor stations would be constructed, additional compressors would be added at three existing stations on a parallel line and modifications would be made on 12 other existing compressor units. The system would be capable of transporting 1.25 Bcf/d of gas from the Mackenzie Delta following the third year of construction. An additional 2 Bcf/d could be transported from the Prudhoe Bay Field following the fourth construction year.

Since gas absorbs heat during compression, gas chillers must be added to reach or maintain desired temperature levels where differences between the pipe and soil temperature cause unwanted side effects. North of Fort Simpson, Northwest Territories, Canada closed system propane refrigeration chillers would be used. This is the area of continuous permafrost and the gas would be maintained at a temperature of 32° Fahrenheit or less to maintain the integrity of the permafrost. Approximately 16 propane chillers would be constructed and south of Fort Simpson 18 air exchange coolers would be constructed.

1.OV.2 Corridor Route Location

Specific Route

The portion of the proposed pipeline to be constructed by the Alaskan Arctic Gas Pipeline Company originates on the southwest shore of Prudhoe Bay, Alaska (Figure 1.OV.2-1). From that point it runs southeasterly along the Arctic Coastal Plain anywhere from 3 to 30 miles from the south shore of the Beaufort Sea. At Milepost 61 on the west bank of the Canning River the route enters the Arctic National Wildlife Range. From that point the route climbs to an elevation of almost 800 feet in the transition area between the coastal plain and the foothills of the Sadlerochit Mountains and then drops back to an elevation of 350 feet at the Egaksrak River at Milepost 161. The remainder of the route is across level terrain and passes within 5 miles of Demarcation Bay before entering Canada.

Three supply lines are proposed in northern Canada. These include: 1) the continuation of the Prudhoe Bay Supply Line, which parallels the coast for approximately 150 miles from the Alaska-Yukon border; 2) the Richards Island Supply Line, which runs for 126 miles from the north shore of Richards Island to join the Prudhoe Bay Supply Line at Travaillant Lake Junction; and 3) the Parsons Lake Lateral, which meets the Richards Island Supply Line at milepost 39, after proceeding for 15 miles from Parsons Lake. From Travaillant Lake Junction the line swings to the south, crossing to the west bank of the Mackenzie about 45 miles downstream of Fort Simpson. The line then continues southeasterly to Caroline Junction.

At Caroline Junction, Alberta, the line forks and one leg assumes an easterly direction through Alberta and then southeast to Monchy, Saskatchewan. The other fork proceeds south, swinging southwesterly to Kingsgate, British Columbia, paralleling an existing line.

The line from Monchy, Saskatchewan will be continued by the Northern Border Pipeline Company. It will continue across the northeast corner of Montana, southwestern North Dakota, and northeastern South Dakota, passing within 3 miles of Aberdeen. The route crosses southwestern Minnesota, northeastern Iowa, and turns in a more easterly direction at the Illinois boundary. It cuts across the northern quarter of Illinois, north central Indiana, continuing in an easterly direction across Ohio, 8 miles of West Virginia, and terminating at Delmont, Pennsylvania about 20 miles east of Pittsburgh.

The line from Caroline Junction to Kingsgate enters the United States near Eastport, Idaho. The Kingsgate Lateral proceeds south to the Alberta-British Columbia border, at which point delivery will be made to Alberta Natural Gas, which will carry PGT/PG&E's share of the gas to the PGT line near Kingsgate. Alberta Natural Gas will loop its existing line through British Columbia for a distance of 102 miles. Canada Arctic will parallel these lines to Kingsgate, a distance of 107 miles from the delivery point. The two West Coast legs are parallel for 245 miles to a point south of the Snake River in Washington. The west leg angles off southwesterly through southeastern Washington, then southerly through Oregon and northern California, terminating at Antioch, California 35 miles east of San Francisco. The Pacific Gas Transmission Company (PGT) and the Pacific Gas and Electric Company (PG&E) will construct this line from Eastport, Idaho to Antioch. The new line will parallel an existing PGT gas pipeline through Washington and Oregon, except for a 21.4 mile reach through the John Day River Canyon; an existing PG&E pipeline right-of-way is followed through California.

The east leg turns south, passing through eastern Oregon, terminating at Rye Valley. Interstate Transmission Associates (Arctic) (ITAA) will construct the east leg from Eastport to Rye Valley. This means that between Eastport and the separation point just south of the Snake River, the pipeline constructed by ITAA will parallel both the existing and new PGT-PG&E pipelines except for about 23 miles through the Kootenai River Valley, and will parallel or loop an existing pipeline owned by the Northwest Pipeline Corporation for most of the remaining distance. Approximately 23.5 miles of the existing pipeline would be used so that no construction will take place on that segment.

The proposed alignment is shown on the route map in Figure 1.OV.2-1. (The proposed alignment is shown on a larger scale on Figure 8.OV.3-1.)

Location of Facilities

The location of all facilities to be constructed for each segment of line are shown on large scale maps in Section 1 of each of the geographic volumes of this EIS. Table 1.OV.1-3 in the preceding section summarizes the number of major facilities that will be constructed along each segment. It is important to note that single sites such as compressor stations may include several of these facilities.

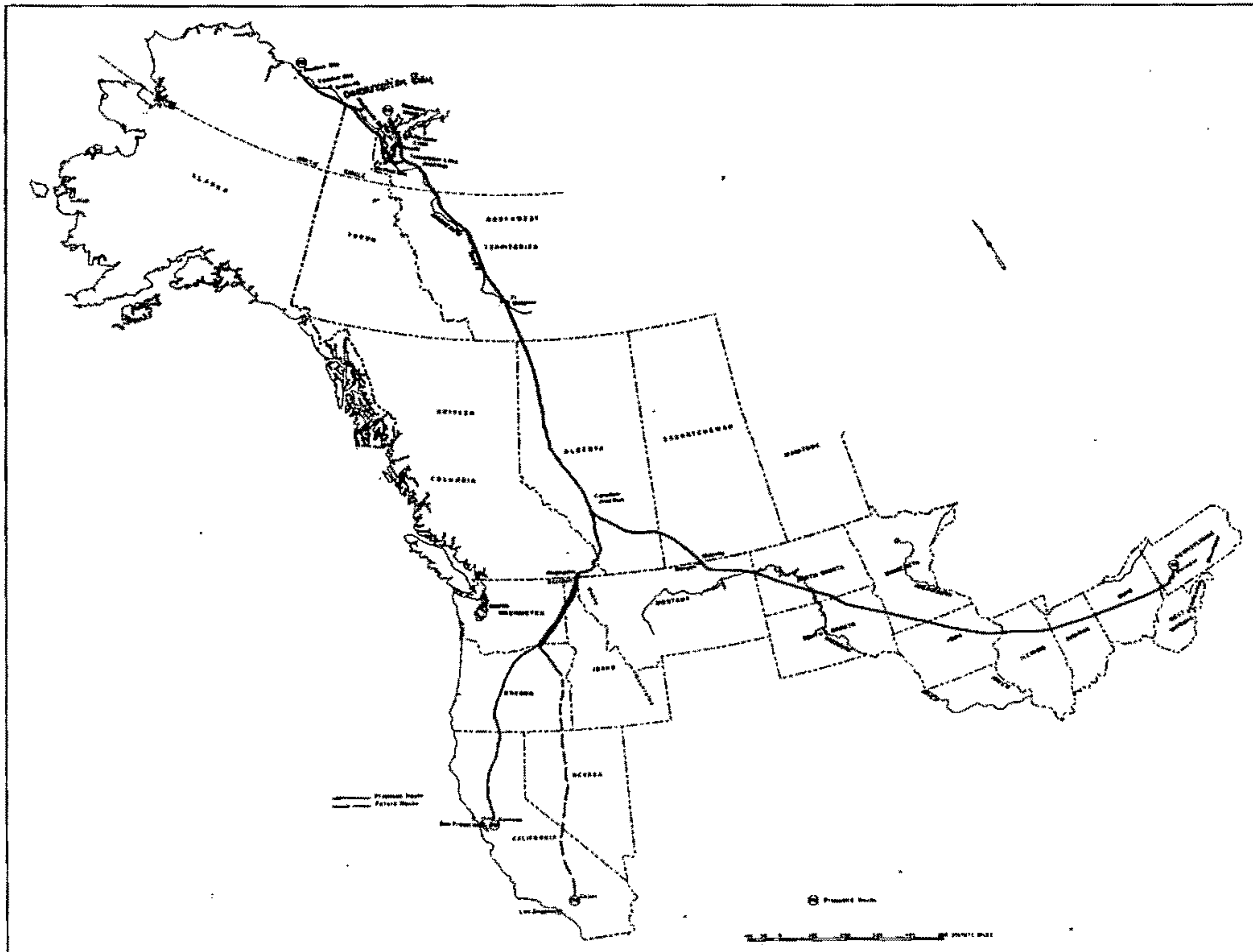


Figure 1.0V.2-1 Overall systems map

River Crossings

Since rivers occur all along the pipeline, listing all of them is impractical. Major river crossings are the only ones that require special engineering and construction techniques. Major rivers are those that drain an area of at least 300 square miles. On the entire route, there are approximately 57 major river crossings. These are listed in Table 1.OV.2-1. The list is preliminary and subject to change following further evaluation.

1.OV.3 Facilities

Pipeline Design

The system will consist primarily of a buried high pressure pipeline. The only above-ground portions will be at compressor stations, and at certain stream crossings and concrete-lined drainage canals.

Three types of pipe may be used in construction of the pipeline system. Most pipe will be designed to meet requirements of the American Petroleum Institute Specifications for High Test Line Pipe (API Specification 5-LX), 19th Edition. This pipe, i.e., API 5LX-65 and API 5LX-70 steel pipe, meets Federal safety standards as set forth in 49 CFR 192 concerning the transportation of natural and other gas. Due to the low temperature at which the gas will be transmitted in the northerly reaches of the system, a transition temperature to prevent brittle fracture will be specified. The properties of API X-70 steel should be reviewed against the intent of Title 49 of the Code of Federal Regulations to determine if any revisions are required to incorporate the use of API X-70-type steels under Arctic conditions. Should spiral-weld pipe be used in the pipeline, it will meet the API Specification for Spiral-Weld Line Pipe (API 5-LS), 7th Edition. PGT, PG&E, and ITAA have specifically excluded spiral-weld pipe in their segments of the pipeline system. Table 1.OV.3-1 provides information on pipe diameter, wall thickness, yield strength, operating pressures, and the total mileage for each of the Applicants. In addition to the pipe described in Table 1.OV.3-1, ANG will install approximately 102 miles of 36-inch pipe on their existing right-of-way.

Title 49 of the Code of Federal Regulations provides that gas pipelines must be buried at least 18 inches with a maximum requirement of 36 inches subject to certain exceptions, such as the prescribed depths at river crossings. The prescribed depths vary with class, location and soil conditions; class locations are described in 49 CFR 192.5, Subpart A. A class location unit is that area which extends 220 yards on either side of the centerline of any continuous 1-mile length of pipeline. The several unit classes are defined on the basis of the number of buildings in the unit that are intended for human occupancy. A Class 1 unit has 10 or less buildings; a Class 4 unit is one where buildings having 4 or more stories are prevalent. Most Applicants have indicated a minimum depth of burial of 30 inches. Burial will be below scour depth at water crossings; the depth of burial at Sagavanirktok River crossing in Alaska would be more than 10 feet, for example.

Gas in a pipe flows toward lower pressure; the highest pressures are immediately downstream of compressor stations. Unless some form of gas chiller is employed, gas temperature downstream from the compressor station will be higher than that upstream.

After leaving the Prudhoe Bay field compressor station, gas would be delivered to a metering station at Prudhoe Bay, Alaska. It would enter the pipeline at a temperature of 25° Fahrenheit and at a pressure of 1,680

Table 1.OV.2-1 Summary of major river crossings

AAGPC-Sagavanirktok (2)	N.B.-Missouri
Kadleroshilik	Little Missouri
Shaviovik	Oahe (?)
(Unnamed) M.P. 40.8	Wapsipinicon (2)
Canning	Mississippi
Katakturuk	Illinois
Sadlerochit	Wabash
Hulahula	Muskingum
Jago	Ohio
Aichilik	Monongahela
Kongakut	Youghiogheny
CAGPC-Mackenzie (3)	PGT-Moyie (10)
Peel	Kootenai (2)
Great Bear	Pend Oreille (2)
Peace	Snake (2)
Smoky	John Day
Athabasca	Fall
N. Saskatchewan	Sacramento (2)
S. Saskatchewan	San Joaquin
Kootenay	
Elk	

Table 1.OV.3-1 Pipeline data for Alaska Natural Gas Transportation System

Co.	O.D.	Thick (in)	Yield (psi)	Press (psi)	Grade	Length (miles)
AAGPC	48"	.80	70,000	1680	x-70	195
CAGPL	48"	.72	70,000	1680	x-70	1981
	42"	.63	70,000	1680	x-70	158
	36"	.54	70,000	1680	x-70	281
	30"	.45	70,000	1680	x-70	15
N.B.	42"	.64-.93 1/	65,000	1435-40 2/	x-65	1138
	36"	.55-.80	65,000	"	x-65	305
	24"	.37-.53	65,000	"	x-65	176
PGT	42"	.65-.1.02	65,000	1440	x-65	478
	42"	.56-.89	65,000	1250	x-65	140
PG&E	42"	-- 3/	-- 3/	-- 3/	-- 3/	299
ITA(A)	30"	.47-.69	65,000	1440	x-65	391 4/
Total						5557

1/ Thickness varies eith construction class (see text)

2/ Classes 1 and 2 - max. pressure of 1435 psi and class 3 at 1440 psi

3/ Information in Table obtained from application to FPC
PG&E, is not required to file with FPC as an intrastate carrier.

4/ Total project length will be 414 miles.

pounds per square inch gauge (psig). The gas will be maintained at this pressure throughout the line from Prudhoe Bay and through Canada. Until throughput in the line exceeds 2,250 million cubic feet per day, no additional compressors will be required in Alaska. The next compressor station will be in Canada, approximately 224 miles from Prudhoe Bay, and will be equipped with propane refrigeration gas chillers. Gas will be maintained at 25° Fahrenheit to Travaillant Lake Junction; there temperatures will be reduced to the 12° to 16°F range and maintained in this range to Fort Simpson. South of Fort Simpson, the temperature would rise to about 70°F, but at succeeding stations would be maintained at approximately 60°F to Caroline Junction by means of air exchange chillers located at all compressor stations south of Zama Lake.

Gas will be delivered to the Northern Border Pipeline Company at approximately 85°F and 1435 psig. There will be 12 compressor stations on the Northern Border line. The pressure will range from 1043 psig to 1440 psig at temperatures averaging between 49° and 75°F in the summer and 35° and 70°F in winter. The discharge pressure at most compressor stations will be 1435 psig.

Flow temperature of the gas in the Kingsgate to Antioch leg will range from 45°F in winter to 65°F in the summer. Operating pressures along this line will vary from 1440 psig for the initial 723 miles to 1040 psig at the Antioch terminus. The Rye Valley leg will operate at an average temperature between 60° and 65°F and at a pressure up to 1440 psig.

Operating Characteristics

Table 1.OV.1-3 in a preceding section summarizes the proposed facilities required for operation of the pipeline. No compressor facilities will be constructed along the line in Alaska until the volume of gas transported is increased beyond 2.25 Bcf (billion cubic feet) per day. Four maintenance sites will be selected and developed with certain initial facilities so that the sites can be used for compressor stations in the future. Each site will be a 15-acre pad of gravel placed over the undisturbed surface or on insulating materials. The purpose of the pad is to maintain the integrity of the permafrost.

Initial development will include the following facilities: liquid fuel storage, equipment storage, garage and repair facilities, living quarters, water storage, sewage treatment facilities, incinerator building, open storage, in-line cleaning facilities, and generators for electricity. Primary communication facilities and a 2,400 foot airstrip with fuel storage will be constructed near each of the four maintenance sites.

In addition, one primary communication site will be developed at Prudhoe Bay and four repeater communication sites will be constructed at intermediate points between the maintenance sites. Each repeater site will be served with a helipad and an electric generator.

A material stockpile site will be developed at Camden Bay and another at Demarcation Bay. Facilities will include a wharf, material storage area, equipment storage area, a camp area, a fuel storage area, and related facilities. All material will be shipped by water and moved to the pipeline route over snow or ice roads. Both stockpile sites will also be served by a 2,400 foot airstrip.

Other facilities would include nine block valve sites with helipads, the measurement station, a field operating headquarters at Prudhoe Bay, and approximately two miles of permanent roads. These roads will be 30 feet wide and serve the maintenance sites, connecting the maintenance sites with the primary communication sites and each of the six airstrips with the facility being served.

In Canada, 36 compressor stations would be built; those in the continuous permafrost zone which extends to Fort Simpson would be equipped with propane gas chillers. The sites range between 15 and 25 acres. Typical associated facilities at the compressor sites are living quarters, garage, water storage, an incinerator building, fuel storage, chilling facilities, sanitary waste disposal facilities, and material storage. The actual foundation of these sites will depend on the individual site conditions. The applicant indicates several possibilities but reports the final design will depend on sub-soil investigation of the individual sites. See Chapter 1, Canada Volume, for additional detail.

Other related facilities along the route in Canada include 21 airstrips, five being 6,000 feet long and the balance being 2,400 foot strips for short-take-off-and-landing aircraft (STOL). In addition, there would be 170 helipads located at the remote communication towers, block valves, and metering stations. Communication facilities will consist of more than 80 microwave towers built at compressor stations, measuring stations, and at intermediate line-of-sight points. All remote communication towers will include a small building for an electric generator, and the site will be served by a helicopter.

Five gas measuring stations independent of the compressor stations would be constructed on fenced sites of 5 to 6 acres. The facilities would include a meter building and an instrument building. Two meter runs would be installed to provide continuous gas transmission in the event of a meter failure.

Block valves will be constructed at the compressor stations and at points approximately midway between compressor stations. The more remote valve sites will be served by helicopter and the others either by helicopter or low ground pressure (LGP) vehicles.

Prior to and during the initial stages of construction, material must be stockpiled at sites along the pipeline. This is especially true of the northern portion of the route. To accomplish this, water transportation and overland transportation would be used. Temporary winter roads and trails would be used in the permafrost areas to interconnect facilities at compressor station sites. The trails would be for the use of tracked (LGP) vehicles and would only involve clearing as necessary. A total of 18 wharves and stockpile sites will be built with appropriate overland access to the pipeline and an additional nine stockpile sites will be established. The Applicants propose road construction as shown in Table 1.OV.3-2.

The Northern Border line would be constructed with 12 compressor stations; 13 additional sites for future development have been selected. Each station will require about 20 acres of land. Ancillary facilities will include an equipment building, communication towers, in-line cleaning facilities, sanitary waste disposal, water supply, and material stockpile areas. In-line cleaning facilities will also be constructed at each compressor station. These stations will be served by powerlines from nearby sources.

Ten measuring delivery stations consisting of small buildings for control equipment, gas heating equipment, if required, to prevent freezing of regulators, and piping for above-ground measuring will be required for a complete system. There will be three emergency stations as well. Each station will require a powerline and each will have a communication tower.

Table 1.OV.3-2 Proposed road construction for Alaska Natural Gas Transportation System

(Miles ot Road by Class)

Line Segment	Permanent	Temporary [1/]	Trails [1/]	Total
Alaska	2	250	Unknown	252 [2/]
Canada	67	255	230	552
North Border	52	50	0	50
San Francisco	1	1	0	1
Los Angeles	21	0	0	21
Total	124	556	230	875

1/ Although these are classified as temporary, they often become permanent travelways and ultimately function as permanent roads, especially in formerly roadless areas.

2/ Total is incomplete. Total length of trails is unknown.

A total of 87 transmission-reception communication towers will be required for the Northern Border leg. Each compressor station and measuring station will be served by a tower. The remaining 39 towers would be located to assure reliable communication.

This system will also require the construction of 100 block valves. Twenty-five of the valves will be constructed at the compressor station sites; exact location of the other valves will not be determined until final design. The valves will be automatic and self-actuating and require no electrical power.

On the portion of the West Coast line from Kingsgate to San Francisco compressors will be added at four existing stations. In addition, modifications will be made on 13 units at nine of the existing stations.

The Rye Valley leg of the West Coast line will require additions to three existing Northwest Pipeline Corporation compressor stations and modifications to two others to achieve maximum capacity between Kingsgate and Ignacio, Colorado. To accomplish the transportation from Ignacio to Blythe, California, one additional compressor unit will be required at each of three existing compressor stations on El Paso Natural Gas Company's existing system. Facilities at each compressor station may include: cooling facilities operating controls, gas measuring equipment, on-site electric generating equipment, offices, and maintenance shops. Other facilities will be a waste disposal system, water supply, and roads.

Figures 1.OV.3-1 through 1.OV.3-5 provide diagrams and sketches typical of the facilities described above.

1.OV.4 Land Requirements

Although right-of-way locations are not finalized, estimates of acreage required for rights-of-way, related facilities, and temporary areas required for construction activities have been developed. The initial projected requirement for the 195 mile section in Alaska is 4,633 acres overall. Of these, approximately 3,723 acres will be permanently committed and about 910 acres will be for temporary construction activities. For the Canadian portion it is estimated that about 43,060 acres will be required for the pipeline and related facilities. Overall, Northern Border requirements for construction are 20,736 acres with a permanent land requirement after construction of approximately 11,516 acres. The Pacific Gas Transmission/Pacific Gas and Electric line from Kingsgate, British Columbia to Antioch, California, will require 1,201 additional acres of permanent area and 544 acres on a temporary basis since provision was made for a second pipeline when the existing R.O.W. was acquired. The Interstate Transmission Associates (Arctic) line to Rye Valley requires an estimated 4,775 acres of land during the construction phase; 2,385 acres would be classed in the permanent category. Table 1.OV.4-1 shows overall right-of-way lengths, permanent and temporary acreage, and Federal and non-Federal land requirements for applicant companies.

In Alaska there is no existing right-of-way along the North Slope towards the Mackenzie Delta Region. From maps it would appear that portions of the Canadian Arctic Gas Pipeline Company route in Alberta follows existing rights-of-way. The Applicant, however, does not address the use of existing rights-of-way. ANG will loop their existing line for its entire length. (Figure 2.OV.11-2 shows the existing line.)

The Northern Border Pipeline Company indicates that their line "adjoins or abuts 23.6 miles of existing rights-of-way." On the West Coast lines

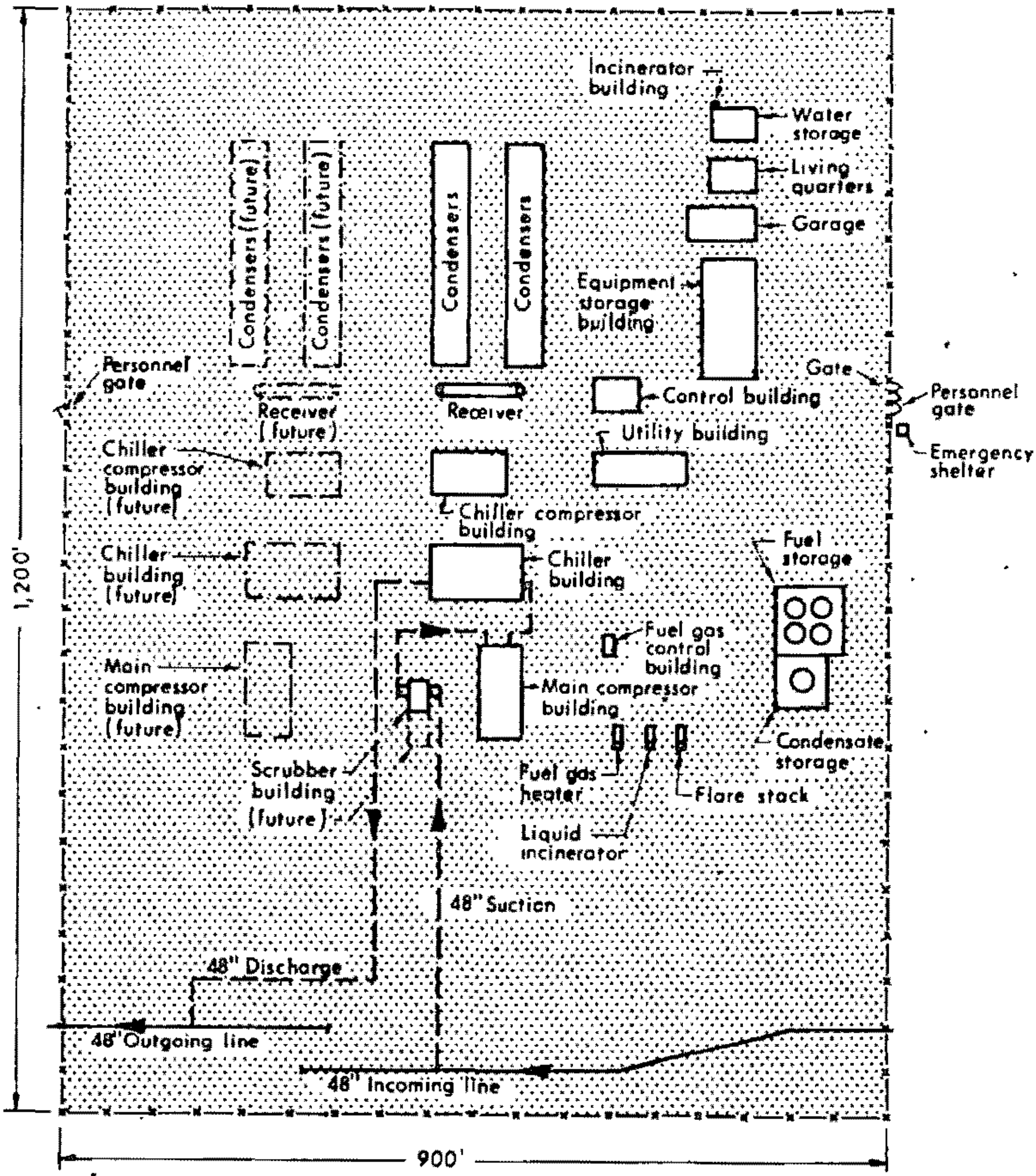


Figure 1.0V.3-1 Diagram of typical layout of compression station

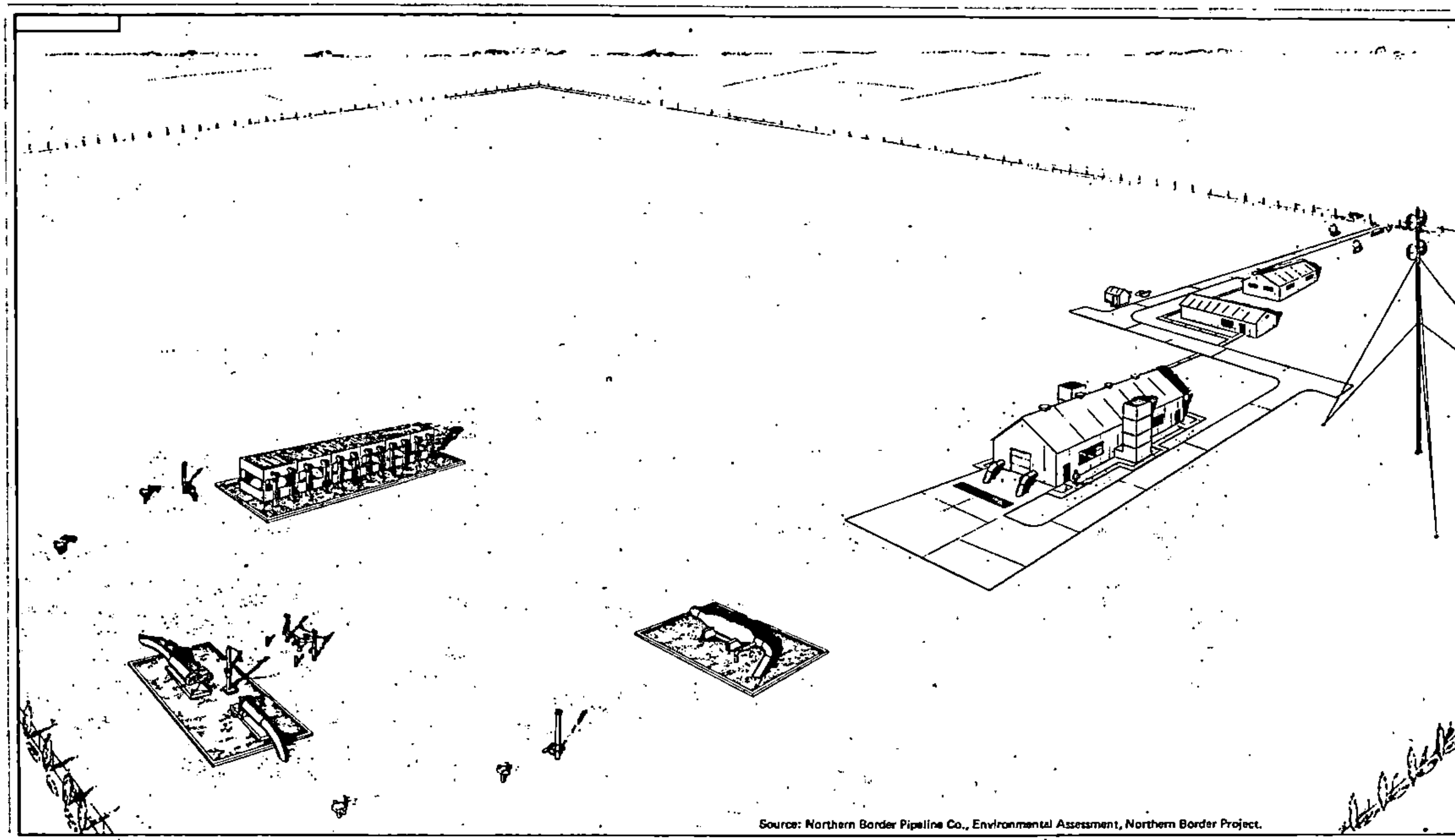
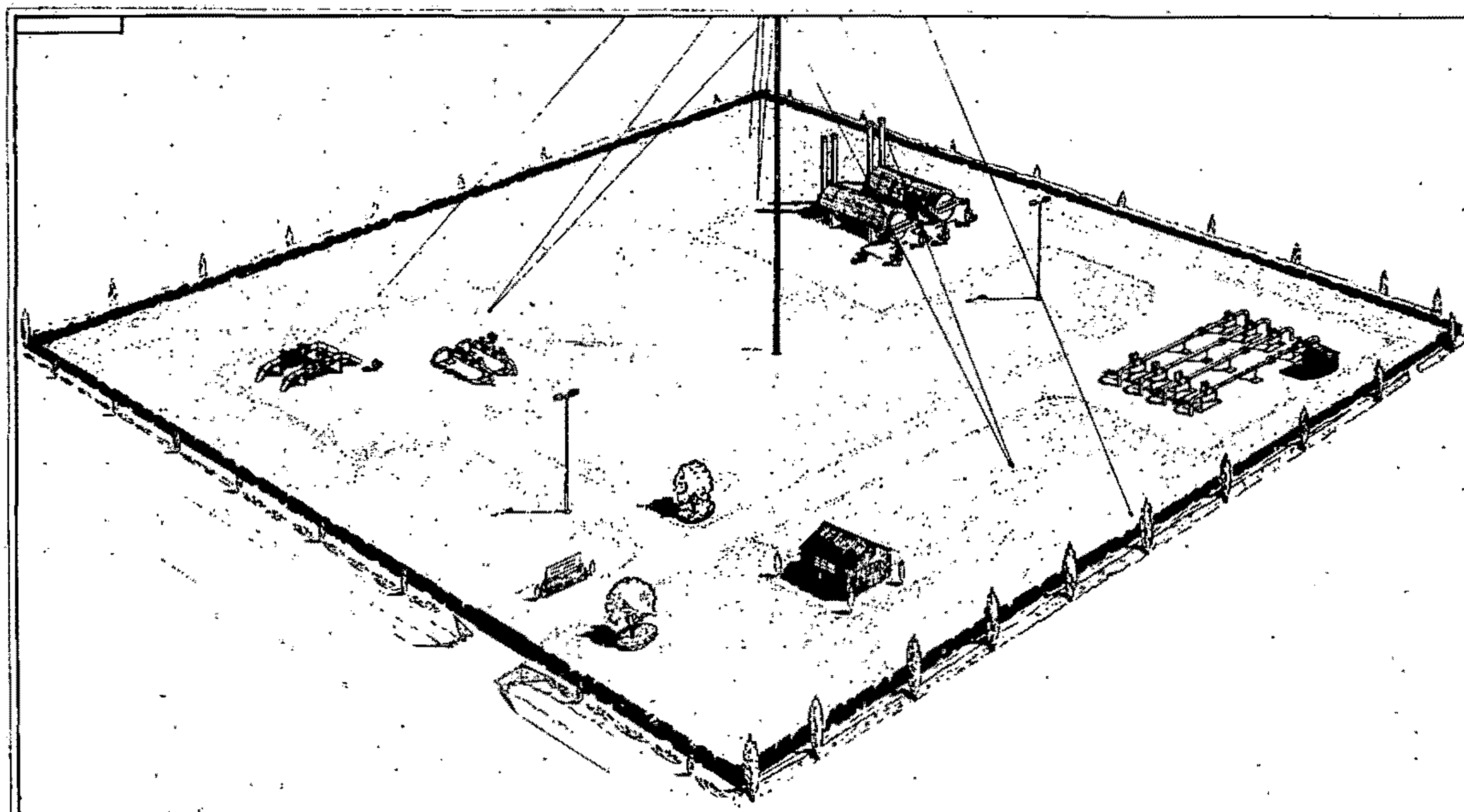
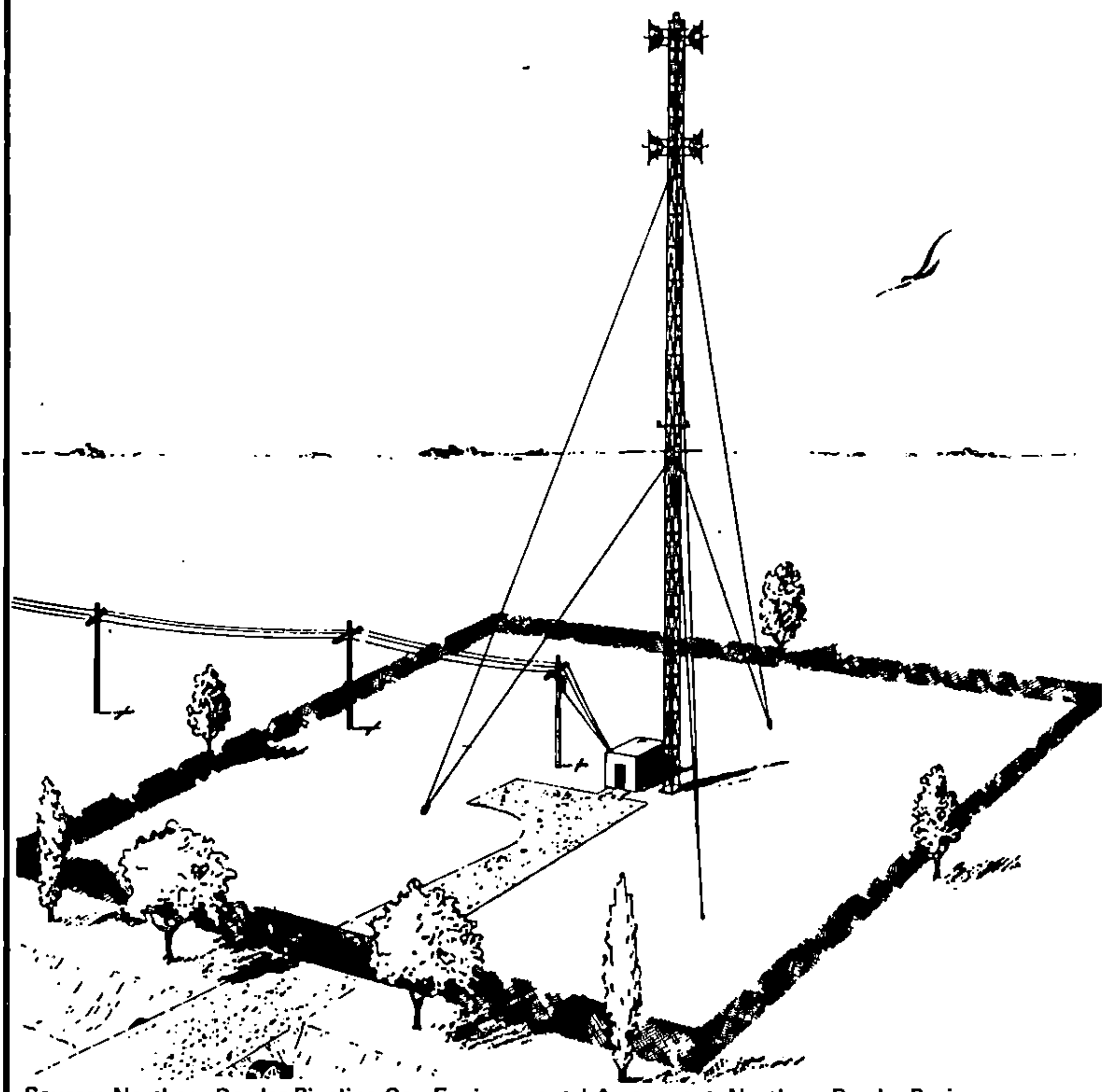


Figure 1.0V.3-2 Sketch of typical compressor station



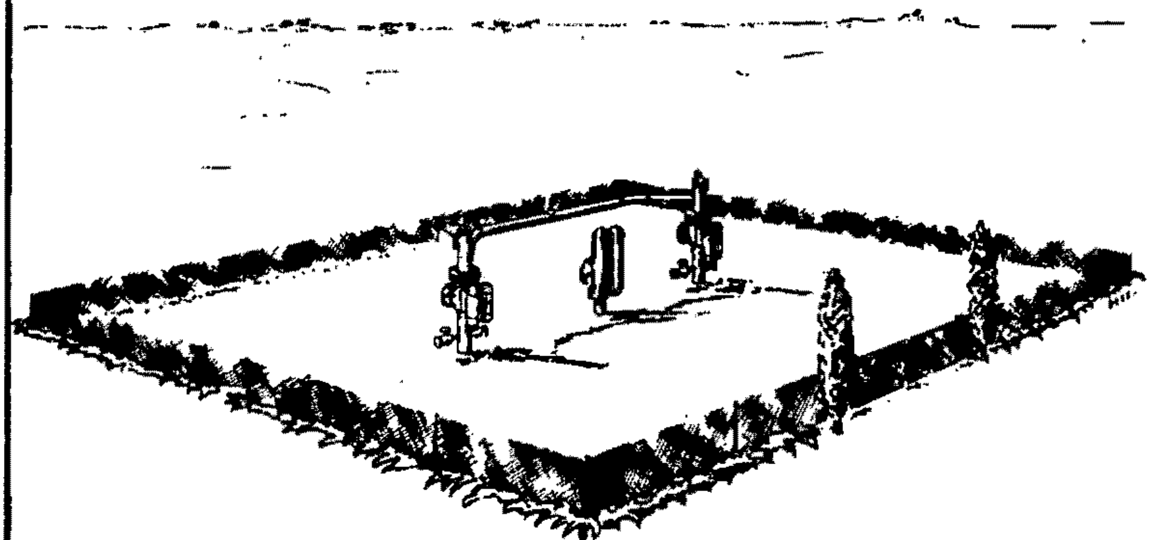
Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.3-3 Sketch of typical measuring station



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.3-4 Sketch of typical communication tower



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.3-5 Sketch of typical block valve

Table 1.OV.4-1 Overall land requirements

	Right-of-way Length (Miles)			Land Requirements (Acres)				
				Permanent			Temporary	Total
Applicant	Federal	Non-Federal	Total	Federal	Non-Federal	Total	Temporary	Total
Alaska Arctic Gas Pipeline Co.	133	62	195	2638	1085	3723	910	4633
Canada Arctic Gas Pipeline Limited	N/A	N/A	2435 1/	N/A	N/A	N/A	N/A	43060 1/
Northern Border Pipeline Co.	98	1521	1619	638	10878	11,516	9220	20736
Pacific Gas Transmission Co. & Pacific Gas & Electric Co.	140	777	917 2/	972	9418	10,390	544	10,934 2/
Interstate Transmission Associates (Arctic)	35	356	391 3/	207	2178	2385	2390	4775
Totals	406 4/	2716 4/	5557	4455 4/	23559 4/	28014 4/	13064 4/	84,138

N/A Information not available

1/ Only gross totals are available for Canada.

2/ PGT/PG&E currently have 747 miles of this right-of-way, totaling some 8200 acres.

3/ New pipeline construction only. An existing 23 mile reach of pipe will be utilized also.

4/ Totals for U.S. only.

there will be considerable use of existing rights-of-way or use of a parallel right-of-way. The San Francisco and Rye Valley legs of the West Coast line will be parallel for the first 206 miles in the United States. The entire Rye Valley leg is adjacent to or within existing pipeline rights-of-way, except for the 35 mile reach through the Kootenai Valley. The San Francisco leg is adjacent to or within existing pipeline rights-of-way except for the 21-mile reach through the John Day River Canyon.

Acreages required for some facilities have not been specifically identified and in many cases a range of acreage is provided. Furthermore, some facilities will be built at existing sites, particularly on the West Coast lines, so that little additional acreage will be required.

Based on the information provided the facility acreage requirements for selected facilities are shown in Table 1.OV.4-2. In addition, there would be temporary commitments of acreage for stream crossings, roads, staging areas and similar activities of short duration.

Except in Alaska, where the only roads are the North Slope haul road and private roads within the Prudhoe Bay oil and gas fields, existing roads will be used as much as possible. During construction, traffic on certain segments will be increased. In all parts of the system in the United States the Applicants indicate no displacement of existing housing. Refer to individual geographic volumes for a complete discussion.

1.OV.5 Duration and Phasing of the Project

Construction

Most companies propose to start construction approximately 1 year after approvals are received. In most cases this would involve construction of support facilities. Depending on the time of the year that approval was granted, certain preliminary work, such as surveying and clearing, might be undertaken immediately. In other cases weather conditions could delay the start of construction by nearly one year. Figure 1.OV.5-1 contains a graphic portrayal of the proposed construction periods on each segment.

The construction of the proposed gas pipeline in Alaska, including the related facilities, will be phased over a three year period beginning the first summer after project approval. Most construction work will occur during the winter months, from November to April, and snow roads will be used to provide access throughout the pipeline construction area. If there is insufficient snow accumulation, snow-making equipment will be used. If snow roads cannot be constructed, ice roads will be developed using trucks to spray water to form successive coatings of ice. The actual installation of the pipe will be accomplished in the third winter construction season.

In Canada the construction of the pipeline, related facilities, and the Richards Island supply line would be completed in the seventh construction year. Actual pipeline construction would begin late in the second year and be completed in the fifth year. Preparatory work such as stockpiling, surveying, and site preparation would be accomplished prior to that. Compressor station construction would be accomplished between the third and seventh years.

Construction in the Arctic and Subaractic area is scheduled for the winter months, from about November 1 to April 1. Construction and removal of heavy equipment could continue until May 1 according to applications. The proposed schedule for construction in Alaska is a one-year period. In Canada, the actual laying of pipe is scheduled for a three-year period.

Table 1.0V.4-2 Estimated acreage requirements for selected facilities

	Maximum	Minimum
Compressor Stations	1,600	1,180
Air Fields	1,860	430
Helipads	1,470	1,470
Block Valves	15	10
Communication Sites	360 1/	20 2/
Totals	5,365 Acres	3,190 Acres

1/ Northern Border estimates 4 acres per site which is 40 times larger than the next highest estimate.

2/ If Alaskan and Canadian Arctic Gas use satellite communications, they will require no additional acreage for communication sites.

CONSTRUCTION YEAR OPERATING YEAR	1	2	3 1	4 2	5 3	6 4	7 5
PIPELINE CONSTRUCTION							
1. CANADIAN ARCTIC GAS PIPELINE LIMITED							
2. ALASKAN ARCTIC GAS PIPELINE COMPANY							
3. NORTHERN BORDER PIPELINE COMPANY							
4. INTERSTATE TRANS-MISSION ASSOCIATES							
5. PACIFIC GAS TRANS-MISSION COMPANY		CONSTRUCT LOOP SECTIONS AS REQUIRED					
COMPRESSOR STATION UNIT CONSTRUCTION							
CANADIAN ARCTIC GAS			14	15	4	15	3
TOTAL OPERATING UNITS			14	29	33	48	54
APPOX. DAILY DELIVERY RATES MMCFD							
FROM PRUDHOE BAY				2000	2000	2250	2250
FROM MACKENZIE DELTA			1250	1250	1500	1750	2250
TO MONCHY				1380	1380	1530	1530
TO KINGSGATE VIA CAGPL				410	410	450	450
TO KINGSGATE VIA ANG				210	210	230	230

Source: Comments of Arctic Gas Project Applicants to Part I overview, pp. 1-12 (1975).

Figure 1.OV.5-1 Total project construction and gas delivery schedule. It is assumed that the schedule does not include preconstruction stockpiling and construction of support facilities.

Possible problems in meeting the proposed schedule might involve unforeseen labor disputes or difficulties in obtaining sufficient construction materials such as pipe. Delays in either of the first two construction years in Canada could be compensated in the following year. However, such a delay during the third construction year in Canada or the coincident construction year in Alaska could necessitate an additional winter construction year, if the necessary construction work could not be completed by early May. Any construction in May will be contingent upon the condition of the snow and ice roads. Softening of these roads begins in early May.

Based on the construction schedule, start-up of the lines from the Mackenzie Delta field to Kingsgate and Monchy would be achieved toward the end of the third year. The Prudhoe Bay field would come on line one year later and the system capability would be 2.0 Bcf (billion cubic feet) per day. Continued construction of compressor stations into the seventh year would bring the Alaska-Canada system to the 4.5 Bcf per day capacity.

The feasibility of sustained winter construction over several years period in the Arctic has been questioned. Study by the Department (USDI, 1975-ANGTS:FS) has raised the question of whether or not adherence to a winter schedule that avoids prolongation into the Spring and Fall seasons (periods of intense wildlife activity) can be maintained in the Arctic, avoiding serious environmental conflicts and the construction of a permanent road along the right-of-way.

The North Border portion of the line will be constructed in one phase in approximately 26 months. No winter construction is contemplated and most work will be accomplished between May and November. The work will consist of the construction of approximately 1600 miles of pipeline, 12 compressors stations, 12 major river crossings, and 87 communication towers.

A two year period will be required to complete the line from Kingsgate to Antioch, California. Construction would commence one year after approval is received.

The Kingsgate to Rye Valley, Oregon, leg would be constructed in one phase requiring approximately 12 months. Delivery of gas is expected to begin following completion and testing of the facilities. After two operating years, the volumes of gas then being transported would be expected to have increased to the fifth year level.

Because of the uncertainty as to when the necessary approvals, permits, and authorizations will be granted, most companies indicate that construction will begin one year after approval of the project. The time of the year that approval is given can affect the proposed schedules, since some companies propose only winter construction; others indicate no winter construction.

Construction will progress more or less concurrently on all lines. The longest projected completion period is 7 years. This is the scheduled construction period for the trans-Canada system; however, the last 3 years of the 7-year period will be devoted to increasing the compressor capacity. Canadian Arctic Gas Pipeline, Limited, indicates that work would commence in a summer season and that during the fourth year they would be ready to accept gas from Prudhoe Bay. Timing of the approval of the Canadian segment is therefore critical to any overall projection of delivery.

Time Requirements

The start of actual pipeline construction is dependent upon several factors including the availability of materials and skilled labor, accessibility and condition of sites, and the weather, generally. The time requirements for preparatory work such as road construction, stockpiling of materials, and surveying will vary, but most preparatory work would be completed within the first or second construction year. In general, time requirements will be more problematical in the Arctic.

Construction of compressor stations will require about six months each, but 10 to 15 months each may be required in the Arctic. In addition site preparation and equipment move-in will require from three to six months lead time. Time requirements will be less for the West Coast lines; compressor stations already exist for these proposed transportation segments.

Actual pipeline construction time is usually proportionate to the ruggedness of the terrain. For example, ITAA estimates that construction will progress as follows:

1. Average progress--5000 feet/day/spread
2. In mountainous terrain--3000 feet/day/spread
3. In flat terrain--7000 feet/day/spread.

However, the construction rates in the Arctic are expected to be slower. For example, the construction on the Arctic Coastal Plain will average approximately 2,300 feet/day/spread, less than one half the average progress for the Rye Valley leg.

The construction time frame for pipeline construction at river crossings must be considered separately. Submerged crossings of major rivers are estimated to require approximately two months each. However, up to 10 months preparation may be required. Preparatory activities consist of approach preparation, prefabrication, weighting, and ditching.

Maintenance of Public Services

There are no public service facilities along the proposed pipeline route in Alaska. In Canada, the preferred method for crossing highways is by open cut. In such cases, detours or temporary bridges will be provided. It is expected that bored and cased crossings will be installed under all major highways and railroads.

The construction methods used along the routes of all proposed lines in the lower 48 States is generally uniform. Where the pipeline intersects a highway the method of crossing will depend generally on the class of the road and specifically on jurisdictional requirements. Some local roads with only limited traffic may well be crossed by open cut methods, that is, the traditional open ditching, laying of the pipe and backfilling.

Interstate highways and other heavily traveled roads that can tolerate only limited interruption of the traffic flow will be crossed by tunneling or boring. Such tunneling or boring will be at sufficient depth under the highway to protect it. Where applicable, carrier pipes without casings, but structurally designed for the superimposed external loads to be encountered (in addition to internal pressures), may be used. Installation of encased pipe requires that the outer casing be vented to the atmosphere. Generally, railroads will be crossed by the jacking or boring technique.

Other underground utilities such as other pipelines, telephone lines, water and sewer lines will be located and marked in advance of the trenching operation. These intersections will be carefully excavated and the pipe will be installed over or under the existing utility and separated from it by means of fill or artificial support. This same technique will be used to protect drainage tiles in agricultural areas. In certain cases where concrete-lined canals or water courses are encountered it may be necessary to run a short section of the line overhead rather than tunneling beneath the utility.

1.OV.6 Construction Procedures

Preparatory Procedures

A considerable amount of preparation is required prior to actual pipeline construction. The scope of these activities is largely dictated by the degree of existing development of transportation facilities, material outlets and urbanization. In undeveloped areas and in certain rural localities, the construction of roads, storage facilities, and temporary housing must precede actual pipeline construction. In developed areas requirements for such support facilities are minimal.

Supplies in the far North will be brought in by ship. To accommodate this shipping, ports and stockpile areas are required at Demarcation Bay and Camden Bay, in addition to the existing facilities at Prudhoe Bay. From there, supplies will be hauled over snow and ice roads to the construction sites. Such road construction is among preparatory activities. Many of the supplies and materials needed in northern Canada will be brought in on barges, via the Mackenzie River and its navigable tributaries. Haul roads are also required as part of the transport system. Since the shipping season is short, supplies and materials must be brought in during a few weeks in the summer. During the remainder of the year, aircraft must be utilized, necessitating the construction of airfields.

In the lower 48 states of the U.S. and in southern Canada, supplies and materials can be hauled nearly to the right-of-way by rail or truck.

The rights-of-way must be surveyed and staked prior to construction. Preconstruction surveying may be carried on concurrently with the later stages of the above activities.

Actual mobilization of the construction spreads must be preceded by construction of camps in sparsely populated areas. On the Alaskan and Canadian segments construction camps will be used. These camps will range from small portable camps for 50 employees or less to modular units capable of housing as many as 800 employees. The type of facilities provided is dependent on the size of the camp. The smallest camps would only be on site for a few months and have self-contained waste treatment and waste disposal facilities. Camps that might serve 200 employees and be in use for about a year would have waste disposal systems and a water supply developed on or near the site. These camps would consist of several buildings for eating, sleeping, recreation and workshops. The largest camps would be for major construction efforts and include additional personal service facilities. These camps are presently planned to be located at the site of the future compressor stations in Alaska.

Pipeline construction in most of the lower conterminous States will not require camps, and workers are expected to provide their own housing. This is usually done by locating quarters in communities within 50 miles of the work site or through the use of personally owned travel trailers and similar equipment. Northern Border will require camps in Montana, North Dakota, and northern South Dakota. Each will be supplied with water, waste disposal facilities, and electric power, as necessary.

Construction Techniques

All companies involved in the various segments of the total pipeline project indicate similarities in their selection of construction procedures. Certain variations are recognized because of geographic location, climate, topography, or combinations of these factors.

Pipeline construction is usually accomplished in a series of simultaneously-constructed reaches, known as spreads. Figure 1.OV.6-1 and Table 1.OV.6-1 show a pipeline construction spread. Typically a construction spread includes between 750 and 800 men in Arctic areas and between 350 and 500 men in more southerly areas. All construction spreads do not progress at the same rate due to variations in terrain, accessibility, or the number of utility and stream crossings involved. Projected daily progress was presented earlier. Each spread is, however, a complete pipeline construction unit from clearing to restoration.

The basic pattern of operation is: survey and stake the rights-of-way, construct temporary service roads, clear rights-of-way and grade. The right-of-way normally required for construction is approximately 100 feet wide. This is sufficient width for stockpiling excavated material, stringing pipe, pipe laying, and travel along the line. Figure 1.OV.6-2 shows a typical pipeline right-of-way construction profile.

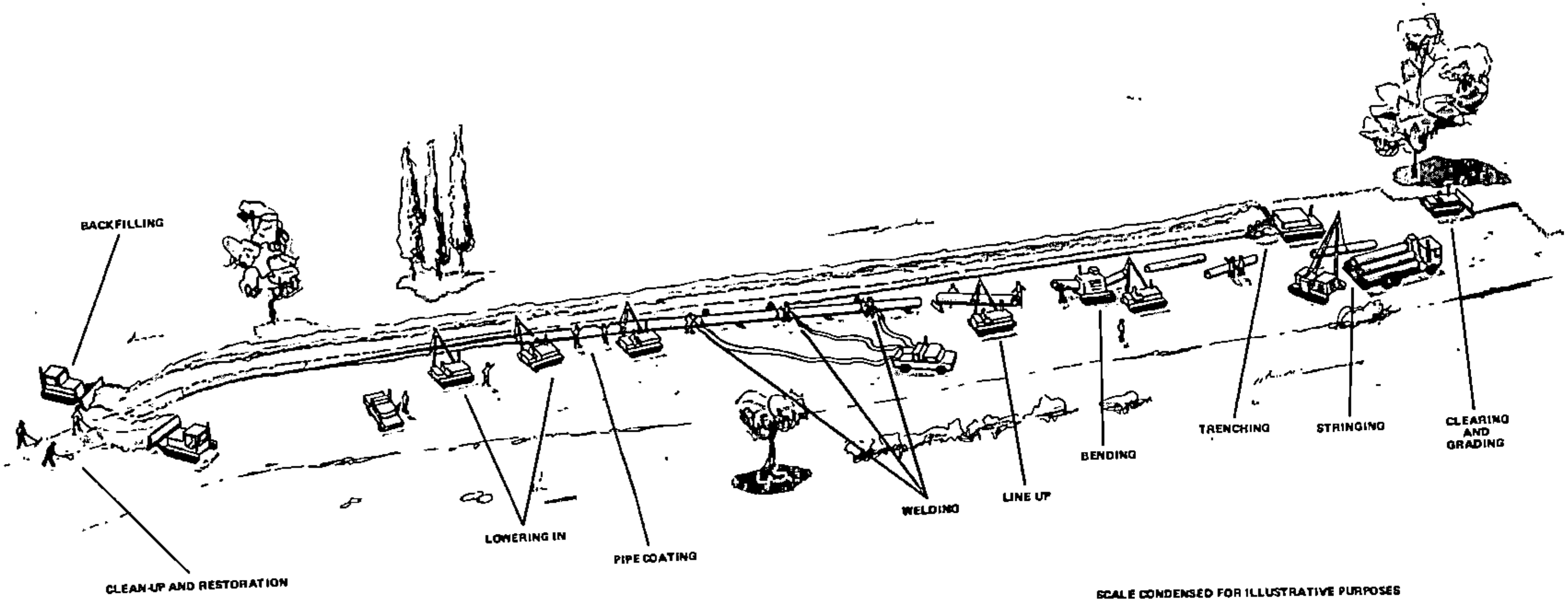
After a suitable road and working area have been developed, the pipe is strung along the route for later welding and placement. Gaps are left in the string of pipe for passage of vehicles, workmen, domestic animals, and wildlife.

The pipe trenches are usually dug in sufficient width to provide a minimum of one foot of clearance on each side of the pipe. The actual depth of cover over the installed pipe depends on several factors such as soil conditions, safety factors, and any specific requirements imposed by a responsible agency such as the Department of Transportation. The base of the trench must be smooth; in rocky areas a layer of sand or similar material might be used as bedding for the pipe.

Trenching is by mechanical ditching machines. These machines can be wheel-mounted, self-propelled or tractor-drawn machines; single toothed rippers; in some cases backhoes may also be used in trenching. In areas where rock or permafrost is encountered, explosives may be used. Where blasting is necessary, precautions will include proper notifications to adjacent land owners, posting of flagmen, and use of mats to minimize flying debris.

Bending, welding, coating, and wrapping are the next operations preparatory to lowering the pipe. Since the pipe is delivered in straight lengths, minor variations in alignment are accomplished by bending. The bending is accomplished by use of a track-mounted hydraulically operated machine.

Welding in the field is performed either manually or with automatic equipment. Welding procedures will be established prior to construction. Regardless of the system, welds will be subjected to visual and mechanical inspection techniques. The latter involves radiographic sensors to detect skips or incomplete welds. "Welding of Steel in Pipelines," in 49 CFR 192,

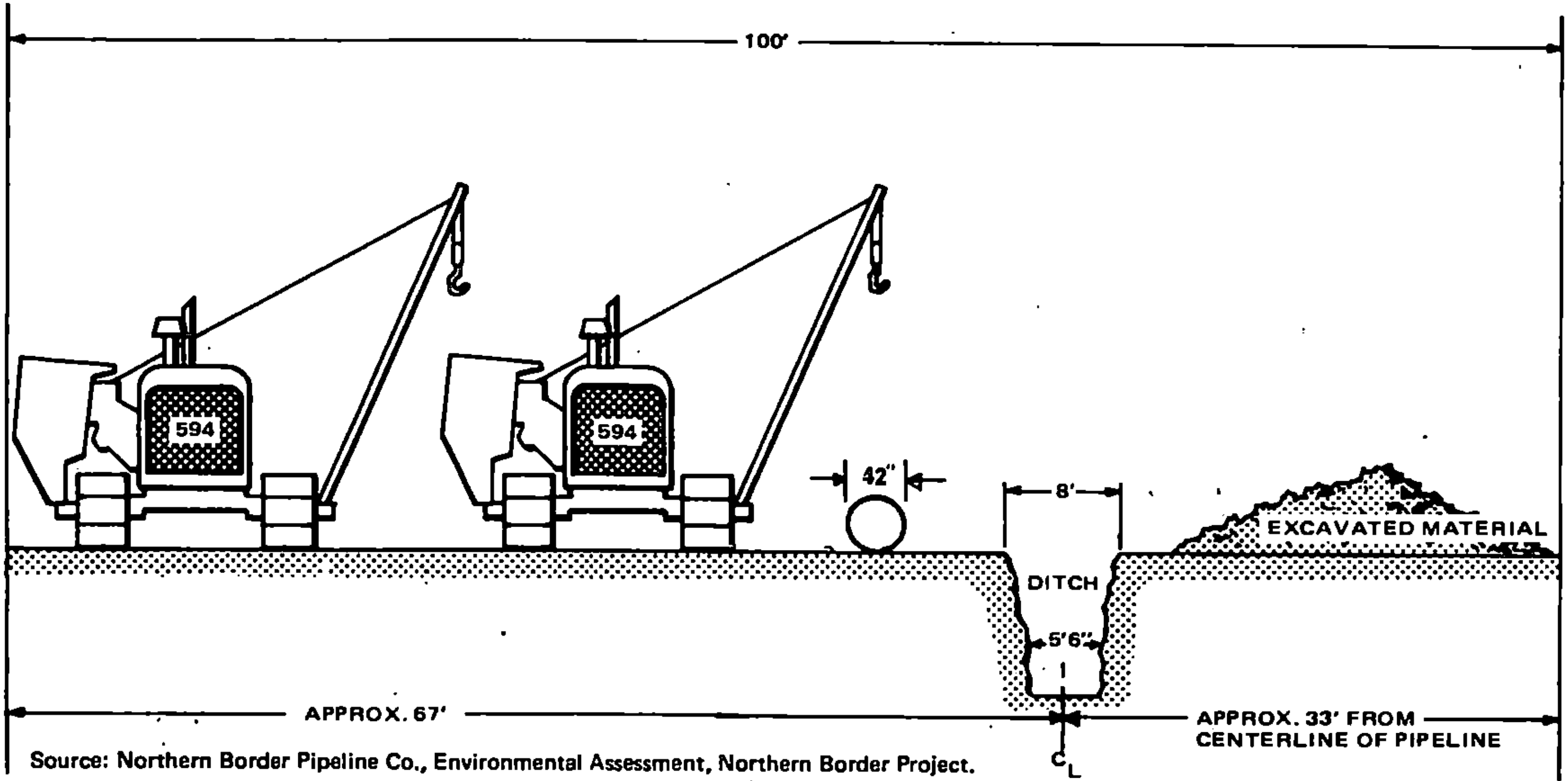


Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.6-1 Sketch of typical construction spread

Table 1.OV.6-1 Typical major equipment used for large diameter pipeline construction

CLEARING AND GRADING	
2 Tractors, D-9, Dozer	1 Pickup Truck
2 Tractors, D-8, Dozer	1 Motor Patrol
1 Fuel Truck	1 Carryall
PIPE STRINGING	
25 Pipe Trucks	1 Truck, Gin Pole
1 Tractor, Pipelayer	1 Pickup, 4-Wheel Drive
2 Tractors, Tow	2 Pickup Trucks
TRENCHING	
1 Ditching Machine	1 Front End Loader
8 Backhoes, 22B	3 Sets Twin Drills
1 Tractor, D-9, Dozer and Ripper	4 Air Compressors
3 Tractors, D-7, Dozer	1 Truck
1 Tractor, D-8, Dozer	3 Pickups
3 Carryalls	1 Pickup, 4-Wheel Drive
2 Tractors, Pipelayers	
LINE-UP, WELDING, LOWERING-IN	
4 Buses	18 Welding Rigs, Pipeline
1 Fuel Truck	2 Tack-Welding Rigs
2 Fuel Wagons	1 Water Pump, 2-Inch
1 Buffing Rig	1 Truck, Tack Rig
7 Welding Rigs, Utility	1 Pickup Truck
3 Tractors, AC-16, Pipelayers	1 Tractor, D-7
4 Tractors, AC-21, Pipelayers	1 Tractor, D-8, Dozer
1 Backfiller	5 Float Barges
2 Water Pumps, 6-Inch	1 Air Compressor 125 cfm
2 Tractors, Tow	1 Jet Pump
3 Trucks, Flatbed	
BENDING	
1 Bending Machine	1 Pickup Truck
1 Tractor, HD-16, Pipelayer	
WRAPPING	
1 Tractor, D-7	2 Pickup Trucks
2 Trucks, Flatbed	1 Front End Loader
CLEANUP	
1 Motor Patrol	2 Tractors, D-7, Dozer
1 Tractor	1 Truck, Flatbed
2 Tractors, D-8,	2 Pickup Trucks
MISCELLANEOUS	
4 Trucks, Mechanic Rig	3 Vans
1 Truck, Grease	1 Office Trailer
4 Trucks, Winch	1 Trailer, Lowboy
1 Trailer, Float	



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.6-2 Sketch of typical construction profile

Subpart E, sets forth requirements for establishing welding procedures, qualification of welders, and inspection of welds.

Coating and wrapping are applied for the protection of the pipe. Coating can be factory or field applied. The wrapping material or system is chosen for its resistance to soil corrosiveness, chemical content of water, and other aspects of coating technology. Coating and wrapping materials include asphalt and asphalt-saturated paper, somastic (asphalt and sand mixture), coal tar with coal-tar saturated paper, butyl tape, or thin film epoxy.

The lowering-in operation is normally integrated into the wrapping and coating sequence. Commonly, side-boom crawler tractors are used to lower the pipe into the trench. If the pipe cannot be lowered immediately, it is placed along the trench on supports that will protect the coating until the pipe can be placed.

After placement of the pipe, the excavated material is backfilled over it. If the backfill material is rock, frozen soil, or similar type material, it may be necessary to pad the pipe with processed spoil or borrow material such as sand. The soil over the pipe is mounded to allow for settling. Gaps are left in the mound so as not to interfere with lateral surface drainage.

Site clean-up, revegetation, and restoration are the final steps in pipeline construction. Clean-up involves disposal of unused excavated materials, construction waste and debris, removal of temporary camps, and obliteration of temporary roads. Disposal of waste and debris can be accomplished in several ways: burial, burning, or dumping at a selected site. The actual method will depend on local regulation and any special requirements imposed by the landowner.

Where actual pipeline work is accomplished in the winter, revegetation and restoration will carry over into the following summer. Where the climatic conditions are extreme or where soil fertility is low, more than one year may be required to assure satisfactory restoration both in terms of proper backfilling to assure surface configuration and reestablishment of vegetative cover.

River Crossings

The philosophy of pipeline design and construction at river crossings is to bury the pipe below the anticipated or potential maximum depth of scour. The alignment at river crossings is usually perpendicular to the principal direction of stream flow. Designing river crossings includes consideration of the erosion potential of the flood plain and river banks. In general, the pipe at river crossings will be encased or have greater wall thickness. Where the potential for damage to the pipeline is estimated to be sufficiently great, dual crossings will be constructed.

Buoyancy is another concern in areas where the pipeline will be partially or fully submerged in water or a soil-water slurry. Final determination of areas requiring buoyancy control will be made on the basis of surveys, subsurface investigations, and visual assessments up to the time of installation. Methods of buoyancy control and areas of possible use include: 1) continuous concrete coating at major river crossings, certain minor river crossings and high water table areas; 2) bolt-on river weights at smaller water course crossings; 3) saddle weights in other wet areas, e.g., muskeg; 4) pipe anchors, in lieu of saddle weights where underlying soil or rock will maintain anchorage; 5) deeper burial; 6) use of selected granular backfill where trench walls are sufficiently stable to resist lateral yielding.

Smaller streams may be trenched by use of draglines on shore; on larger rivers it may be necessary to use barges to float the excavation equipment. Figures 1.OV.6-3 and 1.OV.6-4 illustrate two trenching methods with floating equipment. Three methods of pipe installation across rivers and streams are depicted in Figures 1.OV.6-5, -6, and -7.

Highway and Railroad Crossings

The technique used in crossing highways and railroads depends upon applicable regulations, especially as they apply to interruption of traffic. Sometimes, trenching from the surface is permitted. At other crossings, augering or jacking procedures that will not interfere with the flow of traffic are required (railroads and primary roads, for example).

Drainage Tile Field Crossings

Precautions are also taken in crossing cultivated fields with tile drainage systems. Among the measures taken are the installation of temporary drainage tiles if necessary and installation of permanent replacement tiles during the backfilling operation. (See North Border Volume, Figure 1.1.3.6-3 for designs.)

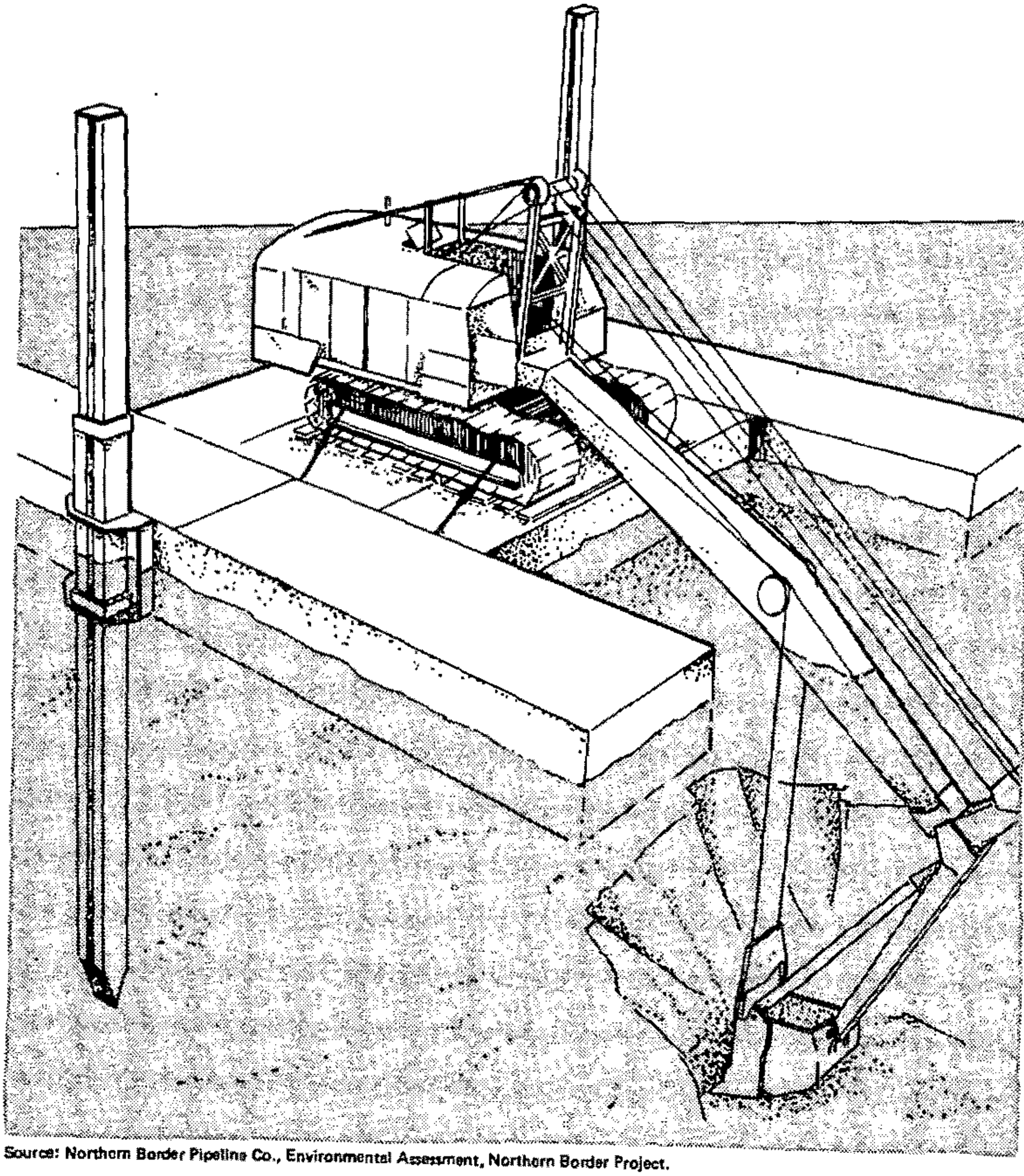
Testing Procedures

After construction but prior to operation, the gas pipeline will be hydrostatically pressure tested for leaks in the pipe or welds and to verify the structural integrity of the welded pipe at its expected operating pressure. In the test, segments are filled with water and the line is pressurized for a prescribed period of time. Test standards are set forth in 49 CFR 192.

In Alaska, northern Canada, and places where freezing temperatures may be a problem, methanol will be added to the water to depress its freezing point. Disposal of the methanol solution would include reduction from a test strength of 26 percent to less than 1 percent by dilution or distillation. Methods of disposal of the test liquids are outlined by the Applicant. (See Chapter 1 of the Alaska, Canada, San Francisco, Los Angeles, and North Border Volumes for details on disposal and water sources in specific areas.) Relative amounts of water that would be required to test one-mile sections of various size pipe have been calculated; 48-inch pipe would require 496,000 gallons, 42-inch pipe would require 397,000 gallons, 36-inch pipe would require 259,500 gallons, and 30-inch pipe would require 180,000 gallons. In all cases, after treatment (if necessary), test water will be released to streams or water courses at a sufficiently slow rate to prevent channel erosion.

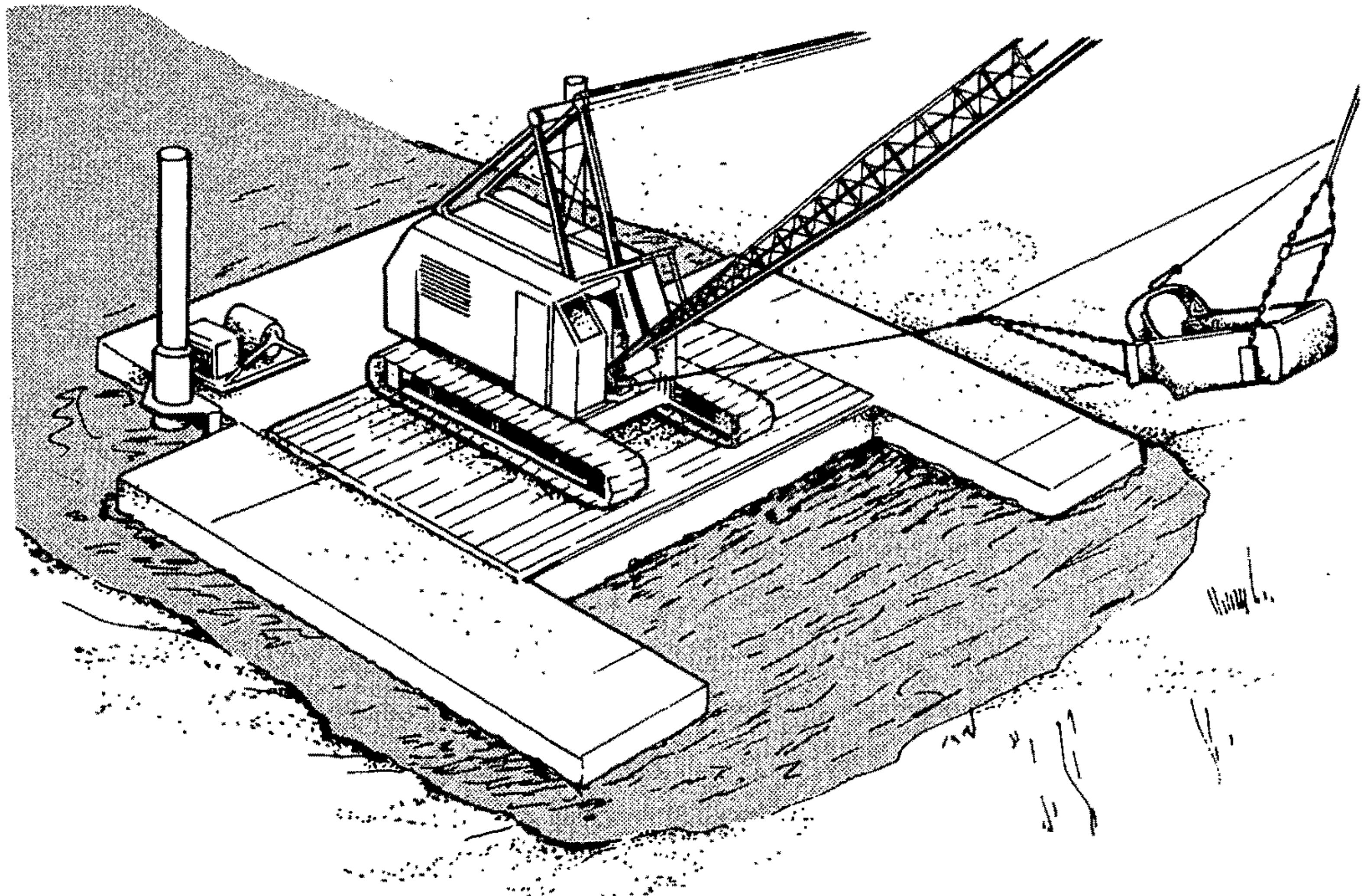
Work Force

The maximum number of employees directly involved in construction work on the pipeline at any one time will probably be about 14,000. The peak employment would occur about the second or third year after approval. At that time the actual pipeline installation would be under way on all segments of the pipeline system.



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.6-3 Sketch of river crossing construction - backhoe dredge



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.6-4 Sketch of river crossing construction - drag line

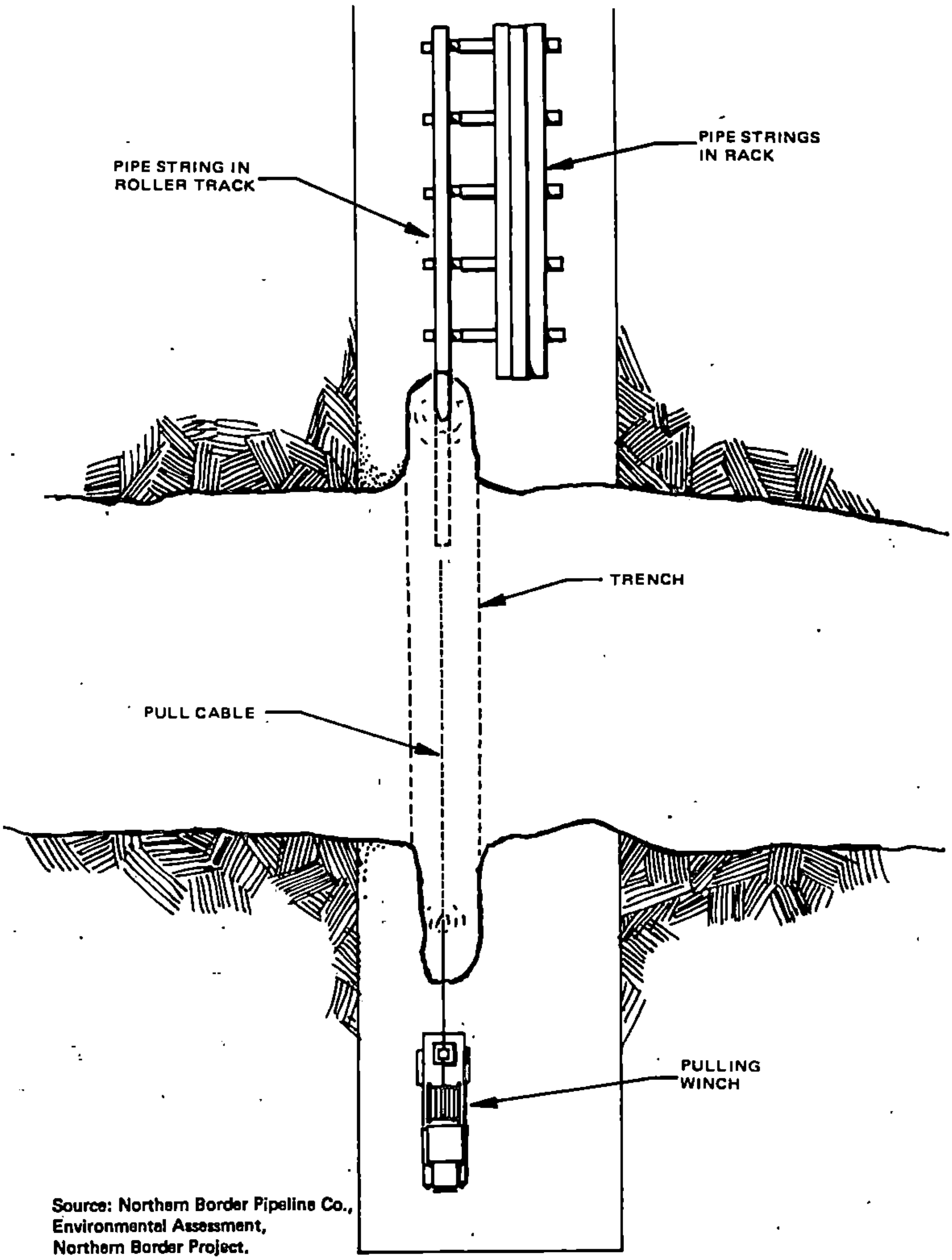
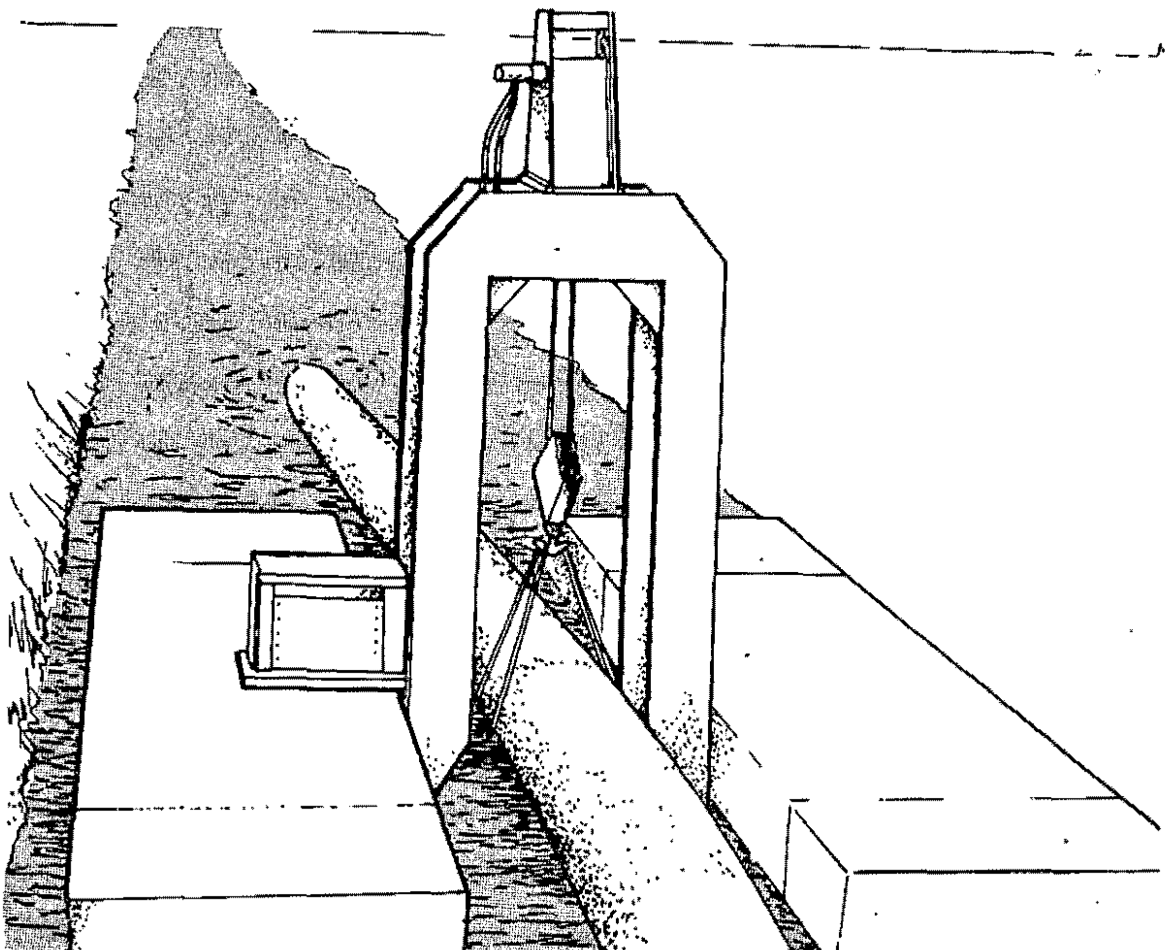
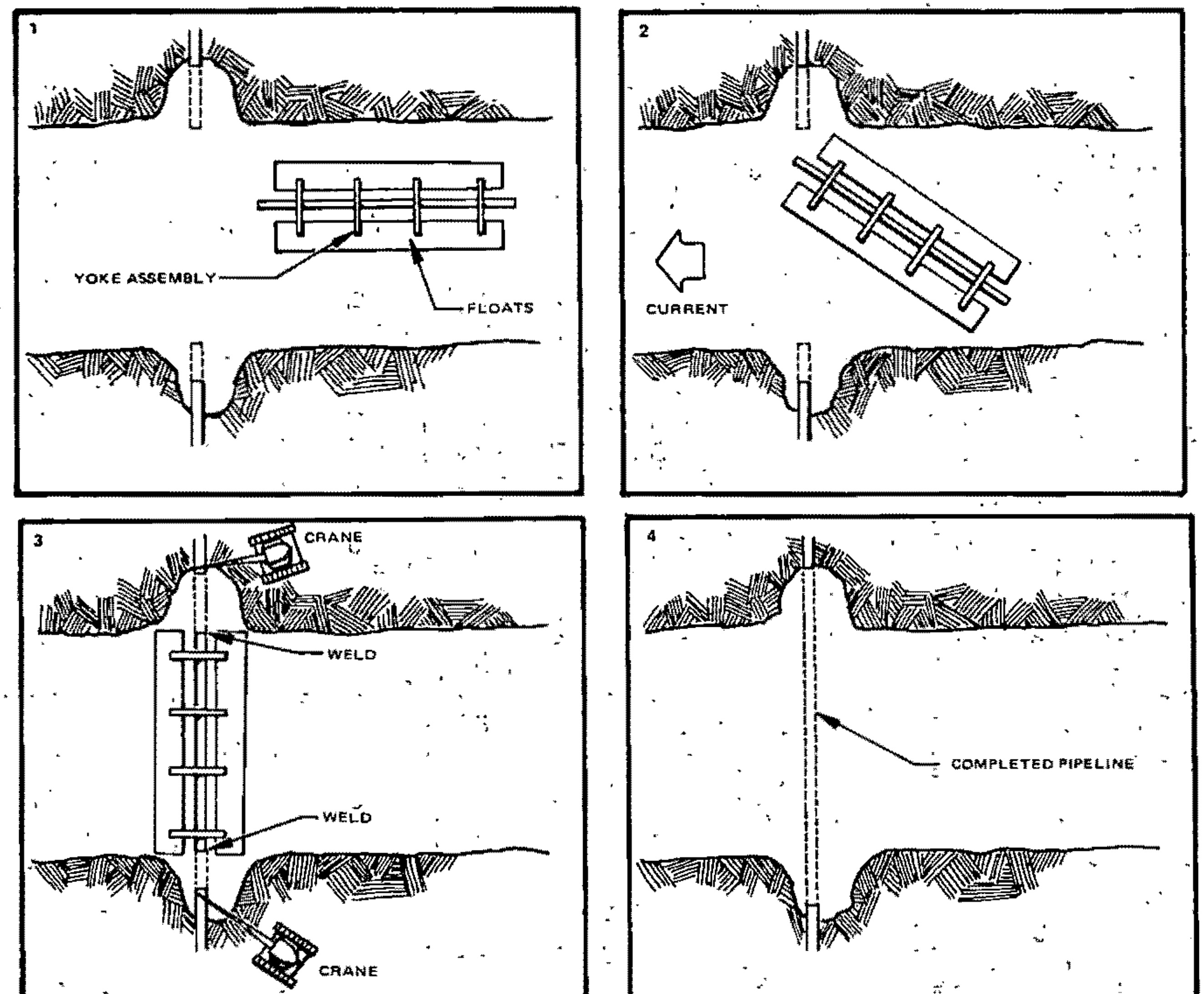


Figure 1.0V.6-5 Sketch of bottom pull method of river crossing



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.6-6 Sketch of floating bridge with yoke assembly for river crossing



Source: Northern Border Pipeline Co., Environmental Assessment, Northern Border Project.

Figure 1.0V.6-7 Diagrammatic of floating bridge river crossing

The estimated numbers of workers directly employed on pipeline-related construction over the anticipated 7-year period of construction are presented in Table 1.OV.6-2. The figures in this table are a combination of information provided by the Applicants and extrapolations of their information. This table is not intended as a precise presentation of the work force for any given time period, but the figures in it may be helpful in giving some idea of the magnitude and trend of manpower requirements.

The companies indicate that 65 to 75 percent of the work force will be skilled pipeline workers, such as welders, equipment operators, inspectors, and foremen. The balance of the work force will be relatively unskilled and would be hired locally.

1.OV.7 Operational, Maintenance, and Emergency Procedures

Compressor stations on all segments of the system are designed to operate automatically by remote control. The individual Applicants did not specifically indicate all other facilities that would operate in this manner. Measuring stations on the Alaskan, Canadian, and Northern Border segments were identified as designed for automatic remote operation. Block valves were identified as being pressure activated except on the Pacific Gas Transmission and Pacific Gas and Electric leg, where mainline block valves will be manually operated; at compressor stations, automatically controlled valves will be installed. This will conform to the practice currently followed by PGT on their existing Alberta-California pipeline system.

The location of some of the gas control centers for remote operation of the pipeline have been identified as Anchorage, Alaska; Calgary, Alberta; Salt Lake City, Utah; and Los Angeles, California. ITAA will use existing telephone communications system on their portion of the line. These centers will receive and transmit via the system of communication towers that are to be constructed as part of the system. Gas temperature, pressure, rate of flow, and quality are some of the information that will be monitored.

Mainline block valves are located at 15 to 20 mile intervals along the pipeline, and commonly at compressor and measuring stations. By closing these valves portions of the pipeline can be isolated for repair. Block valve assemblies generally include a blowdown valve and stack. The purpose of the blowdown valve is to vent gas to the atmosphere to clear the line. However, overpressure protection devices are installed on the discharge piping of compressor stations.

The location of scraper traps and "pig" launching and receiving traps has not been clearly identified. A pig is a pipeline scraper, or plug, that is propelled through the line by differential pressure and is used for internal cleaning. Traps are part of the in-line cleaning system. The traps are for release and capture of cleaning pigs. In-line cleaning removes liquids and maintains pipeline efficiency.

External and internal corrosion of the pipe will be monitored and checked by visual inspection and through the use of readings from test terminals attached to the pipe. In addition to the previously discussed coating, corrosion would be further prevented by "cathodic protection." Cathodic protection is a system whereby the direction of flow of electric current is reversed, so that it flows from the soil to the pipe. This reduces corrosion. Effectiveness of this system would be measured at test terminals.

All maintenance procedures have not been identified at this time. Several Applicants indicate that both operating and maintenance procedures

Table 1.0V.6-2 Projected work force

Line Segment	Construction Year 1	2	3	4	5	6	7	Total Man Years
Alaska	445	1590	6800	8205				17,040
Canada	750	6700	7500	3500	2500	1500	750	23,200
Northern Border		1080	2300	350				3,730
San Francisco		1500	3000	1500				6,000
Rye Valley			900	900				1,800
Total	1195	10870	20,500	14,455	2,500	1,500	750	41,770

will be set out in detailed manuals that will be available at compressor stations, maintenance sites, and other operating stations, including operating headquarters.

Right-of-way inspections, which will be a continuing activity, will be conducted by aerial surveillance, motorized patrol, or in some cases, foot patrol. In Alaska and Canada, aerial patrols using helicopters or short take off and landing (STOL) aircraft either once or twice a month. During spring runoff, the frequency will be increased to once per week to closely monitor river crossings. Where aerial patrols could have an adverse effect upon wildlife, foot patrols or LGP vehicles will be used. In the lower United States, inspections will be conducted in compliance with 49 CFR 192.705, which provides for annual inspections at a minimum, with unspecified, but more frequent, surveillance at highway and railroad crossings.

Compressor stations, measuring stations, and communication towers are under continuous remote monitoring. Visual inspections will be accomplished on a daily basis at some stations or several times per week at others in conjunction with company staff visits to the sites to perform operational duties. Pressure relieving devices at compressor stations, as well as pressure limiting or regulating stations, must be tested at least once per year.

Emergency features have already been discussed to some extent. The pressure activated block valves that would close off a segment of the line automatically in the event of a rupture are part of the emergency controls. Although all Applicants did not discuss these features in detail, other emergency features include fire-sensing photoelectric eyes and heat sensors that could shut down the system in the event of fire, trigger alarms in operating centers, and actually release chemicals to smother a fire. Other controls could automatically shut down portions of the line and vent gas if pressure became excessive or if equipment failure occurred.

Emergency plans will be developed by all companies to cover procedures in the event of a line break from any cause. These plans would consider terrain, accessibility, and climatic problems. Included would be construction diagrams, facility design, map information, equipment locations, and material inventories. Some plans will include information on local authorities that can be mobilized in the event of a catastrophic rupture so that local populations can be warned and control assistance rendered. Such plans would include local police and fire fighting personnel.

1.OV.8 Future Plans

Since the ultimate reserves in the North Slope of the Arctic have yet to be determined, the useful life of the pipeline system cannot be projected accurately. The Alaskan Arctic Gas Pipeline Company indicates a physical life of more than 50 years. Canadian Arctic Gas Pipeline Limited cites a pipeline that has been in operation in excess of 60 years. The pipeline will more than likely be in operation for as long as there is sufficient gas for profitable operations. Current estimates of reserves indicate that the pipeline will operate for 20 to 30 years. Any operation beyond the 20-30 year period would depend on the discovery and development of additional gas reservoirs that could be tied into the pipeline system profitably. The pipeline could also be converted to carry crude oil, if additional oil reservoirs are developed with no further recoverable gas reserves being discovered.

The Alaskan Arctic Gas Pipeline Company (AAGPC) has no firm plan for termination. When they terminate operations, removal of the pipe would be dependent on the economics of salvaging the steel at that time or other factors that may influence their decision. Several alternatives are presented. Other related facilities would be sold or salvaged. The information does not cover restoration of these sites.

No pipeline looping has been proposed by AAGPC; however, looping of the proposed system would permit quantities larger than the proposed capacity of 4.5 Bcf/d. Based on current projections of possible reserves on the North Slope, there is a high probability of either looping the pipeline or constructing another system in a second corridor.

On the Canadian section the Applicant indicates no specific plans for termination or abandonment, but presents several alternatives. If abandonment did occur, the present concept is to leave the pipe in place; surface facilities would be removed and the sites would be restored. Any transmission capacity beyond 4.5 billion cubic feet per day will require looping and additional compressor stations. At this time, the company has no firm plan for such additional construction.

The Northern Border Pipeline Company states that the project would have a life in excess of 30 years, based on the proven reserves in the Arctic. The pipeline would have a probable minimum life of 50 years with a 100 year life within the realm of possibility. It is also possible that the Northern Border pipeline could be used to transmit coal gas from gasification plants in Montana and North and South Dakota at some future time.

In the event of abandonment or termination, all surface facilities would be removed and the sites restored. The Northern Border Applicant states that the pipe itself would also be removed, and it could either be reused or sold as scrap, depending on the condition of the steel.

Future expansion of the Northern Border pipeline could include a 42-inch looped line instead of a single 42-inch line as proposed. This possibility is more fully discussed in the alternatives section of the Northern Border Volume. There are also the 13 additional sites that are identified as future compressor stations. These would be developed to increase capacity on the proposed 42-inch line.

Pacific Gas Transmission and Pacific Gas and Electric did not provide information on the life expectancy of the line and facilities to Antioch, California. They did indicate that if abandonment were necessary, the pipe would be removed and salvaged. Above-ground items with the exception of concrete would be salvaged and the sites restored as after construction. If capacity were to be increased above the 1.2 billion cubic feet per day capacity of the proposed line, a third line with related facilities would have to be constructed. The Applicant has no plans for any of these additional facilities at this time.

The Applicants for the other leg of the West Coast line to Rye Valley, Oregon do not present any definite plans for termination or abandonment. They indicate that if salvage were required, impacts would be similar to those encountered during construction. However, expansion of the proposed system 1.1 Bcf/d is possible. Expansion would involve the construction and installation of a new 30 inch pipeline from Rye Valley, Oregon to the California-Nevada Border. Southern California Gas Company would then construct the remainder of the line from the border to a terminus at Cajon, California. This proposal is further described in Section 1.1.5.8 in the West Coast Volume.

1.OV.9 Federal, State, Canadian, and Provincial Actions

The proposed gas line will require permits, authorizations, and approvals from the several levels of Government. The Federal Power Commission and the Department of the Interior have three major permit actions. These are the granting of a Certificate of Convenience and Necessity, a Presidential Permit Authorizing the Construction, Operation, and Maintenance and Connection of Facilities on the International Boundary between the United States and Canada, and the granting of right-of-way permits to cross Federal lands. Table 1.OV.9-1 lists the Federal agencies involved along with their activity and statutory authority. Table 1.OV.9-2 gives the number of miles to be crossed on lands that are managed by Federal agencies.

The basic actions in Canada are an application to the National Energy Board of Canada for a Certificate of Public Convenience and Necessity and for "grants of interests in Territorial Lands" from the Department of Indian Affairs and Northern Development of the Government of Canada, as well as other permits, approvals, and authorizations.

In addition, most of the States have jurisdiction and organizations holding responsibility for many of these same actions. Permits, approvals, or other clearances may be required for moving oversize vehicles on highways; construction permits may be required; permits may be needed to draw the quantities of water that will be required; and various special construction procedures may have to be approved. Additionally, air and water quality standards must be met, plus waste disposal regulations and requirements relative to erosion control and interruption of drainages.

Local units of Government such as counties, towns, and special districts can all be assumed to have similar responsibilities. These may in some cases be covered by a permit from a higher level of jurisdiction, but not without consultation with the local authorities. In Alaska there are local jurisdictions that must be consulted, including the community of Kaktovik, the North Slope Borough, and the North Slope Regional Native Corporation.

Table 1.0V.9-1 Federal agencies having project approval requirements

AGENCY	RESPONSIBLE SUBDIVISION	ACTIVITY REQUIRING APPROVAL	FORM	STATUTORY AUTHORITY
FEDERAL POWER COMMISSION		Construction and operation of an interstate natural gas transmission pipeline	Certificate of public convenience and necessity	Section 7(c), Act of June 21, 1938 as amended, 15 U.S.C. 717(f), Title 18 C.F.R., Part 157.
		Construction, maintenance, and operation of facilities at the Canadian border for the importation/exportation of natural gas	Presidential Permit	Section 1(a)(2), Executive Order 10485, Sept. 3, 1953, 18 FR 5397. Title 18 C.F.R., Part 153.
		Importation/exportation of natural gas	Authorization to import/export natural gas	Section 3, Act of June 21, 1938 as amended, 15 U.S.C. 717(b). Title 18 C.F.R., Part 153.
		Other procedures, forms, rate schedules, tariffs, and the like, related to the gas pipeline	Regulations and codes	Title 18 C.F.R., Parts 2.69, 154, 157-160, 201, 216, 225, 250, and 260.
ENVIRONMENTAL PROTECTION AGENCY		Discharge of water. Air quality and pollution control	Discharge permit, where applicable. Regulations for pollution control	Section 402, Federal Water Pollution Control Act as amended, Public Law 92-500, Oct. 17, 1972. Title 40 C.F.R., Part 125. Also, Title 40 C.F.R., Parts 50, 125, and 136.
FEDERAL COMMUNICATIONS COMMISSION	Safety and Special Radio Services Bureau	Installation and operation of microwave transmitters and associated tower facilities. Maintenance regulations.	Radio station authorization (construction permit and station license). Maintenance regulations.	Act of June 18, 1934, as amended, 47 U.S.C. Chapter 5, especially Section 301. Title 47 C.F.R., Part 1, Subpart D, and Part 91. Also, Title 47 C.F.R., Part 17.
DEPARTMENT OF THE ARMY	Corps of Engineers	Pipeline construction across navigable waters.	Permit for work in navigable waters.	Section 10, River and Harbor Act of 1899, 30 Stat. 1151, 33 U.S.C. 403. Title 33 C.F.R., Part 209, especially Section 209.120 issued May 10, 1973, 38 Fed. Reg. 12217.
DEPARTMENT OF THE INTERIOR	Bureau of Indian Affairs	Pipeline construction and compressor station location on tribal, individually owned, and government owned Indian lands administered by the B.I.A.	Right-of-way and Decree	Title 25 C.F.R., Part 161.
	Bureau of Land Management	Pipeline construction across Public Lands administered by the B.L.M. as well as those usually administered by the U.S.D.A. Forest Service, the Corps of Engineers, the Dept. of the Interior's Bureaus of Reclamation and of Sport Fisheries and Wildlife, and the like.	Grants of right-of-way and temporary permits	Section 28, Mineral Leasing Act as amended, 30 U.S.C. 185, Title 1, Public Law 93-153, approved Nov. 16, 1973. Also, Title 50 C.F.R., Part 2800.
DEPARTMENT OF TRANSPORTATION	Coast Guard	Pipeline construction across navigable waterways, requiring elevated crossings, bridges, causeways, etc.	Permit for work in navigable waters	Section 9, River and Harbor Act of 1899, 30 Stat. 1151, 33 U.S.C. 401. Title 33 C.F.R., Part 115.50.
	Federal Aviation Administration	Installation of microwave transmitter towers.	Per F.A.A. Circular No.: AC-70-7460-2D	Title 14 C.F.R., Section 77.
	Office of Pipeline Safety	Pipeline safety during the transportation of natural gas	Safety standards and codes	Title 49 C.F.R., Parts 190-192.

Table 1.OV.9-2 Federal land requirement (Total - Permanent and Temporary)

Pipeline	Total Length	FWS	BLM	Indian Trust and BIA	C/E	FS	Total Federal	Total Non-Federal
Alaska Arctic	195 miles	133.2 miles 3,194.35 acres	-	-	-	-	133.2 miles 3.194.35 acres	61.8 miles
Canadian Arctic	2,435 miles	-	-	-	-	-	-	-
Northern Border	1,619 miles	22.2 miles 347.8 acres	17.7 miles 232.42 acres	35.8 miles 451.46 acres	7.1 miles 122.21 acres	1.7 miles 21.1 acres	91.5 miles 1,174.99 acres	1,527.5 miles
PGT	618.1 miles	-	34.79 miles 224.53 acres	-	0.5 miles 4.84 acres	67.96 miles 442.6 acres	103.25 miles 671.97 acres	514.85 miles
PG & E	289.9 miles	-	2.6 miles 29.11 acres	-	1.6 miles	43.7 miles 494.87 acres	47.9 miles 523.98 acres	251 miles
ITA(A)	391 miles	-	8.26 miles 10.01 acres	14.07 miles 170.54 acres	-	11.89 miles 144.12 acres	34.22 miles 324.67 acres	356.78 miles 4,324.60 acres
Total	5,557 miles	162.4 miles 3,542.15 acres	63.35 miles 496.07 acres	49.87 miles 622 acres	9.2 miles 127.05 acres	125.25 miles 1102.69 acres	410.07 miles 5889.96 acres	2,711.93 miles

2.OV Description of the Existing Environment

2.OV.1 Climate

Progressing from the Arctic latitudes to the latitude of the contiguous United States, the climate moderates. Winters become shorter and less severe while summers become longer and warmer (see Table 2.OV.1-1). Climate zones are shown in Figure 2.OV.1-1.

The coastal Arctic climate of Canada and Alaska is characterized by generally long, cold winters with minimum temperatures ranging to -60°F (-51°C) and with average temperatures between -9° and -20°F (-23° to -29°C). In this area, spring and autumn are transitional and of short duration. In summer the warmest month is July with an average temperature in the 30's to lower 40's (°F) with a maximum of as much as 75°F (24°C). In summer a semipermanent front oscillates between the Brooks Range and the Beaufort Sea. When it lies North of the coast it may warm all areas. The Arctic Ocean has a moderating effect on the ambient air temperature of the Arctic Slope. Southward and inland towards the Brooks Range, winters are colder and summers somewhat warmer.

South of the Arctic Coastal Plain, conditions become more continental. Since the pipeline corridor through Canada is located primarily to the east of the Continental Divide, the Rocky Mountains tend to negate moderating effects of the Pacific Ocean. Summers are also cool and relatively short in the North, becoming increasingly warmer and longer to the south. In the North, the climate is dominated by continental and maritime Arctic air masses, with infrequent intrusions of warm, moist air masses from the South. The influence of mild Pacific air increases in southern Canada and alternates with cold Arctic air, resulting in irregular periods of mild and cold winter weather. Summer conditions are more complex due in part to the more frequent passage of low pressure systems, convectional heating, and the more frequent incursion of tropical air masses from the United States.

The weather patterns on the plains of Canada and the United States are influenced by similar system. As is true of southern Canada, the incursion of tropical air becomes more frequent, while the Arctic air masses become less influential. Table 2.OV.1-1 indicates that average winter temperatures increase from west to east. Winter winds in the northern U.S. are primarily from the northwest, i.e., Arctic, and are moderated somewhat in the East by the Laurentian Great Lakes. In the summer, prevailing winds are from the southwest and average temperatures tend to be more uniform.

Temperatures on the plains near the Rockies are subject to rapid change. Chinook winds, a winter phenomenon of the leeside of mountains resulting from katabatic winds from the southwest, often cause abrupt temperature rises of 20 to 40°F or more. Blizzards and tornadoes are also common on the plains. Blizzards are more common to the West, while tornadoes more often occur in the Midwest (most frequently in Indiana).

From the Rocky Mountains to the west, climate is highly variable due to topographic influences. In general, summers are cool and winters are cold in the Northern Rocky Mountains. Climate moderates on the Columbia Plateau, where cool winters and warm summers are the norm. To the south, through the Basin and Range, Southern Cascades and the California Central Valley, summers are hot and dry with drought conditions frequent, while winters are cool and wet.

Annual precipitation, as might be expected over such a wide geographic area, varies greatly. From the Arctic coast southward, conditions range from arid to semi-arid near the Canada-U.S. border. This area is wholly

Table 2.0V.1-1 Summary of climatological data for representative locations along Alaska Natural Gas Transportation System Pipeline

Location	Average Temperatures Winter	Average Temperatures Summer	Precipitation Annual Precipitation	Precipitation Periods of Heaviest Precipitation	Precipitation Annual Snowfall	Winds Average Speeds
Alaska						
4 Stations Along Proposed Route	-9°F to 1/ -12°F	32°F 2/	4-10 in. (no more than 20 in. in mts.)	July-Aug. (mostly rain)	40-55 in.	15-59 m.p.h. 3/ (coastal area)
Canada						
Aklavik, North-West Territories (on Mackenzie Delta)	-20°F 4/	55°F to 5/ 60°F	7-8 in.	July-Aug.	No more than 7 1/2 ft. (Mackenzie Delta)	12-15 m.p.h. 6/ (Beaufort Sea Coast)
Fort Simpson, Northwest Territories (62° N. Latitude)	-15°F 4/	55°F to 5/ 60°F	12-14 in.	July-Aug.	No more than 5 ft. (north of 60° N. Lat.)	6-8 m.p.h. 6/
Olds, Alberta (near Caroline Junction, Alta.)	12°F 4/	55°F 5/	18 in.	May-Sept.	49 in.	Less than 10 m.p.h. 6/
Shaunavon, Saskatchewan (near Monchy, Sask.)	12°F 4/	59°F 5/	Not Available	Not Available	Not Available	Less than 10 m.p.h. 6/
Cranbrook, Brit. Columbia (Near Kingsgate, B.C.)	15°F 4/	64°F 5/	16 in.	June (rain) Oct.-Feb. (snow)	64 in.	Less than 10 m.p.h. 6/
Northern Border						
Bismarck, N.D.	10°F 7/	72°F 8/	12-16 in.	Summer	Approx. 3 ft.	11 m.p.h. 9/
Chicago, Ill.	26°F 7/	76°F 8/	32-36 in.	Summer	More than 3 ft.	10 m.p.h. 9/
Pittsburgh, Pa.	29°F 7/	72°F 8/	36-40 in.	Summer	More than 3 ft.	10 m.p.h. 9/
West Coast (San Francisco Leg)						
Sandpoint, Id.	26°F 7/	65°F 8/	32 in.	Winter (Less than 1 in./mo., July-Aug.)	73 in.	4-10 m.p.h. 10/
Walla Walla, Wa.	33°F 7/	76°F 8/	16 in.	Winter (Less than 1 in./ month, July-Aug.)	20 in.	5 m.p.h. 10/
Klamath Falls, Or.	29°F 7/	69°F 8/	14 in.	Winter (Less than 1 in./ month, Apr.-Sept.)	48 in.	Not Available
Red Bluff, Calif.	46°F 7/	84°F 8/	32 in.	Winter (Less than 1/2 in./mo., July-Aug.)	2 in.	9 m.p.h. 10/
West Coast (Los Angeles Leg						
Winnemucca, NE	28°F 7/	74°F 8/	9 in.	Oct.-Mar.	28 in.	8 m.p.h. 10/
China Lake, Calif.	43°F 7/	86°F 8/	3 in.	Oct.-Mar.	Trace	4-7 m.p.h. 3/

1/ Average Winter Temperature
2/ Average Summer Temperature
3/ Average Wind Speeds
4/ January Daily Mean Temperature
5/ June Daily Mean Temperature
6/ Mean Hourly Winds
7/ Average January Temperature
8/ Average July Temperature
9/ Annual Mean Speed
10/ Mean Hourly Speeds

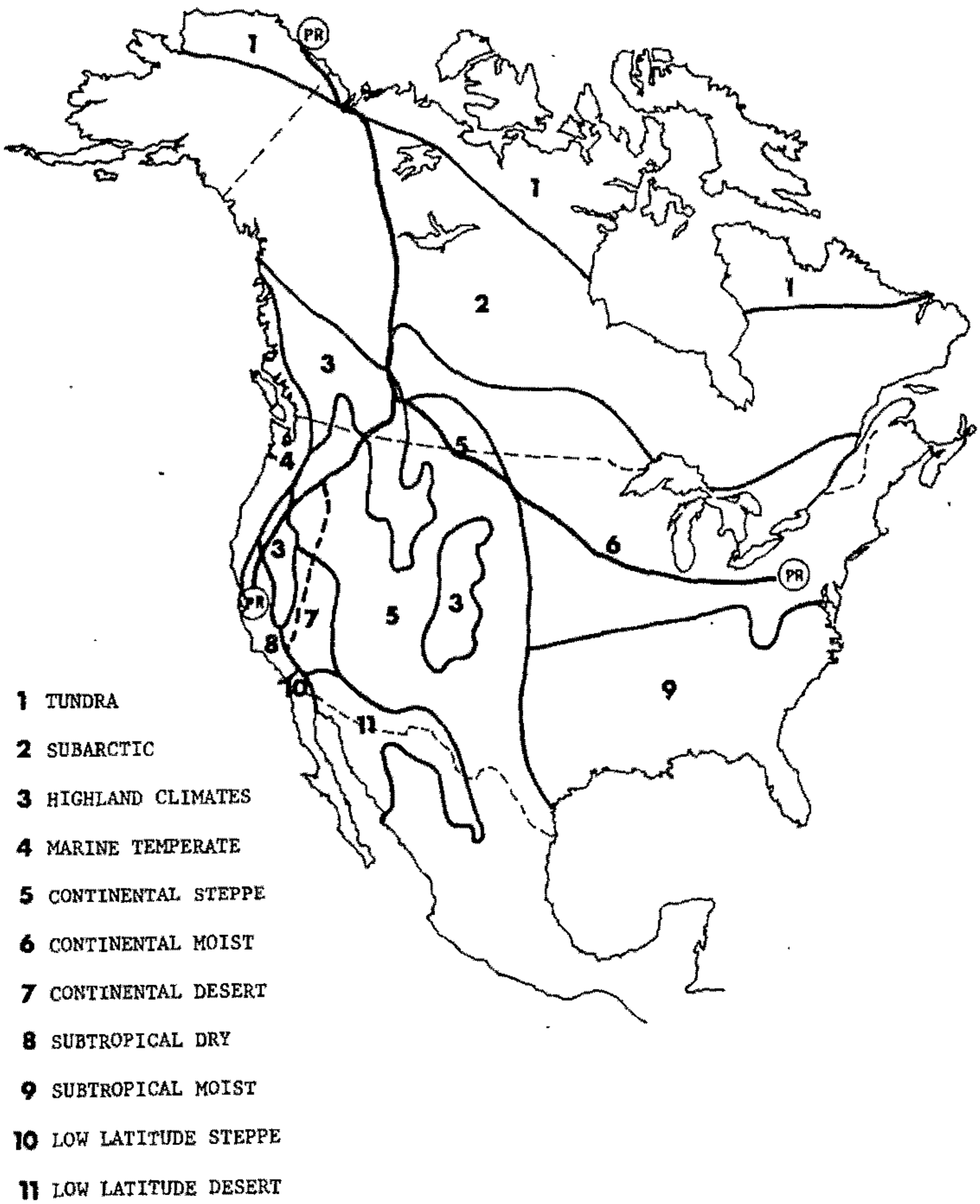


Figure 2.0V.1-1 North American climatic zones

within the rain shadow of the Rocky Mountains. Eastward from the Rockies, average annual precipitation exhibits a gradual, but constant increase, ranging from 12 inches or less in Montana to 45 inches or more in the mountains of West Virginia and Pennsylvania. On the other hand, annual precipitation, decreases from Sandpoint, Idaho on the windward side of the Rockies to the southwest, where the Cascade Mountains exert the rain shadow effect. The Central California Valley lies between the Coast Ranges and the Sierra Nevada Range and is semi-arid. In general to the west of the Rockies, most of the precipitation falls in the winter, while to the east, summer is the wettest season.

2.OV.2 Topography

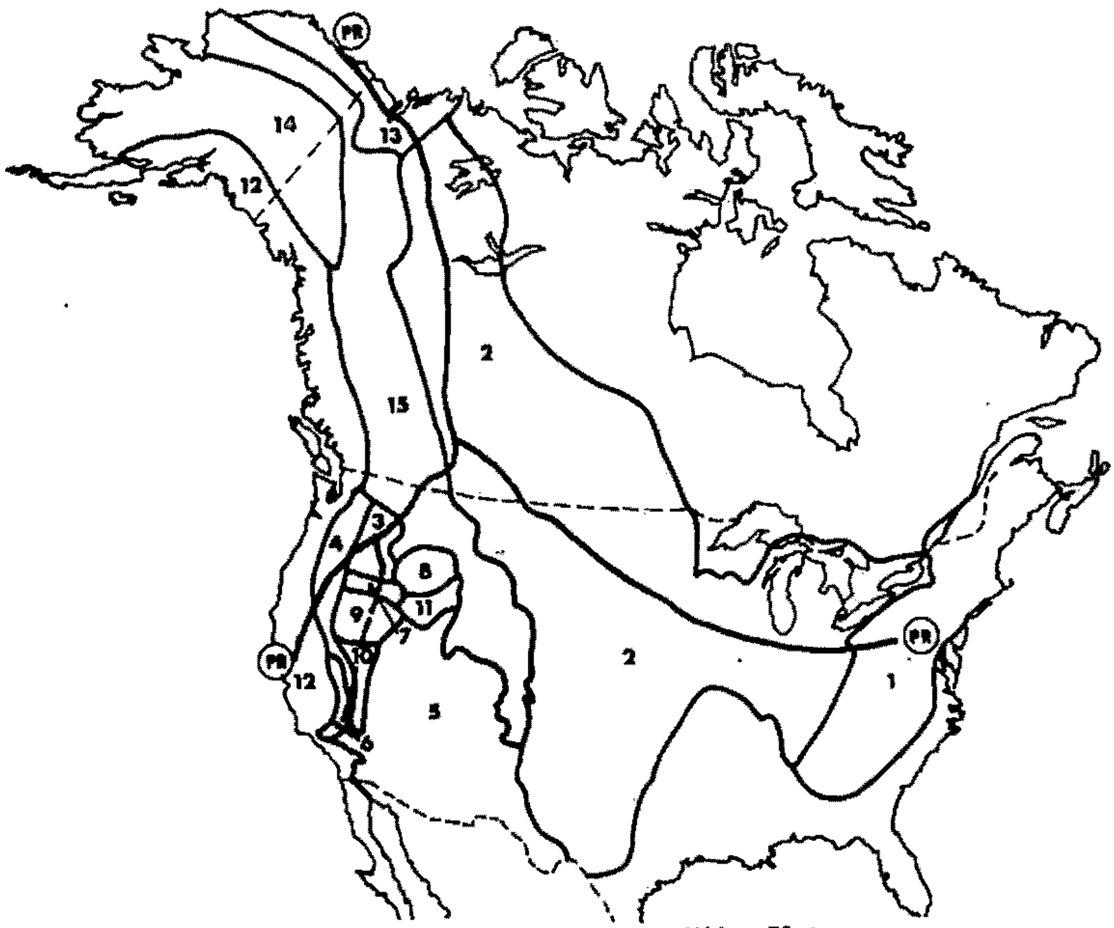
The pipeline route in both Alaska and Canada traverses the Artic Coastal Plain, which is known as the Yukon Coastal Plain in Canada (see Figure 2.OV.2-1). The Arctic Coastal Plain is characterized by nearly level and occasionally marshy terrain with thaw lakes and pingos (small isolated hills with soil covered ice). River valleys traverse the plain from south to north. Major rivers that cross the plain and flow into the Arctic Ocean include the Sagavanirktok, Canning, and Mackenzie. River channels are intricately braided within broad floodplains. The braided channel system develops as a result of aufeis, which is a thick burden of ice that restricts the underflowing water and forces it to seek new channels.

The Canadian pipeline corridor originates on the Mackenzie River Delta and links up with the Alaska segment to the south of the delta. Although the Mackenzie River carries very little silt, its delta is one of the largest systems on the continent and reflects the large size of the drainage basin.

The Arctic Coastal Plain is relatively flat with local relief as much as 50 feet in Alaska and 250 feet in the Yukon. However, slopes are for the most part flat to gently sloping with 90 percent of the slopes traversed in Alaska being less than 3°. Steep terrain (slopes between 14° and 35°) is confined to slump and thaw banks and river channels. In the Yukon, about 95% of the slopes traversed are less than 3°. Slopes of less than 3° are considered inherently stable. However, the short, swift tributaries of the Mackenzie River show steep slopes with a few that could be classified as very steep (slopes greater than 35°).

The Interior (Great) Plains lie to the south of the coastal plain and extend into the southern United States. The route traverses 1300 miles of the Interior Plains Province, which is characterized by broad undissected plains and low plateaus. River valleys provide the greatest relief within this province, with those in the upper Mackenzie Drainage Basin showing the steepest slopes. Other major river basins crossed in the Interior Plains include the Peace and Athabasca River Basins, which are tributaries to the Mackenzie; the Saskatchewan Basin, which flows to Hudson Bay; and the Missouri River Basin of the northern United States. The maximum elevation along the corridor through the Interior Plains occurs south of the Athabasca River at 4120 feet, with local relief as much as 600 feet. The many tributaries of the Peace, Smoky, and Athabasca Rivers flow through valleys with sideslopes rated as moderately steep (between 6° and 14°). However, the intervening plateaus are flat lake and muskeg areas.

From the west to the east, the Great Plains gradually decrease in elevation from 3050 feet in Montana to a low of 460 feet at the Illinois River. The primary factors determining the topography of the plains are the continental glaciations of the Ice Ages and the drainages of the upper Mississippi and the Missouri River Basins. In the western reaches of the



1 Appalachians
2 Interior (Great) Plains
3 Columbia Plateau
4 Cascade Mountains
5 Basin and Range
6 California Central Valley
7 High Lava Plains
8 Blue Mountains
9 Modoc Plateau
10 Sierra Nevada Range
11 Owyhee Upland
12 Coast Range
13 Arctic Coastal Plain (Yukon Coastal Plain in Canada)
14 Yukon
15 Rockies

Figure 2.0V.2-1 Physiographic regions along the pipeline route corridor through the Great Plains, topography is similar to the Canadian part of the Interior Plains. Badlands topography is found along Frenchman Creek in Montana and along the Little Missouri River in North Dakota. Included within the Great Plains are the Glaciated and Unglaciated Missouri Plateaus. The former is nearly flat, while the latter includes the Killdeer Mountains. The easternmost subprovince of the Great Plains through which the corridor passes is the Missouri Coteau, a gently sloping escarpment. Local relief is as much as 600 feet at the Missouri and Little Missouri Rivers and 800 feet in the Killdeer Mountains. Most of the region is gently rolling prairie and flat agricultural lands which are nearly flat to very gently sloping (slope of less than 1°). However, moderately steep to steep slopes are found in the Montana and North Dakota Badlands, which comprise as much as one-third of the terrain in that area. Occasional gentle to moderate slopes are encountered farther to the east in the Killdeer Mountains and the ramp-like Missouri Coteau.

In the eastern part of the Great Plains is the Central Lowlands Province. Major subprovinces within the Central Lowlands include: the Western Lake Subprovince, a region of lakes and potholes; the Coteau des Prairies, another gentle escarpment and counterslope to the Missouri Coteau; the Dissected Till Plains, an eroded plain in Iowa; and the Till Plains, which extend through Illinois, Indiana, and western Ohio. Most of the Central Lowlands are flat or gently rolling, with gentle to moderate slopes on the Coteau des Prairie. Steep slopes are confined primarily to river valleys. These include, for example, those of the Illinois River and its tributary, Pecumsaugan Creek, which are incised into narrow V-shaped valleys with slope angles ranging from 30 to 60 percent.

The easternmost reach of the corridor lies in the Appalachian Plateau and includes the Southern New York, Kenowna, and Allegheny Subprovinces. This region is mountainous and river valleys are typically narrow and V-shaped with little floodplain development. The valleys of the Monongahela and Youghiogheny are classified as very steep. Elevations are as much as 1400 feet with local relief up to around 500 feet. Mine subsidence pits are fairly common and may have moderately steep slopes, which are likely to be less stable than their natural counterparts.

The West Coast leg of the pipeline corridor branches from the east branch about 100 miles north of the U.S. border near Caroline Junction, Alberta, and crosses the Rocky Mountains Province. Subprovinces of the Rocky Mountains Provinces, in order of their traversal, include the Rocky Mountains Foothills, Continental Range (including the Continental Divide), Rocky Mountain Trench, Columbia Mountains, Moyie River Valley, and the Purcell Trench. The Columbia Mountains straddle the Canada-U.S. border.

The Rocky Mountain Foothills consist of linear ridges that rise from the plains to the east and have a local relief between 500 and 1000 feet. However, within the corridor slopes are rather gentle. The Continental Range, Rocky Mountain Trench, and the Columbia Mountains are all characterized by broken and precipitous mountain terrain with steep-walled glacial valleys and swiftly running streams. The trench, separating the two mountain ranges, is a long narrow valley as much as 15 miles wide occupied by the Kootenai River. The mountain passes of the surrounding two mountain ranges consist of low saddles with most slopes classed as moderately steep.

The pipeline corridor through Idaho follows the Moyie River Valley in the northern reaches and has a flat well-developed terraced flood plain about 1/3-mile wide. The valley becomes extremely narrow in the southern reaches where the Moyie River has locally cut an inner canyon.

The southernmost extension of the Rocky Mountains Province traversed by the corridor is the Purcell Trench. The trench is a structural valley that averages about 2 miles wide and has low relief. Although the valley floor is relatively flat, slopes averaging 11° to 20° are encountered entering and leaving the Purcell Trench. Relief on these slopes ranges as much as 600 feet.

The Columbia Plateau Province lies to the southwest of the Rocky Mountains Province. The Cajon leg of the pipeline will branch to the south within the Columbia Plateau. The Columbia Plateau consists of gently rolling terrain with occasional stretches of rough, eroded scablands and steep-walled, V-shaped canyons, such as those of the Snake, John Day, and Columbia Rivers. Relief in the John Day Canyon totals 2000 feet, but the relief in the province as a whole averages between 200 and 400 feet. Short, but steep, slopes are encountered in the scablands, but in places the canyon walls present long, steep to very steep slopes.

Through central Oregon the corridor traverses the High Lava Plains to the east of the Cascade Mountains Province, which in that region is fairly level and plateau-like with mountains formed by recent volcanic activity rising above the surface. The terrain is rocky and rough and is underlain by lava beds. In general, slopes are less than 6°, but slopes between 6° and 14° are locally encountered.

The corridor bears to the southeast from the Cascades and enters the Basin and Range Province near Klamath Falls, Oregon. The part of the Basin and Range Province that is traversed by the corridor is similar to the region of the Cascades described above.

The Modoc Plateau, a subprovince of the Cascade Province, lies to the south of the Basin and Range Province. The pipeline corridor enters the Modoc Plateau just to the south of the California border. This province exhibits terrain that is very similar to the previous two provinces. The terrain is rough and irregular and also underlain by lava beds and volcanic remnants. Local relief in the Modoc Plateau is as much as 800 or 900 feet where deeply incised, V-shaped canyons have been cut. These may exhibit slopes that are classified as steep.

To the southwest lies the California Central Valley Province. In this province the terrain is primarily gently rolling, although the Sacramento Delta is nearly flat. The Sacramento River Valley ranges from low V-shaped walls in higher elevations to a broad braided channel with a well-developed flood plain in the lower reaches and on its delta. Local relief in the Central Valley is no more than 50 feet with slopes that are moderately steep or less.

The pipeline corridor branches near the Washington-Oregon border and traverses the Columbia Plateau, Blue Mountains, and Owyhee Upland Provinces. The other physiographic province along the corridor is the extensive Basin and Range Province, in which the corridor terminates in the Mohave Subprovince (Desert) near the foothills of the Transverse Ranges.

The Columbia Plateau Province shows a varied topography, which, from the mountainous terrain of the northern Blue Mountains, grades into the basalt flows and terraces of the Owyhee Uplands in the southern part of the province. These provinces encompass some rugged terrain, especially at the steep-walled valleys of the Powder and Burnt Rivers and the small badlands near Willow Creek in the Blue Mountains and the steep to very steep slopes of the deeply incised canyons of the Owyhee Uplands. Local relief ranges to 1000 feet in the Blue Mountains and declines to a maximum of 600 feet in the Owyhee Uplands.

2.OV.3 Geology

Surficial Materials (Engineering Soils)

"Surficial material" refers to the unconsolidated geologic surface materials or soils of the earth. The word "soil" is confusing. Agriculturalists speak of soil as the upper 2 to 3 feet of material which supports growth of plants. Geologists and engineers refer to all unconsolidated material below the agricultural soil as "soil," regardless of thickness or use. In this particular discussion engineering soils are described under this section, Surficial Materials; agricultural soils are discussed under Section 2.OV.4, Soils.

In the Alaskan-Canadian section and in the Northern Border section, the surficial material was primarily transported by glacial action. This "glacial drift" consists predominantly of unsorted sand, silt and clay, with a few cobbles and boulders of rock as much as 10 feet or more in diameter found locally. This unsorted material ranges in thickness from less than a foot to several hundred feet; it generally is more than 15 feet thick. The thinner sections are found in the eastern part of the Northern Border route from eastern Ohio to Pennsylvania; where the pipeline route crosses mountains; and, in the Great Plains areas in Canada and the United States, at river crossings where the rivers have cut through the drift in the underlying rock.

On the route through Idaho to California, the surficial material was deposited either by running water or by the wind. Little glacially deposited material is found here. The water-deposited material is found in terraces or on the flood plains of the rivers, in former lake beds, or in alluvial fans on mountain fronts. The material found along rivers is generally gravel, with sand, silt and clay mixed in. The material is somewhat stratified. Some cobbles and large boulders may also be found. The lake bed deposits are generally fine sand, silt and clay, as much as 100 feet thick. These deposits are found in the lowest parts of valleys and basins. Alluvial fan deposits may be as much as several thousand feet thick and consist of all sizes of material, roughly stratified, ranging from clay to cobbles and boulders. This material is found along the sides and foot of mountains, where it may coalesce with material from a neighboring fan and fill a valley or basin to depths of thousands of feet. Talus, rock fragments that have been carried by gravity, are found at the foot of very steep slopes. This material, although creating unique problems in construction, will be little encountered in the pipeline route.

Surficial material on steep slopes is minimal.

Bedrock Geology

The geology of bedrock along the pipeline will be a concern only in those areas where: (1) the surface of bedrock is less than approximately 15 feet from the ground surface, (2) bentonitic shale occurs on sloping ground, and (3) lava tubes, sinkholes and caverns in the bedrock may collapse under the pipeline. Where the bedrock surface is more than 15 feet below ground surface, it is unaffected by trenching and is also of little interest environmentally.

In the permafrost area of Alaska and northern Canada, the bedrock is close enough to the surface to be cut by a trench in less than 2 percent of the total route, and consists of weakly-cemented sediments. On the route south of the 67th parallel to Montana and North Dakota, the rock exposures are limited to stream and river crossings, where the running water has cut through the surficial material into the bedrock, and on slopes of mountains where the surficial material is thin. The rocks range from very hard quartzite and other metamorphic material to soft bentonitic and bituminous shales. Bentonitic deposits are located primarily in southern Canada and Montana and North Dakota. This material is in beds no more than 2 feet thick, and should cause concern only in those areas where the pipeline route is on slopes underlain by dipping bentonitic shale. It has been estimated that the bedrock will occur close enough to the surface to cause concern in only about 10 percent of the area.

In the North Border section, in eastern South Dakota and Minnesota, exposures of rock occur only along rivers and streams. These rocks are hard quartzites and other metamorphic rocks. This rock will be involved in trenching in less than one percent of the route. From that part of the route that extends from Iowa to Ohio, the rock, which will be encountered only near the drainages, will consist of moderately hard limestone, sandstone and shale. The bedrock exposures are more numerous in this section and exposures in trenches will probably occur along about 10 percent of the route. In eastern Iowa, much of the area is underlain by limestone which contains caves and caverns.

From eastern Ohio to Pennsylvania, the bedrock is mostly within 10 feet of the surface, and consists of moderately-hard sandstone and shale. Minor coal beds will be found in these rocks.

The bedrock along the western part of the pipeline route from the U.S.-Canadian border to San Francisco and Los Angeles is generally within 10 feet of the surface in slopes and at the rivers and streams where the water has cut through the surficial material. Elsewhere, in Eastern Oregon and Washington flat-lying basaltic lava flows occur on the upland surfaces throughout much of the area within 15 feet of the surface.

In the western route, bedrock is close enough to the surface to be involved in construction of the trench in an estimated 50 percent of the area; in alluvial valleys the rock is generally buried more than 15 feet.

Permafrost

Permafrost (permanently frozen ground) is defined as soil, rock or any other earth material which remains at or below 32°F (0°C) continuously for two or more years (Muller, S.W., 1947). Although ice is not a necessary prerequisite of permafrost, its presence and amount in relative proportion to soil is of extreme importance to construction in the Arctic. In Alaska and Canada permafrost decreases in thickness from North to South. Two major zones are distinguished; a northern zone, called the continuous zone in which the entire area is permanently frozen; and the discontinuous zone, in which there are scattered permafrost areas. In the pipeline area the junction between the two zones is at about 67°N. At the southern edge of the discontinuous zone is a poorly defined zone (geologically speaking) called the sporadic zone or southern fringe of the discontinuous zone, where areas of frozen ground are scattered in small patches.

In the continuous zone the ground can be frozen many hundreds of feet deep. The distribution of the permafrost is governed by many geographic and climatologic factors, the most important of which is the mean annual ground and air temperature. Large bodies of water act as heat reservoirs that tend to increase the ground temperature locally, thus causing a thinning of the permafrost adjacent to the water and an absence of frozen ground below the water body. The ground above the permafrost which thaws in summer and refreezes in winter is known as the active layer. Its thickness, like that of the permafrost, is governed by the many factors that influence the flow of heat into and out of the earth's surface. When winter freezing does not penetrate through the active layer to the permafrost layer, a layer of unfrozen ground remains. This unfrozen material is called talik.

Mineral Resources

The main geologic mineral resources encountered along the proposed pipeline route are the sand and gravel deposits, which occur in abundance along much of the proposed route. The only exceptions occur along the western leg east of the Cascade mountains of Oregon and California, and on the Modoc Plateau in California. Clay and shale also occur in commercial quantities along much of the proposed route.

Of possible significance also are the deposits of oil and gas that are found in places along the route, for these may be sources of material for transport by the pipeline. Besides the deposits on the north slope of Alaska other deposits are found in the Alberta-British Columbia fields; the Mackenzie River Delta area; along the Northern Border Route from Montana to Pennsylvania; and in the Central Valley of California on the Western Route. Gas could be made from the coal and lignite deposits found along the route and distributed by the pipeline. These deposits are found in the Rocky Mountains in British Columbia, in large areas of plains in southern Alberta and Saskatchewan, in eastern Montana and western North Dakota, in southern Illinois, and in eastern Ohio, and western Pennsylvania.

2.OV.4 Soils

Agricultural soils make up from a few inches to as much as 4 feet of the surficial material along the entire pipeline route. These soils contain 3 horizons: the "A," or organically rich horizon; the "B" or mixed layer, and the "C" or weathered parent material horizon.

Soil Classification

The system of soil classification used throughout America includes (ranging from broadest to lowest category): order, suborders, great groups, subgroups, families, and series. Figure 2.OV.4-1 shows the location of the soil orders along the proposed pipeline route.

Soil Orders

Entisols (Recent Soils): These are mineral soils without natural horizons or with only the beginnings of such horizons. The central concept of this order are soils in deep regolith with no horizons except a plow layer. Included are the extremes of highly productive soils on recent alluvium, and infertile soils on barren sands. Shallow soils on bedrock are also included. The common characteristic of all Entisols is lack of significant profile development. Small areas of Entisols occur as inclusions within the other soil orders.

Inceptisols (L. Inceptum, Beginning): Inceptisols may be termed young soils since their profiles contain horizons that are weakly developed and result mostly from alteration of parent materials. The horizons do not represent extreme weathering. The profile development of soils in this

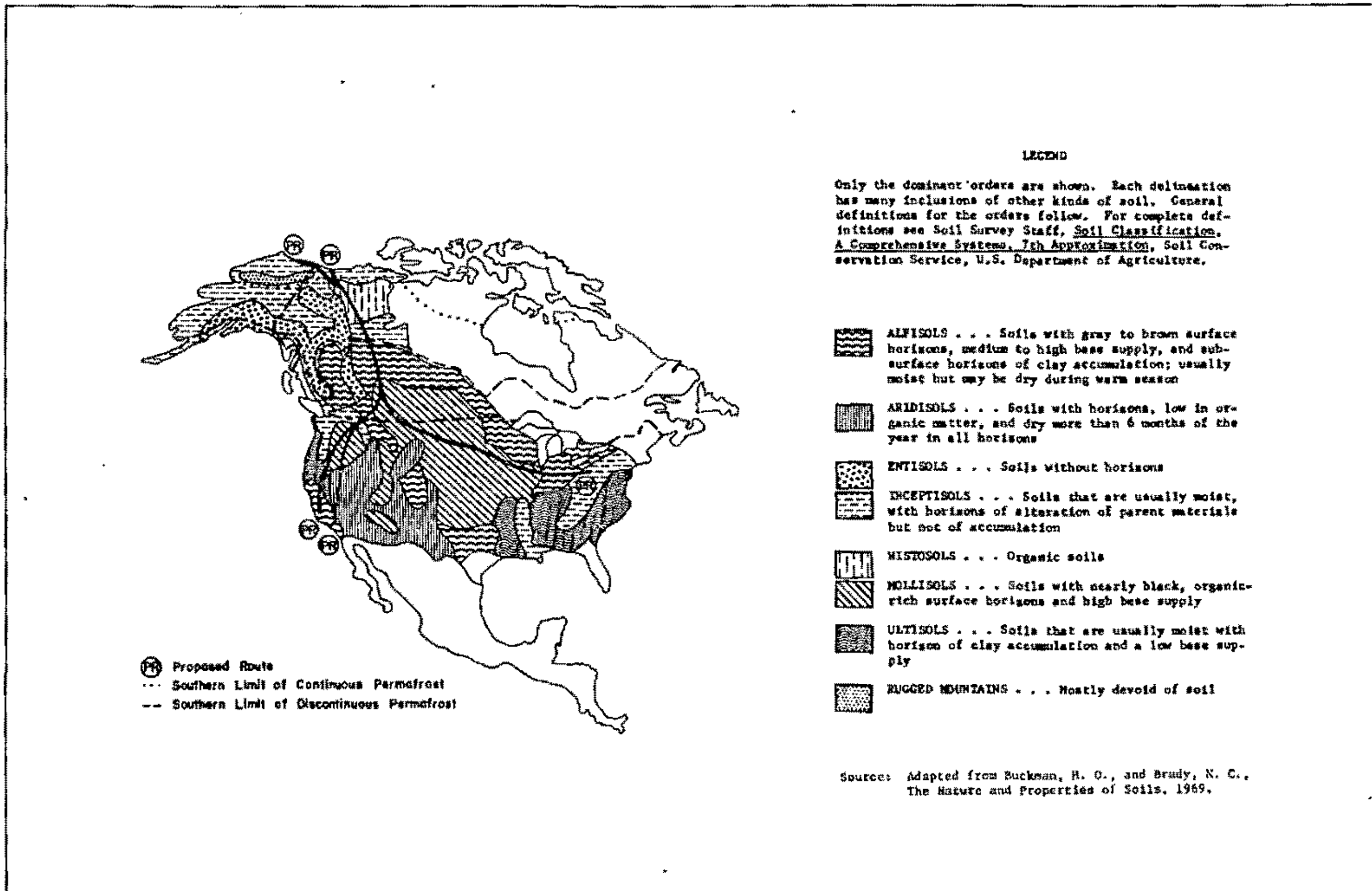


Figure 2.0V.4-1 Soil order in United States and Canada

order is more advanced than that of the Entisol order, but less so than that of the other orders.

Many agriculturally useful soils are included, along with others whose productivity is limited by factors such as imperfect drainage. Approximately 900 miles of Inceptisols will be encountered by the proposed pipeline route.

Aridisols (L. Aridus, Dry): These mineral soils are found mostly in dry climates. Except where there is ground water or irrigation, the soil layers are dry throughout most of the year. Consequently, they have not been subjected to intensive leaching. They may have a horizon of accumulation of calcium carbonate, gypsum, or even more soluble salts. If ground water is present, conductivity measurements show the presence of soluble salts. Aridisols include most of the soils of the arid regions of the world.

Without irrigation, Aridisols are suitable for growing only dryland cultivated crops. Some areas are used for sheep or goat grazing, but the production per unit area is low. Where irrigation water is available Aridisols can be made most productive. Irrigated valleys of the Western United States are among the most productive in the country.

Small areas of Aridisols occur as inclusions within the other soil orders, particularly in Washington and Oregon. Future pipeline expansion from Rye Valley, Oregon to Cajon, California would involve approximately 550 miles of Aridisols.

Mollisols (L. Mossis, Soft): This order includes some of the world's most important agricultural soils. They are characterized by a surface horizon which is thick, dark, and fertile. The surface horizons generally have granular or crumb structures and are not hard when the soils are dry. This justifies the use of a name which implies softness. Most of the Mollisols have developed under prairie vegetation. So-called grassland soils of the central part of the United States make up the central core of this order.

The native fertility of Mollisols dictates that they be rated among the world's best soils. When first cleared for cultivation, their high native organic matter releases sufficient nitrogen and other nutrients to produce bumper crops even without fertilization. Yields on these soils are unsurpassed by other non-irrigated areas. Even today when moderate to heavy fertilization gives a competitive advantage to less fertile soils in more humid areas, Mollisols still rate among the best. Approximately 2550 miles of Mollisols will be encountered by the proposed pipeline. Potential future expansion of the pipeline would involve an additional 100 miles of Mollisols.

Alfisols: Alfisols have gray to brown surface horizons, medium to high base status and contain a horizon in which silicate clays have accumulated. The Alfisols appear to be more strongly weathered than the Inceptisols. Alfisols are formed mostly in humid-region areas under native deciduous forests, although grass is the native vegetation in some cases.

In general, Alfisols are quite productive soils. Their medium to high base status, generally favorable texture and location in humid and subhumid regions all favor good crop yields. In the United States, these soils rank favorably with the Mollisols and Ultisols in their productive capacity. The proposed pipeline will encounter approximately 1000 miles of Alfisols.

Potential future expansion of the pipeline would involve an additional 75 miles of Alfisols.

Ultisols (L. Ultimus, Last): Ultisols are usually moist soils and develop under warm to tropical climates. Ultisols are more highly weathered and acidic than the Alfisols. Except for the wetter members of the order, their subsurface horizons are commonly red or yellow in color, evidence of accumulation of free oxides of iron. Ultisols are formed on old land surfaces, generally under forest vegetation, although savannah or even swamp vegetation is common.

While Ultisols are not naturally as fertile as Alfisols or Mollisols, they respond well to good management. They are located mostly in regions of long growing seasons and of ample moisture for good crop production. Where adequate chemical fertilizers are applied, these soils are quite productive. In the United States the better Ultisols compete well with Mollisols and Alfisols as first class agricultural soils. Approximately 200 miles of Ultisols will be encountered by the proposed pipeline.

Histisols (C. Histos, Tissue): Histisols include the so-called organic soils (Bog soils) as well as some of the half-bog soils. These soils have developed in a water-saturated environment. They contain a minimum of 20 percent organic matter if no clay is present and 30 per cent if the clay content is more than 50 per cent. In virgin areas, the organic matter retains much of the original plant tissue form. Upon drainage and cultivation of the area, the original plant tissue form tends to disappear.

Less progress has been made on the classification of these soils compared to those of the other orders. These soils are of great practical importance in local areas, however, being among the most productive especially for vegetable crops. The proposed pipeline will encounter approximately 600 miles of Histisols.

Soil Associations

In the soils description section of each geographical volume (Alaska, West Coast and North Border) soil association maps are provided on a state by state basis which show groupings of associated soil series referred to as soil associations. Within any given delineated area, only two or three soil series are named but there usually are lesser amounts of other series which are not named. The term "soil series" refers to soils essentially uniform in differentiating characteristics and in arrangement of soil layers.

For detailed soil information the reader is referred to the soil description section of each geographical report (sections 2.1.1.4, 2.1.2.4, 2.1.3.4, 2.1.4.4, 2.1.5.4). A detailed description of the soil associations in each section is given in each of the geographic volumes. Only those soils and soil conditions that may cause some environmental concern during and after pipeline construction will be mentioned here.

2.OV.5 Water Resources

Surface Water

The proposed pipeline traverses drainage basins whose waters ultimately flow to the Arctic Ocean, Hudson Bay, Pacific Ocean, and Gulf of Mexico (see Figure 8.OV.3-2). In addition, a 42-mile segment of the proposed route in northwestern Ohio traverses an area which drains to the Atlantic Ocean. The two largest drainage basins on the North American continent are crossed, although the Mississippi Basin is traversed only in its upper portions.

From the starting point of the pipeline at Prudhoe Bay, through Alaska to the Mackenzie River valley, the streams crossed flow to the north to the Beaufort Sea, and for the most part, originate in the Brooks Range and are thus fed by glaciers. The major rivers crossed along the Arctic Coastal Plain and Arctic Foothills are the Sagavanirktok, Canning, Sadlerochit, and Firth.

The pipeline route then enters the 700,000-square-mile drainage basin of the Mackenzie River and its tributaries for a distance of about 1,350 miles; 650 of those miles lie in the Mackenzie Valley itself. The Mackenzie River is crossed at two locations, the first between Fort MacPherson and Travaillant Lake near the mouth of the river, and the second about 50 miles upstream from Fort Simpson and the confluence with the Liard River.

Major tributaries to the Mackenzie in its upper reaches that are crossed by the proposed route, include the Hay, the Peace, and the Athabasca Rivers. The Peace River at the proposed crossing drains approximately 70,000 sq. miles.

After crossing the Athabasca River, the proposed route crosses the upper reaches of the Saskatchewan River, which rises in the Rocky Mountains and flows to the Nelson River.

In the area of Caroline Junction, Alberta, the proposed route splits, and the eastern portion traverses the Upper Missouri, Upper Mississippi and Ohio River Basins. The western segment of the route traverses the Columbia, Klamath, Lost River, Pit and Sacramento River Basins.

Major streams crossed by the North Border segment are the Missouri, Little Missouri, Oahe Reservoir of the Upper Missouri Basin; the Wapsipinicon, Mississippi and Illinois of the Upper Mississippi Basin; and the Wabash, Muskingum, Ohio, Monongahela and Youghiogheny of the Ohio River Basin.

Major streams crossed by the western leg are the Kootenai(ay), Pend Oreille, Snake and John Day (Columbia drainage); the Williamson and Sprague Rivers (Klamath drainage), and the Sacramento. The Stanfield to Rye Valley segment crosses the Umatilla and Grande Ronde River Basins. Both have headwaters in the Blue Mountains; the Umatilla drains into the Columbia directly and the Grande Ronde empties into the Snake.

Along the proposed pipeline route the gradient gradually increases southward along the Mackenzie River Valley, across the Alberta Plain, west to the Rocky Mountains. On the west slope of the Rockies, the gradient generally decreases to the Sacramento Valley. Along the eastern portion (North Border) the gradient gradually rises through gently rolling terrain to the Appalachian Plateau.

River channel characteristics generally change according to gradient. Where slope is gentle, rivers tend to have broad, shallow meandering channels. These characteristics are exemplified on the Arctic Coastal Plain, the Interior and Great Plains, and the Central Valley of California. As gradient increases, the river channels become narrower and valley walls steeper and water levels deepèr. The Sagavanirktok (Alaska), James (South Dakota) and Sacramento (California) are examples of the former, and the Moyie (Idaho) and Youghiogheny (Pennsylvania) examples of the latter.

Most streams along the proposed pipeline route arise in the mountainous regions such as the Brooks Range, Rockies, Appalachians and Coastal Ranges of the Pacific Southwest. These streams are fed primarily by precipitation--snowmelt and summer storms. Some streams, such as the Great Bear in the Mackenzie Basin, are fed also by springs and large lakes. Others, such as the Athabasca, have some flow from headwater glaciers. For the most part maximum discharge of streams along the proposed route occurs in the spring as a result of snowmelt and, in the far north, glacier melt. Major summer storm events can also cause significant discharge. Generally, however, flow declines after spring flooding, either because of low precipitation and/or high evapotranspiration, as in the Upper Missouri River Basin, or because of winter freezeup, as in the Arctic Coastal Plain. Here winter flow may vary from year to year, depending on the amount of ice storage and the amount of inflow to and discharge from unconsolidated alluvial deposits; some streams may in fact flow year-round because they are fed by springs and lakes. Flow in some streams may cease altogether. The James River, in South Dakota, and its tributaries receive little or no sustained ground-water flow; hence most streams in the basin cease flowing for extended periods in most years. In fact, the main stream and all but one tributary did not flow from August 1958 to March 1960; low flow on the one tributary was maintained only by releases from upstream storage.

Most of the major river systems of the North Border and West Coast legs of the proposed pipeline are regulated by extensive reservoir systems, thus generally severe flooding is avoided. In some regions, such as the Coteau des Prairies, South Dakota, and the Williamson River in the Klamath River Basin, California, lakes provide natural off-stream storage, thereby reducing the threat of serious flooding.

Major flood events do occur, however, along the proposed route in the Arctic Coastal Plain, in the Northwest Territories, on unregulated streams in the Upper Missouri River Basin, and in the Ohio River Basin. Along the Arctic Coastal Plain flooding occurs because of spring snowmelt, ice breakup and frozen permafrost which blocks downward percolation of runoff. The water flow is sometimes impeded by ice jams and their breakup further aggravates flooding.

Flooding and resultant excessive erosion in the Upper Missouri Basin can be attributed to severe summer thunderstorms. One such storm dumped about 13 inches of rain on Stanton, North Dakota in 2 hours, causing flashflooding in the short, steep coulees along the Missouri River and its tributaries.

The James River, South Dakota, is subject to more moderate flooding, but because of the almost level gradient (averaging 0.2 ft./mi) the one-quarter to one-half-mile-wide flood plain may be inundated for as long as a month because of one flooding event.

Severe flooding has also occurred at the confluence of the Monongahela and Allegheny Rivers at Pittsburgh, Pennsylvania in the Ohio River Basin. Although there are two reservoirs on the Monongahela upstream from the confluence, only 22 percent of the flow is regulated presently. More reservoirs are planned.

Surface-Water Quality

Surface-water quality along most of the proposed route is generally good for most uses. Suspended sediment increases during peak flow periods (usually during spring runoff) but decreases with decreased flow. Other characteristics, such as dissolved oxygen and dissolved solids, are usually at their lowest levels during peak flow; they increase inversely as the flow decreases. Waters encountered along the route are, for the most part, soft to moderately hard.

The easternmost portion of the proposed route (i.e., along the Wabash and Ohio Rivers) appears to exhibit the greatest pollution problems, with increased discharge to the waters of industrial, agricultural and municipal wastes. Thermal pollution occurs from generating plants located along these streams. Acid-mine drainage also lowers the quality of the water, especially in Ohio, West Virginia, and Pennsylvania. The Walla Walla basin in Washington also has pollution problems, apparently resulting from discharge of incompletely treated industrial wastes combined with streamflow diversions. Coliform levels are particularly high here.

Ground Water

Aquifers are primarily of two types, surficial and bedrock. The surficial aquifers encountered along the proposed route are mostly of alluvial origin, although glacial and, to a lesser extent (along the western leg), volcanic aquifers are crossed. Alluvial aquifers are generally the most permeable, and the most susceptible to recharge and discharge and therefore the most accessible to development. Bedrock aquifers composed mainly of limestone, dolomite and sandstone are found in the Central Lowlands region. Basalt, occurring along the West Coast leg of the proposed route also acts as an aquifer, the water constrained to spaces between layers and to fractures.

Recharge of aquifers in most cases occurs by percolation and infiltration of precipitation; in the northernmost regions recharge can also occur by seepage from lakes and streams. Discharge of ground water occurs as springs, streams, aufeis (in the continuous permafrost zone of Alaska and Canada) and, where the aquifer is shallow, as evapotranspiration through vegetation.

Withdrawal for domestic, municipal and farming (irrigation) uses generally increases south and east along the proposed route. Exploration and development is minimal in Alaska and Canada; in southern Alberta, for example, withdrawal is estimated at 1.4 percent of the potential yield. Greatest use apparently is occurring in the northern Central Valley of California, near Antioch, where withdrawal for irrigation is creating subsidence problems (see "Geologic Hazards").

Quality of the ground water varies greatly. Prime constituents all along the proposed route are calcium-bicarbonate and sodium-bicarbonate with some sulfate and magnesium also occurring. The aquifers along the route in eastern Ohio are likely to be contaminated by acid seepage from coal-bearing formations above. Brine and acid drainage are also encountered in the oil and gas fields and coal mine areas of western Pennsylvania. Acidic waters are especially prevalent in the Monongahela headwaters. Potability varies greatly as well. Generally, the best quality ground water appears to occur in glacial or outwash surficial aquifers, especially along the Northern Border segment.

2.OV.6 Vegetation

The proposed project will traverse plant and animal communities that occupy about half of the geographical extent of the North American continent. Since there is a most diverse array of associations among plants and animals, the Overview volume describes these associations in their largest ecological unit, the biome. The biome is a large, easily recognizable ecosystem resulting from the interaction of regional climate with regional biota (living things-both plants and animals) and substrate. This and the following sections identify the most characteristic plant and animal communities found in each of the major biomes crossed by the proposed route: tundra, northern coniferous forest, moist temperate coniferous forest, temperate grassland, eastern broadleaf forest, desert, and chaparral (see Figure 2.OV.6-1). The moist temperate coniferous forest would be crossed only by two proposed alternative routes. Section 2.OV.7&8 also identifies sensitive or endangered animal species that may be affected by construction of the proposed gas pipeline. More detailed discussion of vegetation, fish and animal wildlife can be found in Chapter 2 of each geographic volume.

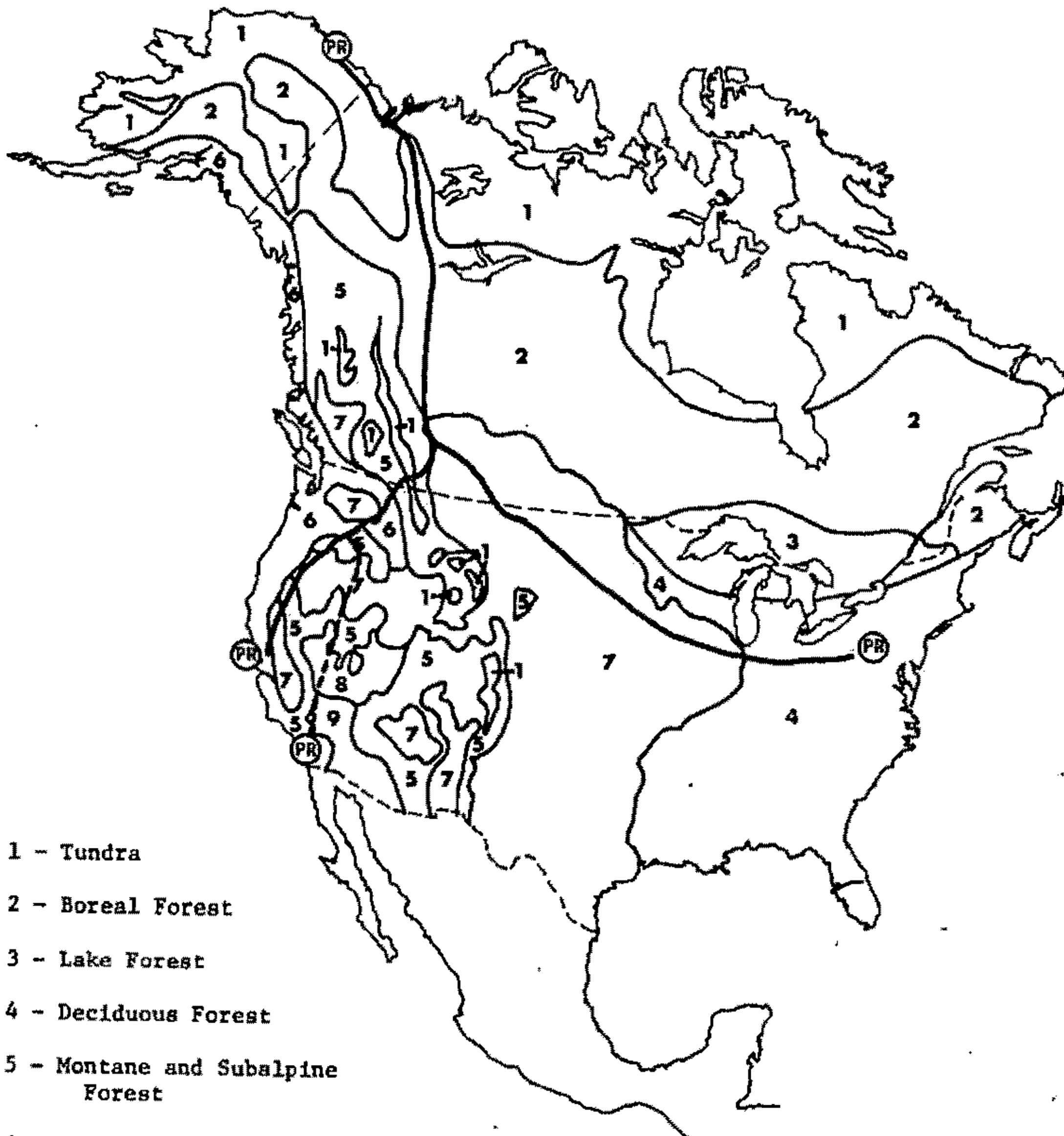
Although the existence of ecotones, which are transition zones between biomes and which possess attributes of adjacent biomes, are recognized, ecotonal or altitudinal variations are not discussed because of their complexity. The following discussion is limited to the seven major biomes encountered along the routes of the proposed pipeline project.

Tundra

The tundra is essentially a wet Arctic grassland consisting of grasses, sedges, and other herbaceous plants and a variety of dwarf shrubs. Tundra is usually underlain by permafrost and predominates on the Arctic Coastal Plain of Alaska and Canada, with discontinuous extensions to the south, particularly at higher elevations (alpine tundra). Alpine tundra is underlain by impervious bedrock at shallow depths; this bedrock is similar in function to the permafrost of the Arctic. The permafrost is overlain by frozen tundra soils that when thawed maintain the small amount of moisture near the surface. Low temperatures, short growing seasons, limited nutrient cycling, and the lack of well-developed soil are the principal limiting factors to plant growth (primary production). The pipeline will traverse a total of 821 miles of tundra in Alaska and Canada.

The joint Federal-State Land Use Commission for Alaska (1974) has identified three broad plant communities on the Arctic Slope within the pipeline corridor. These include the wet tundra, moist tundra, and high brush (see Alaska volume, Section 2.1.1.6 for a more comprehensive discussion of tundra). Wet tundra occurs in areas of standing water and little topographic relief. However, microrelief results from frost polygons and peat ridges. Dominant plants are sedges and cottongrass, which tend to form a uniform mat which a few herbaceous and woody plants occupying sites above the water table. Moist tundra on the other hand may vary from continuous and uniformly developed cottongrass tussocks with a sparse growth of other sedges and dwarf shrubs to areas where tussocks are scarce or lacking and dwarf shrubs predominate. The moist tundra is often associated with polygonal patterns formed by icewedges and occupies south-facing slopes and low moraines with well-drained loamy soils. The high brush community, not truly tundra, is characterized by deciduous shrubs interspersed with barren rocks and rubble and mats of low shrubs and herbaceous plants. This community occupies riparian sites and sheltered valleys where wind ablation is minimal.

The vegetation on the Arctic Coastal Plain and the Arctic Slope is extremely important in terms of its insulative value. In its undisturbed state it plays a prime role in maintaining the thermal balance in the ice-rich soils. Once this balance is disturbed it requires a great amount of time to achieve a new equilibrium.



Source: Modified from Weaver, John E., and Clements, Frederic E., Plant Ecology, 1938.

Figure 2.OV.6-1 Natural vegetation

South of 60°N the proposed route begins to enter less sensitive country. Permafrost problems are behind. The pipeline would be buried and the route revegetated quickly.

Northern Coniferous Forest

This biome stretches northwestward across Canada and Alaska as a broad belt; made even broader by the ecotones on either side, the subarctic forest and the aspen parkland. Along the prime route, this vegetative formation dominates from the central Mackenzie Valley south to southern Alberta. It is also found in the lower 48 States at the northernmost end of the San Francisco and Los Angeles routes. In Alaska, it extends from the southern foothills of the Brooks Range south to Thompson Pass in the Chugach Mountains. Long fingers of this vegetation extend down the high spines of the western mountains in Canada and the United States. The dominant plants are the conifers, such as spruce, pines and fir. Because of the acid litter on the forest floor, heath plants are common. Paper birch, balsam poplar, and aspen are the most common deciduous trees. The lichen *Cladonia* spp. still tends to be dominant on the forest floor. Twinflower, starflower, and dwarf cornel are common herbaceous plants. Bog and muskeg vegetation which can be found almost anywhere in this forest type includes many of the same genera of plants found on the tundra. The pipeline will traverse 1212 miles of boreal forest in Canada and 413 miles of montane forest in the contiguous United States.

Moist Temperate Coniferous Forest

The coniferous forest of the western coastal fringe of North America is quite distinct from the preceding biome. It is quite moist, deriving its moisture from high rainfall, coastal fog and persistent cloud cover. The seasonal temperature range is quite narrow. This vegetative formation is found along the coastal fringe of southeastern Alaska and would be encountered around Point Gravina and Haines in two of the proposed alternative routes.

The sitka spruce and western hemlock are characteristic species of the forest canopy. Along streams the black cottonwood is dominant. Mosses cover the forest floor, along with downed timber and tree limbs. Sitka alder, devils club, bluejoint, and ferns dominate the unforested hillside openings. Blueberries, copperbrush, Labrador tea, and salmonberry fill the open spaces on the forest floor. Skunk cabbage, one-flowered wintergreen, fireweed, and ferns also abound.

Temperate Grassland

The temperate grasslands occur from southern Alberta through the Great Plains east to central Ohio and at scattered locations west of the Rocky Mountains. Typically, rainfall that supports grassland ranges between 10 and 36 inches. On the Plains average annual precipitation increases from the Rocky Mountains to the east. West of the Rockies, grasslands occur primarily on plateaus, where precipitation is determined by the various mountain ranges that rise between the Pacific coast and the Rocky Mountains. The pipeline will traverse 1,187 miles of the temperate grasslands in Canada and the United States.

Prairies in the U.S. are classified into one of three types based on the height of the component grasses. The short grass prairie is located on the higher and drier sites immediately to the east of the Rocky Mountains.

This grades into the mid-grass prairie as elevation decreases and rainfall increases. Historically, the mixed grass prairie graded into the tall grass prairie at the eastern extension of the prairie provinces, where rainfall was greatest. West of the Rocky Mountains the grasslands are of the mixed grass type, and may be extensive in Washington and Oregon. Mixed grass prairie includes both the short grass and mid-grass prairie.

Much of the original prairie has been converted to agricultural uses, including the production of non-native pasture and range, as well as both irrigated and nonirrigated crops. Of the prairie that remains, the vast majority is utilized as rangeland. Due to overgrazing, successional plants dominate the rangelands, and there is little climax prairie still in existence. Climax prairie is largely confined to roadsides and conservation areas. This is especially true of tall grass prairie.

The short-grass prairie extends from the Rocky Mountains through central and eastern Montana on the high plains to about 75 miles west of the North Dakota border. The short-grass prairie is dominated by western wheatgrass, blue grama, and green needlegrass. This prairie grades into the mid-grass prairie, which is dominated by western wheatgrass and green needlegrass and eventually acquires a distinctive bluestem component in the eastern Dakotas. Taken together, the short and mid-grass prairie constitute the mixed grass prairie. Buffalograss usually dominates overgrazed range anywhere within the mixed grass prairie. Needle and thread may also become codominant on favorable sites. Shrubs that are common to the prairie include fringed silver, and big sagebrush, especially on north-facing slopes with soapweed (yucca) and cacti common in drier areas.

Trees in the mixed grass prairie are restricted to riparian areas. Species which may dominate the riparian communities include the plains cottonwood, green ash, and slippery elm. There are also forests in southwestern North Dakota. These are an extension of Rocky Mountain forests and are restricted to the Black Hills and Little Missouri Badlands. Dominant species in these communities include ponderosa pine, often in open parks, lumber pine, and columnar cedar (Rocky Mountain juniper). The unusual growth form of the latter tree, as indicated by its name, is thought to result from the effect of underground burning coal seams.

An important community in glaciated areas of the plains occupies the potholes. Wet meadow zones are dominated by relatively short, fine-stemmed grasses such as fowl bluegrass, northern reedgrass, wild barley, and salt grass. Deepmarsh zones are dominated by coarser and taller plants such as cattails, river bulrush, hardstem bulrush, and alkali bulrush. In shallow marsh zones species of intermediate height predominate. These communities may include tall mannagrass, giant burreed, slough sedge, whitetop, and slough grass (Leitch undated). The potholes vary in salinity and are dominated by species that range in tolerance to salinity from species such as giant burreed and broadleaf plantain in freshwater, hardstem bulrush and sago pondweed in intermediately brackish waters, to alkali grass, alkali bulrush, and widgeon grass, which dominate saline sites.

Tall grass prairie extended from the eastern Dakotas to north-central Iowa. Dominant grasses include big and little bluestem, switch grass and Indian rice grass. From northeastern Iowa and Illinois through southern Illinois and Indiana, the tall grass prairie forms a mosaic with the oak-hickory forests. This mosaic is characterized by open savanna in forested areas. These gradually become more closed from west to east, finally grading into the oak-hickory forests in Indiana. There are few remnants of tall grass prairie and oak savanna remaining.

Dominant trees of the flood plain forests are similar to those of the mixed grass prairie. However, in the tall grass prairie region, there is a much greater diversity of associated species. The associates increase in importance from west to east. Gradually, these grade into the floodplain hardwood forests of the east.

Eastern Broadleaf Forests

The eastern broadleaf forest dominates the Appalachian Plateau. This forest is propagated by a moderate continental climate with plentiful precipitation and a distinct seasonal cycle. There are 252 miles of eastern broadleaf forest along the pipeline right-of-way.

There are numerous climax forest types within the eastern broadleaf biome. Upland forests comprise similar species but differ in dominance, primarily as a result of microclimatic influence, but also as a result of soils and their drainage characteristics. Ultimately, slope and exposure seem to determine the type of climax that will result.

Overall, the mixed oak association is most common. These are also highly variable, but the white oak-red oak-hickory is most widespread, with white oak predominating in moister sites. Drier sites tend to support scarlet oak, black oak, chestnut oak and scrub oak; the climax tends to be dominated by chestnut oak (Soc. of Am. For., 1967). Mixed mesophytic forests, which comprise a number of codominant species with a distinct maple component, occupy coves and sheltered areas. The flood plains of major drainages generally support the Central Flood Plain Forest, which is dominated by silver maple and American elm, although the latter has declined of late due to Dutch elm disease. Swamps in Indiana and Ohio are wooded with the black ash- American elm-red maple association, while bogs usually support a variety of ericaceous shrubs, such as cranberry, blueberry, and huckleberry among others.

Desert Shrub

The salt-desert shrub vegetation along the route is located primarily in the valleys (basins) of Nevada. Generally, four subunits are recognized (Nevada Vegetation Type Map, undated):

Saline-alkali bottomland, dominated by black greasewood, rubber rabbitbrush, four-wing saltbrush, horsebrush, and buffaloberry

Shadscale-bud sagebrush-black sagebrush association, dominated by shadscale, bud sagebrush, Nevada ephedra, white burrobrush, and black sagebrush

Mixed-desert shrub association, a mixture of all the previous shrubs, winterfat, and spiny hopsage

Winterfat, occurring as nearly pure stands.

Distribution of these subtypes is probably dependent on local edaphic factors. Though shrubs are the dominant plants in the salt desert shrub vegetation type, there are a variety of forbs and grasses present.

There is also a distinct sagebrush-scrub community in southern Oregon. Typical vegetation includes sagebrush, rabbitbrush, and sparse scattered grasses, with a distinct juniper component. Once native bunch grasses occurred, but these have been replaced with exotic annuals. The loss is attributable to overgrazing. There is no salt desert shrub on the route as presently proposed. However, in southern Oregon 72 miles of sagebrush shrub will be crossed.

Desert vegetation, which is very sensitive to disturbance, has a highly characteristic spaced distribution. What appears to be bare ground between the scattered plants may not be truly bare. Highly specialized mosses, algae and lichens often occupy this open space, stabilizing the crust and providing nitrogen fixing capability. During seasonal or sporadic periods of relatively higher moisture, annual plants often appear in profusion. The desert vegetation, like the Arctic vegetation, takes decades to centuries to restore once it is disturbed. The disturbance of the crust leaves the area open to accelerated wind erosion.

Chaparral

The chaparral is primarily a transition zone between the upland forests and the grasslands. As currently proposed, 25 miles of the right-of-way traverses this association in northern California. The chaparral is a dry woodland that is highly susceptible to fire. This is in keeping with the high degree of probability that this vegetation is a fire-maintained disclimax. Typical trees are digger pine, bigcone pine, a variety of live oaks, blue oak, valley oak, and California laurel. A number of shrubs, such as California buckthorn, buckbrush, mountain mahogany, and poison oak, make up the understory. Chaparral also occurs in southern California, where different species are typical. The southern California chaparral would be encountered if ITAA were to extend their line to Cajon.

2.OV.7&8 Wildlife and Ecology

Mammals

Typically, grazers on the tundra are of a low species diversity, but populations may be high, although often subject to extreme oscillations, e.g., lemmings. Typical resident grazers on the tundra include the musk ox, ptarmigan, tundra vole, and lemmings which are joined during the warmer months by caribou.

Musk oxen, (Ovibos moschatus), apparently were exterminated about 100 years ago in northern Alaska. In March and April, 1969, 52 musk oxen were released at Barter Island and in June 1970, 13 others were released in the upper Kavik River drainage at approximately 20 to 25 miles (32.2 to 40.2 km) south of the proposed ANGTS right-of-way. Numerous sightings of musk oxen have been made near the proposed route by the U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, and by the Applicant. Because these groups seem to be maintaining their integrity and their reproduction has been successful, the Alaska Department of Fish and Game considers the transplant a success.

The Porcupine Caribou herd, fourth largest on the North American Continent and second largest in Alaska (Alaska Volume, Table 2.1.1.7-1), is international, ranging over a 120,000-square-mile area in northeastern Alaska, Yukon Territory and Northwest Territories, Canada. The annual 1300-1500 air mile movement of 100,000-140,000 animals in the Porcupine Caribou herd, treking along their ancestral paths, is one of the world's most impressive biological phenomena. In response to changing environmental pressures, the caribou herd is continually moving throughout the year and may visit some areas annually, while utilizing others perhaps once in a decade. The herd passes along or in the vicinity of the route at various points at least twice annually in major migrations as well as during summer movements in the northern portion of their range. During June a large portion of the Porcupine Caribou Herd calves on the North Slope in northeastern Alaska in the region traversed by the route. As calving reaches completion, those animals which have calved in the Yukon continue to enter Alaska (at least during 1971 and 1972) and form vast post-calving aggregations in the area of the route.

There is additional caribou habitat along the Richards Island supply line in Canada. Some of the area along the supply line is on the periphery of the seasonal range of the Bluenose caribou herd. Woodland caribou herds range throughout the Mackenzie River Basin and the Mackenzie Mountains. However, the herds are rather sparsely distributed along the pipeline corridor.

Moose are sparsely distributed along the Arctic Coastal Plain where they are at the northern extension of their range. Moose in Alaska and the northern Yukon are restricted to riparian habitat. Moose become more numerous to the south especially in the Mackenzie River Basin. Moose are particularly abundant in the Mackenzie River Valley between the Arctic Red River and Fort Good Hope. Moose continue to be abundant from northern Alberta to Caroline Junction and west of the Porcupine Hills on the Kingsgate Lateral and the West Coast legs in Idaho.

Dall sheep are also common to the Arctic. They are widely distributed throughout the major mountain ranges of Alaska and Canada. However, they do not range into the Arctic Coastal Plain.

The wolf, arctic fox, grizzly bear, and wolverine are prominent predators on the North Slope. The coyote, red fox, and a variety of weasels also inhabit most tundra communities.

Barren-ground grizzly bear (Ursus arctos) historically have been distributed sparsely throughout the Alaskan and Canadian Arctic Coast. The species is an indicator of a wilderness environment (Alaska Planning Group, 1974). The barren-ground grizzly is the most northerly and smallest of grizzly bears and is adapted to the tundra environment. They are more frequently observed near rivers on the Arctic Coastal Plain (Quimby and Snarski, 1974). Denning takes place in November in the mountains inland from the Coastal Plain for the most part. Bears are often sighted in association with caribou herds.

Wolves and wolf signs have been observed in all of the Arctic regions traversed by the pipeline right-of-way, with largest numbers observed in the Yukon. Wolves are most often seen in areas occupied by caribou; observations of predation and close association with caribou have been frequently recorded. To the south especially in the Mackenzie River Valley, wolves are most often associated with riparian habitat where moose and small prey, such as varying (snowshoe) hare, are most numerous. Lemmings and voles are also important prey.

The wolverine is considered scarce along the Arctic Coastal Plain, but more abundant in the Brooks Range and foothills. Although wolverine signs have been seen in all types of terrain, they tend to travel on gentle slopes and along the edges of streams. Ordinarily, wolverines are solitary.

The arctic fox occurs along the Arctic Coastal Plain, where denning areas are located along most of the rivers and their deltas. Red fox may also use dens in the same areas. The abundance of the arctic fox is largely associated with the abundance of lemmings. During the fall and winter, there is a general movement of arctic fox to the sea and sea ice where they follow polar bear and feed on the remains of seal kills. The red fox is relatively scarce on the Arctic Coastal Plain. The red fox is a more generalized predator than the arctic fox and becomes increasingly more abundant to the south.

Lemmings (Lemmus spp. and Disrostonyx sp.) and voles (Microtus miurus, M. occonomus and Clethrionomys rutilus) inhabit the tundra regions while white-footed mice (Peromyscus maniculatus), meadow mice (M. pennsylvanicus), red-backed vole (C. rutilus and C. gapperi), yellow-cheeked vole (M. zanthognathus) and bog lemming (Synaptomys borealis) occur in areas along the Mackenzie River. All are utilized by carnivorous fur bearers (and raptorial birds) and in some cases, particularly in the case of arctic fox, are a primary food source. Microtine populations are also useful indicators of productivity and changes in productivity of habitats.

There is a gradual change in wildlife species to the south of the coniferous (boreal) forest zone. The habitat changes due to the predominance of grassland, with forests restricted to riparian situations and uplands.

Deer become increasingly important large ungulates to the south. Mule deer are usually found in more remote areas, while the distribution of white-tailed deer generally coincides with more settled areas. Both are browsers, but will utilize grasses at certain times of the year. In winter, deer tend to be restricted to small areas of winter range where suitable combinations of shallow snow, adequate cover, and food sources exist.

Mule deer is the common species west of the Rocky Mountains. Mule deer also occur on the plains where ranges of hills or river valleys provide suitable habitat. Winter range extends along streams considerably east into the Dakotas. The east slopes of the Rocky Mountains are excellent mule deer habitat, and winter ranges there often coincide with those of elk.

White-tailed deer are found from the Peace River south, primarily in areas disturbed by cultivation where they have replaced mule deer. Like those of mule deer, winter ranges for white-tailed deer in river valleys are often critical.

Along the eastern branch of the pipeline, white-tailed deer are the major ungulate as there is suitable summer habitat along most of the route. In the eastern United States, white-tailed deer is the only species of ungulate remaining along the pipeline route. In the West, white-tailed deer occur in limited numbers in the northern states.

Pronghorn antelope habitat includes open plains and broken country such as badlands and river breaks. These animals also inhabit the edges of sand hill areas (Rand, 1947). Antelope survival is highly dependent upon restricted wintering grounds to which they migrate. During winters of deep snow and severe storms, entire bands may perish, reducing the populations by as much as 60 percent (Wishart, unpub.). Antelope are predominantly browsers, although in Alberta they utilize forbs and small amounts of grass more so than in the United States (Mitchell and Smaliak, 1971). Several species of sagebrush (Artemisia spp.) are the key food sources. Key antelope winter range occurs along the pipeline route in the Middle Sand Hills and along the Saskatchewan River in Alberta and in the Badlands in the Dakotas. Antelope do not occur east of the mixed grass prairie, but do occur west of the Rocky Mountains where suitable habitats exist, primarily in central and eastern Oregon and in northwestern California.

Elk are predominantly grazing ungulates, which occur in Alberta, and most of the Rocky Mountains. There is excellent elk winter range in the foothills west of the Porcupine Hills in Alberta. Elk also occur in the forested Missouri River breaks in Montana and the Black Hills of South Dakota.

There are a diversity of predators in these areas, but most of the larger ones have a relatively restricted or discontinuous distribution due to various control programs. The cougar occurs in the Rocky Mountains and in most of the more remote areas to the west. To the east, the cougar is restricted to the badlands. Wolves are found throughout the northern section of the pipeline and isolated populations may remain in the Rocky Mountains. Scattered populations of grizzly bear also remain in the Rocky Mountains.

Among the more widely distributed predators are the coyote, black bear, and bobcat. The coyote may be encountered anywhere on the pipeline route. It has largely replaced the wolf as a predator throughout the lower United States, although its original distribution was primarily in the prairie. The coyote is one of the few species to have profited from human activities. The black bear and bobcats are more typically forest species. The black bear may be encountered in forests, but is more common in Canada and west of the Rocky Mountains. To the east, black bear would not be expected to occur on the pipeline route itself. Bobcat is similar in distribution to the black bear, but does range into the prairie.

There is a wide variety of other mammals that occur along the pipeline route. Badger, skunk, red fox, a variety of weasels, and the previously discussed bobcat and coyote, prey on a varied assemblage of cottontailed rabbits, jackrabbits, ground squirrels, gophers, and/or microtine rodents. Most of these smaller mammals are subject to population fluctuations and tend to have a high reproductive capacity to overcome adversity.

Marine Mammals

The Beaufort Sea provides habitat for a number of whales and seals. The polar bear is often labeled as a marine mammal.

The polar bear is a member of a distinct community of animals and birds which live predominantly in sea ice habitats of the polar basin. From September to April or whenever sea ice drifts or new ice forms to connect the coast line, some polar bears move onto shore and travel inland.

In the circumpolar region, there are at least six recognizable populations of polar bears. Each of these populations is associated with one or more core denning areas except the so-called Alaska-north group (Beaufort Sea). It is felt that a part of the Beaufort Sea population dens on various types of sea ice. The area of denning extends inland from the coast as much as 25 miles according to Lentfer. In nearshore areas, the role maternal denning plays in maintaining total population numbers is being evaluated by the U.S. Fish and Wildlife service. A significant number of polar bears come ashore in late October and November to prepare maternity dens, usually in snowdrifts, to give birth in December.

The ringed and bearded seals are circumpolar in distribution and both are associated with the edge of the icepack in summer. The ringed seal is the most abundant mammal in the Arctic Ocean and adjacent seas. Both seals are listed as abundant year around by personnel of the Arctic National Wildlife Range.

The harbor (spotted) seal has a wide distribution in the North Pacific and North Atlantic. These seals are migratory and in summer move into the bays, estuaries, and mouths of rivers along the Beaufort Sea Coast, often ascending rivers to feed on spawning fish. The harbor seal is described as seasonally abundant.

Both Pacific walrus (Odobenus rosmarus) and Steller sea lion (Eumetopias jubatal) are considered rare in the project area. A single sighting of the Stellar sea lion is recorded on Herschel Island in Canada just to the east of the Alaska-Yukon Territory boundary. One walrus is reported in the annual subsistence harvest of the residents of Kaktovik.

The bowhead whale spends the summer in the Arctic Ocean and retreats to the Bering Sea and the North Atlantic during the winter months. It is almost always found in association with drifting ice. Many bowhead whales summer in the eastern Beaufort Sea along the edge of the polar pack ice and are commonly away from shore areas. The bowhead whale is described as seasonally abundant.

The beluga whale is considered a seasonally common whale in the Beaufort Sea. Like the bowhead whales, belugas are closely associated with sea ice. Little is known about the beluga whale in the eastern part of the Beaufort Sea along the Alaskan Coast. Calving of a large herd, however, takes place in June at the mouth of the Mackenzie River Canada.

Similarly, there is little known about the distribution of the narwhale in the eastern Beaufort Sea. This whale, however, has a definite affinity for sea ice contact and probably is in the area, though few have been sighted.

The finback, humpback, and grey whales are considered uncommon in the Beaufort Sea, where they may be found in the summer. Summer range for the gray whale is primarily in the eastern and western north Pacific and any in the Beaufort Sea would be casual.

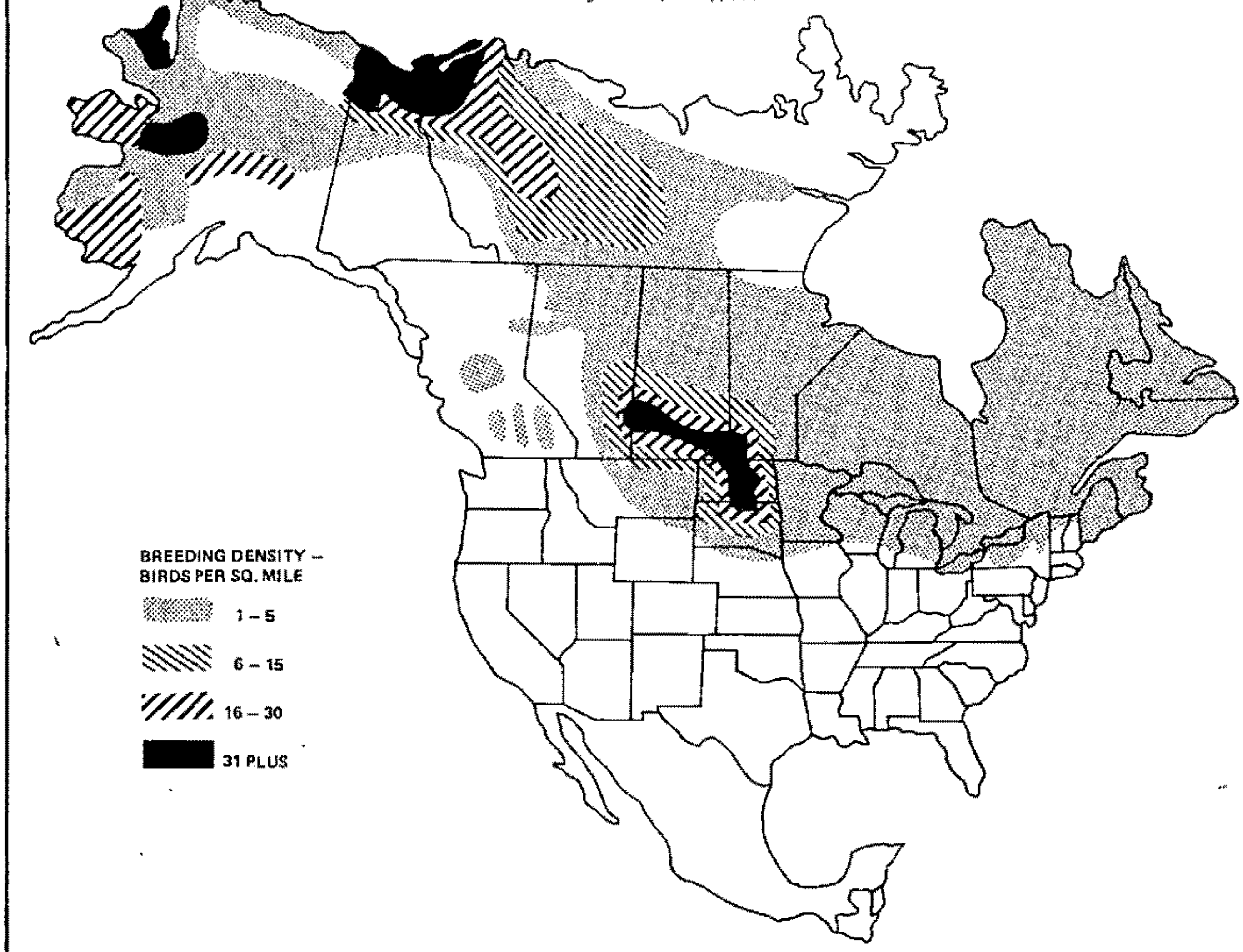
The Pacific killer whale inhabits the Beaufort Sea at least during the ice-free season. Its abundance in the eastern Beaufort Sea off the coast of Alaska and Canada is unknown.

Birds

The Arctic Coastal Plain contains habitat critical to hundreds of thousands of geese, ducks, loons, and shorebirds for nesting and spring and fall migrations. The tundra lakes, from June through August, are major brood-rearing and molting areas for these species. Brant, eider, gulls, and terns nest on spits, lagoons, beaches and islands in June and July. From July through September scoters, olsquaw, eider, and scaup molt there, and brant, ducks, loons, and shorebirds stage and migrate from these waters.

Several hundred thousand snow geese use the Arctic Coastal Plain from Shingle Point in the Yukon territory to the Canning River in Alaska for staging and feeding from mid-August to early October. The Arctic Coastal Plain and the British Mountains also contain several peregrine falcon, gyrfalcon and golden eagle eyries.

The Mackenzie Delta is one of the major waterfowl production areas of North America, and supports an annual breeding waterfowl population of 100,000-350,000 ducks, and more than 20,000 whistling swans (Figure 2.OV.7-1). It supplies waterfowl to all four North American flyways (Jacobson, 1974). The shallow Mackenzie Bay area is an especially critical nesting and molting habitat for whistling swans. Bald eagles nest on the Mackenzie Delta; the Peel Plateau and Richardson Mountains contain active



Source: Adapted from Shaw, S.P., and Crissey, W.F., Wetlands and the Management of Waterfowl, Yearbook of Agriculture, 1955, p. 604-614.

Figure 2.0V.7-1 Distribution of North American waterfowl during the breeding season peregrine falcon and golden eagle eyries. Approximately 139 species of birds from 31 families have been reported in the Delta, according to Jacobson (1974).

The Mackenzie River valley is both a major waterfowl nesting complex and migration corridor. Tens of thousands of ducks, geese, swans, loons, mergansers, shorebirds, and sandhill cranes nest along the alluvial islands and sand bars. Peregrine falcons, golden eagles, bald eagles, and ospreys nest along the Mackenzie River valley.

There are also several major waterfowl production areas in southern Canada and the Dakotas in the U.S. Principal waterfowl species found in the proximity of the proposed pipeline, either as migrants or breeding birds, include blue-winged teal, mallard, shoveller, pintail, gadwall, coot, and Canada goose. Other species are present but in somewhat lesser numbers. The glaciated part of the Mixed Grass Prairie Regicn includes the western part of the prairie pothole region. This area is the backbone of waterfowl production in North America, and it compares favorably with the best on the continent, with parts supporting over 30 ducks per square mile (Figure 2.OV.7-1). Although this pothole region represents only 10 percent of the total waterfowl production area in North America, it produces 50 percent of the duck crop in average years, and more in bumper years.

Very few wetlands are left in the tall grass prairie. Waterfowl migrating through the region benefit from Federal and state refuges, game management areas, the river network, and the few remaining ponds and marshes.

The closed basins of Oregon and the upper Columbia and Snake Rivers are an important resting and feeding area for millions of migratory ducks within the Pacific flyway. The additional irrigation and hydro-electric reservoirs constructed along the Snake River and its tributaries have caused an increase in the already large number of flocks wintering in the area. Devotion of more acres to dry-land and irrigation farming has expanded winter food supplies, especially for geese and some of the shorebirds. As a result, the marshes, low-gradient streams and rivers, natural lakes, and man-made reservoirs and irrigation ditches of these areas are also used commonly by geese, grebes, and some cranes and herons as overwinter habitat. These areas are generally not considered to be good waterfowl rearing areas, but do produce moderate numbers in locally favorable sites.

Fishery Resources

Marine Fish

The three major species of fish observed during surveys in the Beaufort Sea during 1974 were the arctic cisco, arctic char, and four-horn sculpin (Griffiths et al., 1975). Minor species included the least cisco, arctic flounder, and ninespine stickleback. Grayling and inconnu were incidental. Of the major species, the arctic char and arctic cisco are anadromous, while the fourhorn sculpin is a marine species. The arctic flounder is also a marine species. In addition, herring were collected in a survey of the Mackenzie Delta (Mann, 1975) and is probable throughout the Beaufort Sea. The 3 major species and the least cisco were the only species observed in the open sea. All species except the herring were collected during surveys in lagoons (Griffiths et al., 1975).

Freshwater Fish

Aquatic biologists recognize two general fresh-water fishery classifications: (1) cold-water fishery, usually indicated by the presence of salmonids; and (2) warm-water fishery, often dominated by bass, other sunfish, or catfish.

Cold-water streams are characterized by rapidly flowing, well-oxygenated water with a maximum summer temperature of 75°F or less. This applies in general to all streams of the Rocky Mountains and Arctic Coastal Plain, those to the west of the Rockies north of the California Central Valley, those on the Interior Plains in the Mackenzie River Basin, and the headwaters of those in the Appalachians.

The Applicants' have conducted several investigations of fish inhabiting streams and lakes of the Arctic Coastal Plain. Thirteen species of fish were recorded in the area associated with the proposed pipeline system: arctic char, arctic grayling, round whitefish, broad whitefish, lake trout, slimy sculpin, fourhorn sculpin, burbot, arctic cisco, least cisco, ninespined stickleback, arctic flounder, and Chum salmon.

The proposed ANGTS involves streams of three different types as it traverses the Arctic Coastal Plain: mountain streams, tundra streams, and spring streams. All streams probably support at least some fish fauna during the summer months. Smaller tundra streams generally are inhabited only by a few stickleback, sculpin, and occasionally grayling. Only spring streams and certain deep pools in mountain streams are not frozen during the winter. Thus, only these areas, plus a few lakes which do not freeze completely, can support fish populations during the winter months.

Results of the Applicants' fish-sampling program by summer gillnetting and seining in 49 of the larger lakes in the vicinity of the route show that no lakes containing larger resident species, such as lake trout or char, are known to exist in the immediate vicinity of the route. The nearest lake known to support a lake trout population is more than 11 miles south of the proposed route. Most of the lakes are only a few feet deep, and therefore freeze completely each year making them incapable of supporting permanent fish populations.

The Mackenzie River north of the Thunder River lies in the continuous permafrost zone. South of Thunder River to the 60th parallel the river lies in the zone of widespread discontinuous permafrost where mean annual air temperatures are about 8° to 3°C. The Mackenzie River watershed makes up a very rich fishery. Forty-five species of freshwater and anadromous fishes have been reported. Thirty-one species have been found north of the 60th parallel with the arctic grayling and northern pike appearing to have the widest distributions. Arctic char, the smelts, and arctic and least ciscoes are found primarily in the Mackenzie Delta area. Arctic char, ciscoes, and whitefish are abundant from Fort McPherson northward while northern pike are abundant throughout the Mackenzie River system north of 60°. Thirty-six species are reported from the Mackenzie River drainage south of 60° with fourteen of these species not occurring north of 60°. Chief among these are chubs, daces, shiners, and suckers. Among the whitefishes, the mountain and lake whitefish replace the broad and round whitefish of the Arctic.

All rivers on the West Coast legs north of the California Central Valley support coldwater fisheries. Such streams and rivers generally support one or more resident and/or anadromous salmonid species. The primary resident salmonids are cutthroat, rainbow, brook, and brown trout, Dolly Vardon (char), kokanee salmon, and whitefish. Among the anadromous forms are the chinook, coho, sockeye, chum, and pink salmon and steelhead trout. Anadromous fishes other than salmonids include white sturgeon, shad and Pacific lamprey. The salmonids, both anadromous and resident, require clean gravel beds and clear well-oxygenated water for reproduction. Shad, on the other hand, broadcast their eggs, which are consequently less susceptible to siltation than salmonid eggs, which are normally buried in the gravel. The principal streams supporting anadromous fisheries include the Snake, Umatilla, and Walla Walla Rivers.

Cold water streams of the Appalachian Plateau originally supported only brook trout and sculpins. Presently, introduced brown and rainbow trout populations are maintained, primarily through stocking programs.

Warm-water streams are characterized by low-gradient, meandering channels and slowly flowing waters. The stream bottom usually consists of sand or mud, but gravel bars are not uncommon. Average temperatures range above 75°F degrees during the summer, at which time the dissolved oxygen concentration will be reduced. These streams are common to the California Central Valley, the Interior Plains, and lower elevations of the Basin and Range Province.

Warmwater fishes present along the pipeline route include, among others, smallmouth black bass. Smallmouth bass usually build a nest on sand, gravel, or rocky bottoms but also utilize silt, clay, or other soft bottom material where harder material is not available. This species and others would probably suffer from pipeline construction, especially if construction at river crossings were to coincide with spawning periods. Most fish, however, found in the affected warmwaters are highly prolific and relatively tolerant to disturbance. In general, warmwater fish species are relatively tolerant of many disturbances. Typical game species include largemouth bass, bluegill, crappies, channel catfish, walleye, sauger and northern pike.

Excellent sport fisheries for sauger and walleye exist on Oahe Reservoir, and in the Heart and Knife Rivers in North Dakota. The Wapsipinicon River in Iowa, on the study list for designation under the Federal Wild and Scenic River Act, furnishes an excellent warm water fishery in attractive surroundings.

Where the route crosses the Missouri, Mississippi and Ohio Rivers and Oahe Reservoir, commercial fishing is permitted under license and such species as smallmouth buffalo, bigmouth buffalo, suckers, black bullhead and carp are taken.

Many of the warm water fish are nest-builders like the smallmouth bass. Among the more common are the various sunfishes, catfishes, and bullheads. Eggs of carp, pike, buffalo, pickerels, and gars, on the other hand, are simply scattered, while yellow perch eggs are broadcast in scattered ribbon-like masses that tend to become entangled in rooted aquatic vegetation. Eggs in nests are more susceptible to disturbance than scattered free-floating eggs. (See North Border Volume, Section 2.1.3.7, Table 2.1.3.7-1 for further information.)

Endangered Species

There are a total of 13 endangered or threatened species of wildlife that reportedly occur along the proposed route. Table 2.OV.7-1 is a listing of these species, their location, and status. Section 7 of the Endangered Species Act provides for protection of habitat determined to be critical to the continued existence of listed species. Evaluations and delineations of critical habitat are currently being undertaken, but none has been finally

Table 2.0V.7-1 Endangered and threatened species reported along the proposed route

Species	Location	Status
Mammals		
Indiana bat (Myotis sodalis)	Winter in Mifflin & Blair Co. Pa. SE Illinois	E
Northern Rocky Mountain wolf (Canis lupus irremotus)	Montana, Canada	E
Grizzly Bear (Ursus arctos horribilis)	N. Idaho	T
Northern kit fox (Vulpes velox hebes)	S. Canada	E
Wood bison (Bison bison athabascae)	Canada	E
Black-footed ferret (Mustela nigripes)	Canada, U.S. Montana, Dakotas	E
Birds		
Eskimo curlew (Numenius borealis)	Canada	E
American peregrine falcon (Falco) peregrinus anatum)	North America	E
Arctic peregrine falcon (F.p. tundrius)	Canada, Alaska	E
Whooping crane (Grus canadensis)	Canada, Central U.S.	E
Fish		
Tecopa pupfish (Cyprinodon nevadenis calidae)	Inyo, Co., Cal.	E
Owens River pupfish (C. radious)	Inyo, Co. Cal.	E
Scioto madton (Noturus trautmani)	Big Darby Creek,	E

listed to date. Further discussions of such species appear in Sections 2.-7 of the various geographical volumes.

There is currently a listing of endangered plants in preparation. A review listing appeared in the Federal Register of July 1, 1975 for official comment. No final determination on the various species has yet been made. However, delineation of probable critical habitat for these species is in process. The list of endangered species currently being considered contains some 3000 species and subspecies of vascular plants that have been categorized as endangered, threatened, or recently extinct. The listing for California is quite extensive (second only to Hawaii), but species from every state appear on the list. There is no way at present to determine, which, if any, are within the rights-of-way.

Sensitive Populations

The Arctic Slope is a valuable wildlife breeding area. The area flanking the prime route is the calving area of the last essentially untouched great caribou herd, an international herd ranging across Alaska, the Yukon and the Northwest Territories. The prime route would cross a fall staging area for migrating snow geese. A coastal alternative would pass through a major molting area for Arctic waterfowl.

The prime route generally stays well north of critical raptor nesting areas within Alaska. The alternative route around the Arctic National Wildlife Range would pass through areas with relatively large numbers of breeding Arctic peregrine falcons, gyrfalcons and golden eagles. In the Mackenzie Valley north of 60°N there are a number of areas where raptor eyries can be found within a corridor extending 10 miles on either side of the proposed right-of-way. These include the coastal area between the Mackenzie River and the Alaska Border, the Mackenzie River Delta, and the interior mountains. Peregrine falcons of 2 endangered subspecies, gyrfalcons, golden eagles and northern bald eagles occur within suitable habitats.

The proposed North Border Pipeline would cross a number of fee title and easement Waterfowl Production Areas in the pothole region of the Great Plains (principally in South Dakota and Minnesota). Class I, II, and III pothole habitat areas on these and on private lands would be vulnerable to disruption by pipeline construction activities. These areas are valuable to a large variety of waterfowl and other wildlife.

Sensitive populations and/or habitats have been identified along the North Border route. The Indiana bat which ranges along the proposed route in Illinois, Indiana, Ohio, West Virginia and Pennsylvania is an endangered species. One piece of critical habitat for this species is an abandoned mine within 1,000 feet of the proposed route in Illinois. Along Pecumsaugan Creek in the same general area the route would pass an area unique for this locality, containing a community of white pine, arborvitae, a rare grass, Muhlerbergia cuspidata, and the timber rattlesnake. Big Darby Creek, a tributary of the Scioto River in Ohio but not crossed by the proposed route, contains the madtom (catfish), Noturus trautmani, and 4 mollusks being considered for inclusion on the national list of endangered species. The tubercled-blossom pearly mussel of the Ohio River, the pink mucket pearly mussel of the Muskingum River and the Higgins Eye pearly mussel of the Mississippi River occur in areas crossed by the route, and all have been proposed for inclusion on the Federal list of endangered species. Many of the States have their own listings for species endangered with a State, but not endangered nationally.

A relatively large number of desert plants and animals appear on State and Federal endangered species lists because of serious encroachments on their habitats among other reasons. Most of the land over which these pipelines would cross has been heavily impacted by human use since the early nineteenth century.

Arctic fish populations are characterized by a low recruitment rate, slow growth, great age at maturity, and a large percentage of individuals of older age classes. These populations cannot sustain heavy fishing pressure or significant loss in an age-class without serious impact on their reproductive potential.

2.OV.9 Economic Conditions

Along the pipeline route, one finds great differences in economic activities and conditions, especially in comparing the Alaskan and Canadian Arctic with the southern Canadian provinces and the lower 48 States. There is a trend toward economic development and expansion of the wage economy occurring in the Alaskan and Canadian Arctic, especially as a result of mineral exploration and development. In the Canadian provinces and the lower 48 States, major changes in the types and levels of economic activity are not seen.

Regarding employment and income, unemployment, especially among Natives, has been very high along the portions of Northern Alaska, the Yukon Territory, and the Northwest Territories to be crossed by the proposed route. Personal income is low and most Natives engage at least part-time in subsistence hunting and fishing; in the Mackenzie-Northern Yukon study region, estimated annual cash personal income was $2,100 in 1971. Along the Northern Border route, unemployment has been around or above the national average at the eastern and western ends, and below the national average along the remainder of the route; only seven of the seventy-six counties along that route had per capita incomes above the national average of $4,500 in 1972. For the two West Coast legs of the pipeline, unemployment varied from over 9 percent in nine counties to under 4 percent in eight counties in 1969. Most counties in Idaho and Oregon had per capita incomes clearly below the national average, while counties along the route in Southern California were generally above the national average.

In the North Slope Borough of Alaska and in the States and their subdivisions along the pipeline route, there is heavy reliance on the property tax for revenue. The North Slope Borough also taxes oil and gas production, and the State of Alaska will receive large royalties when oil production begins.

<u>Principal Economic Activities</u>

In Alaska, commercial fishing has been important since the late 1800's. The catch is high value salmon and shellfish, making Alaska the most important State in terms of value of fish caught. Fish processing, timber, and tourism are also important. Petroleum exploration, production, and minor refining also take place. Construction is important; however, much of this is the result of the building of the Trans-Alaska Pipeline System (TAPS); constuction may decline after its completion.

In the North Slope Borough, the important economic activities center around subsistence hunting and fishing, the DEW-line, tourist services, and petroleum exploration and development. Subsistence hunting and fishing are important because they permit people to survive and maintain traditional ways of life, while the DEW-line, petroleum industry, and tourism provide wage employment directly or indirectly.

In the Yukon and Northwest Territories economic activities are centered on the utilization of natural resources. Much of the native population continues the traditional way of life, which is centered on subsistence hunting and fishing with trapping and fur trading carried on to provide a limited cash income. Commercial fishing, logging, and mineral exploration and extraction constitute the major economic activities in the Territories. There is also limited farming along the Slave and Liard Rivers and the central and lower Mackenie as far north as Aklavik. Much of the wage economy is based on services.

The provinces of Alberta, British Columbia, and Saskatchewan have agriculturally based economies, which are oriented toward the production of hay, spring wheat, and livestock. Other major economic activities common to the provinces include manufacturing, construction, and commercial services. Forestry is a major economic activity in Alberta and British Columbia. Alberta produces most of Canada's fossil fuels and over 25 percent of her minerals. Commercial fishing is important to the econcmy of British Columbia and is centered on the anadromous salmon fisheries of the Pacific Coast.

The North Border corridor traverses three generalized economic areas--the Western Grazing and Wheat Area, the Corn Belt Area, and the Great Lakes Manufacturing Belt Area. The population density in general increases from west to east. The economic base also changes dramatically.

The Western Grazing and Wheat Area produces spring wheat and range cattle. Hay, flax, oats, barley, rye and sheep are also products of the area. There is coal production in Oliver and Mercer Counties in North Dakota, and some oil in MacKenzie and Williams Counties in North Dakota and Roosevelt County, Montana. Farm related manufacturing and recreation are found in many small towns, which also provide commercial services to neighboring farmers.

In the Corn Belt about 90 percent of the land is planted in crops; principal farm products include corn-fed cattle and hogs, corn and soybeans. Small towns provide services as in the previous area. Eastern Iowa and western Illinois have heavily industrialized zones which produce many types of farm machinery and have a wide range of other heavy and light industries.

The Great Lakes Manufacturing Belt is a highly urbanized industrialized zone containing 24 Standard Metropolitan Statistical Areas (SMSA) between eastern Illinois and western Ohio. It also contains some of the most productive agricultural land in the world. Farm products include corn, soybeans, and wheat. Manufactured products include processed foods, steel and many others. This area has a much more intense concentration of heavy and light industry than the eastern Corn Belt. In eastern Ohio, western Pennsylvania, and Brook County, West Virginia, truck farms produce for local markets. Coal mining is also important to this area. Much of the coal is used locally for electrical generation or processed into coke for use in the manufacture of steel.

The important crops along the routes crossed by the two West Coast legs may be summarized by State as follows:

States	Crops
Idaho	hay, wheat and other grains
Washington	wheat and hay
Oregon	wheat, other grains, hay, and potatoes
California	hay, fruits and grains

In addition to the above crops, livestock and lumber are also produced, with dairy products being locally important to the economy of Idaho. Forestry and forest products also provide an industrial base; this is most developed in the northwestern states, but extends into northern California. Other main areas of economic activity that are centered in Los Angeles and San Francisco include manufacturing, government, and trade. The tourist trade is important to the economies of the coastal and mountainous areas.

Employment and Income

Forty-two percent of the work force in Alaska is employed by the government. Unemployment is typically twice the national average; seasonal unemployment rates for Natives sometimes reach 80 percent. The vast majority of Natives, however, rely on subsistence hunting and fishing and do not participate in the wage economy during periods when game and fish are obtainable. Therefore, unemployment figures may be misleading. This holds true for northern Canada as well.

Economic activity increased in Alaska in 1974, but so did the rate of unemployment. The latter reflects an increase in immigration brought about by the Trans-Alaska Pipeline System (TAPS) construction, which has transformed Alaska's economy. At the peak of construction one of every five jobs in Alaska will be directly or indirectly related to TAPS construction. In 1972, the northern work force totaled 26,100; 75 percent of this total were based in Fairbanks. The total work force for the state in 1972 was 158,100 and increased to 162,400 in 1973.

Natives receive limited sums from the Alaska Native Claims Settlement Act (ANCSA), amounting to $181.25 in the first year; many residents, especially Natives, receive Federal transfer payments such as Aid for Dependent Children, Bureau of Indian Affairs programs, food stamps, and Supplemental Security Income Program. As a result of ANCSA, Alaska Natives will receive 40 million acres, including both surface and subsurface rights, and $962.5 million over an 11 year period. These lands and funds are provided to establish large corporate investment structures to compensate Natives, in a group basis, for land rights originally abrogated by the U.S. As a result, the major portion of this money will be banked or invested. Communities also are eligible for or receive aid from other sources, including the Rural Electrification Loan Program, Economic Development Administration, Rural Alaska Community Action Program, and Community Enterprise Development Corporation.

In the northern areas of Alaska and the Yukon and Northwest Territories, important sources of cash income include fur trading and employment at DEW line stations.

In the Northwest Territories and Yukon Territory, unemployment is high and available employment opportunities are concentrated in government services. Petroleum development and exploration activities have provided an increasing number of jobs in recent years. In the Mackenzie and Northern Yukon study region, the work force was 13,239 in 1971. Estimated cash personal income in the study region was $2,100. This included earned income and transfers (welfare, unemployment, housing subsidies, etc.), but not income in kind such as could be earned in the subsistence economy.

No data are presented for the Canadian Provinces of Alberta, Saskatchewan, and British Columbia. Presumably, the economy is relatively stable and subject to many economic factors that are of equal or greater importance than the pipeline.

Along the route of the Northern Border pipeline, unemployment rates varied from above the national average in Montana to about the national average in North Dakota, eastern Ohio and western Pennsylvania, and below the national average along the remainder of the route. Only 7 of 76 counties had per capita income above the national average of $4,500 in 1972, but the 7 counties' populations were so high that the average per capita income of the 76 pipeline counties was equal to the national average. The range in per capita incomes in 1972 was from $3,195 (71 percent of the national average) in South Dakota pipeline counties to $4,897 (109 percent of the national average) in Illinois pipeline counties.

For counties along the proposed West Coast legs, there were wide ranges in unemployment rates based on figures from 1964-69. Unemployment was high (over 9 percent) in Idaho; Columbia County, Washington; Union and Baker Counties, Oregon; and Siskiyou, Shasta, and Tehama Counties, California. It was low (under 4 percent) in Whitman County, Wahington; Gilliam and Sherman Counties, Oregon; and Colusa County, California.

As might be expected, per capita income also ranged widely. In general, average annual per capita income was greater than the national average in California. For example, average per capita income for San Bernardino County was 133 percent of the national average; for Contra Costra County, 127 percent. In Idaho, personal income for Bonner and Boundary Counties was 79 percent of the national average. Similarly, the average income of the Oregon counties ranged between 75 and 85 percent of the national average.

Local Tax Structure and Base

In 1973, Alaska state revenue was $369 million. The principal sources were excise taxes ($84 million), income from investments ($43 million), and Federal receipts ($137 million). The heavy dependence upon income from investments and Federal Receipts is unique among the States. Alaska has been running heavy deficits since the sale of the Prudhoe Bay leases because it has increased government expenditures greatly in anticipation of large scale oil production and the State revenue it will bring. When oil is eventually produced at the estimated rate of 2 million barrels a day, using current royalty and production tax rates Alaska's revenue will be about $150 million per year for each $1 of wellhead value. At $7 per barrel this will total $1.05 billion per year. The proposed budget for fiscal year 1974 was $491 million. Since no oil was flowing, revenues were only $448.5 million, resulting in a deficit of $42.5 million.

The budget for the North Slope Borough for Fiscal year 1973-74 was $5 million and was expected to increase to $9 million for Fiscal Year 1974-75. Principal sources of revenue are taxes on oil and gas, property taxes and State impact funds.

In the Northwest and Yukon Territories, the Canadian Federal government is authorized to tax income and game. Northwest Territories tax revenue for 1971-72 was $16 million, which was only 21 percent of operating revenue; the Canadian Federal Government provided an additional $52 million. Expenditures have grown rapidly from $3 million in 1959-69 to $41 million in 1969-70 and $91 million in 1971-72. No municipal taxes are collected in most small communities.

Along the North Border, San Francisco and Los Angeles routes, a maze of intricate overlapping taxing authorities, including municipalities, townships, counties, states, and school, fire, water, and sewer districts, are found. The major local expenditures are for schools and roads. Heavy reliance is placed upon the property tax as a revenue source for local entities.

Reliance of State and local governments upon the property tax in the States along the Northern Border route is shown in Table 2.OV.9-1. Reliance upon property taxes is also heavy in the counties crossed by the proposed San Francisco and Los Angeles routes, as shown in Table 2.OV.9-2.

2.OV.10 Sociological Conditions

Population

Certain generalizations can be made regarding population density systemwide. Along each route the population increases as the pipeline continues south. There is also a significant increase in population as the route heads east or west from the Rocky Mountains, with the eastern and western terminus having the highest population. Total population along the proposed pipeline route, based on 1970 U.S. census data (1971 data from Canada), is shown in Table 2.OV.10-1.

The peoples of northern Alaska and Canada are termed as Native and non-Native. The term Native applies to inhabitants having 25 percent or more aboriginal lineage. Of the 29 population centers in the general corridor area in Alaska and northern Canada above 60°N, 13 are Native communities within 50 miles of the proposed pipeline. In the Alaskan Arctic coastal region Eskimos are the predominant Natives. Those in the Alaskan interior are primarily Athabascan Indians. Aboriginal populations in northern Canada include Eskimo (Inuit) and 6 Indian groups of the Athabascan linguistic stock. Metis are those people having mixed ancestry.

Alaskan population:

Year	Total	Non-Native
1940	72,524	39,566
1960	226,107	174,546
1970	302,173	236,767

The rapid growth of non-Natives since 1940 is primarily the result of immigration. The non-Native percentage of the Alaskan population has increased from 55 percent in 1940 to 66.5 percent in 1960 and to 83.3 percent in 1970.

Alaskan population is unevenly distributed. More than 50 percent of the 1970 population was concentrated in the Anchorage and Fairbanks metropolitan areas, leaving vast portions of the state sparsely or almost totally unpopulated. The sparsely settled areas are mainly inhabited by the Native peoples. Alaska has a young population with a median age of 20 for non-Natives and 18 for Natives. Though population is expected to increase in Alaska at a greater rate than the rest of the nation, growth in the impact region is slow.

The population of the North Slope Borough in 1970 was estimated at 3,385. Inhabitants of the borough are primarily Eskimo (82.7 percent). Indians, Metis and non-Natives constitute the remaining 17.3 percent. Deadhorse-Prudhoe Bay, Kaktovik and Oliktok are the only permanent

Table 2.OV.9-1 Revenue sources in states along proposed northern border route

State	State & Local Taxes (000,000)	Property Taxes (000,000)	%
Montana	367	185	50
North Dakota	272	112	41
South Dakota	313	168	54
Minnesota	2,252	904	40
Iowa	1,458	659	45
Illinois	6,472	2,662	41
Indiana	2,350	1,163	49
Ohio	4,516	1,944	43
West Virginia	697	145	21
Pennsylvania	6,272	1,731	28

Table 2.0V.9-2 Revenue sources in counties along proposed San Francisco and Los Angeles routes

County	Local Government Revenues (000,000)	Property Taxes (000,000)	%
Boundary, Id.	$ 2.5	1.1	44
Bonner, Id.	3.2	1.9	60
Kootenai, Id.	6.6	2.8	43
Spokane, Wash.	67.3	22.2	33
Columbia, Wash.	1.8	.5	28
Whitman, Wash.	8.4	2.6	31
Walla Walla, Wash.	10.8	4.1	38
Umatilla, Or.	15.2	7.8	51
Crook, Or.	3.1	1.5	48
Deschutes, Or.	9.2	4.2	46
Gilliam, Or.	1.2	0.6	50
Jefferson, Or.	3.6	1.9	53
Klamath, Or.	14.2	6.9	49
Morrow, Or.	2.4	1.3	54
Sherman, Or.	1.2	0.6	50
Wasco, Or.	6.9	3.6	52
Baker, Or.	4.8	2.6	54
Malheur, Or.	7.8	3.7	47
Union, Or.	4.5	2.7	60
Churchill, Nev.	5.2	1.5	29
Esmeralda, Nev.	.25	.12	48
Humboldt, Nev.	2.7	1.0	37
Lander, Nev.	.9	.4	44
Mineral, Nev.	2.1	.45	21
Nye, Nev.	2.2	.9	41
Pershing, Nev.	1.6	.7	44
Yolo, Ca.	32.7	15.9	49
Tehama, Ca.	12.6	5.5	44
Solano, Ca.	62.6	21.3	34
Siskiyou, Ca.	16.9	6.2	37
Shasta, Ca.	41.0	15.7	38
Sacramento, Ca.	277.4	108.1	39
Modoc, Ca.	4.3	1.5	35
Glenn, Ca.	9.9	4.1	41
Contra Costa, Ca.	252.7	124.3	49
Colusa, Ca.	9.7	4.6	47
Inyo, Ca.	8.8	3.6	41
San Bernardino, Ca.	277.7	118.7	43

Table 2.0V.10-1 Total population along proposed route

Kaktovik and Prudhoe Bay-Deadhorse, Alaska	3,385*
Yukon-Northwest Territories, Canada+	23,662
Alberta Province, Canada Route Census Divisions	860,123
East Kootenay District, British Columbia, Canada	39,700
Southwestern Saskatchewan, Canada (20 mile corridor)	9,000
Northern Border Route Counties	4,732,400
San Francisco and Rye Valley Route Counties	1,706,701
Total	7,374,971

*Construction workers in Prudhoe Bay-Deadhorse increase this population figure by several thousand

+Applicant's Study Area only

settlements near the proposed pipeline in Alaska. Deadhorse-Prudhoe Bay, which developed as an oil and gas camp, had a combined population of 212, primarily Caucasian. Since 1970 the work force in Prudhoe Bay has increased the population by several thousand. Kaktovik, which is about 20 miles north of the route, had a population of 123, primarily Eskimo. A more current population analysis (1973) shows an increase to 150 in Kaktovik. Oliktok is a newly established, prodominantly Native village located approximately 40 miles west of Prudhoe Bay. At the present time there are less than 10 residents. Though these are the only permanent settlements, summer hunting and fishing camps are set up throughout the area. Many are used year after year. Also, Natives are tending to migrate to established communities, such as Barrow, in search of wage employment.

In the Northwest Territories (NWT), population has grown from 6,507 in 1911 to 34,805 in 1971. Of this, 23,662 or 68 percent live in the study area, which encompasses approximately 310,000 square miles along the proposed corridor. Seven percent are Inuit (Eskimo); 26 percent are treaty Indians (Indians who have signed agreements with the Canadian governments, thereby gaining certain rights); and 67 percent are non-treaty Indians, Metis (persons of mixed blood) and whites (Gemini, 1974). Eleven of the 26 communities in the NWT study area are Native settlements within 50 miles of the proposed line and 8 of these are within 20 miles. The ratio of Native inhabitants to non-Native is decreasing. Within the study area over half of the population is concentrated in the Slave subregion. This is located in the southern portion of the Northwest Territories and east of the proposed route. Also, a trend towards a more urban society is becoming evident. The 5 largest towns contain 72 percent of the total population of the Northwest Territories study area. The largest, Yellowknife, had a 1971 population of 7,224, while the smallest of the 5, Fort Simpson, had a population of 1,004.

Urbanization in Alberta has been rapid since World War II. Approximately 2/3 of the 1.6 million inhabitants live in large towns and cities, with Edmonton (population 438,152) and Calgary (population 403,319) claiming about half of the Province's total population. Native Indians constitute less than 2 percent (30,000) of the total population. The East Kootenay district, the section of British Columbia where the proposed route is to run, has a population of 39,700. This is the slowest growing region in the province. The section of southwestern Saskatchewan where the proposed route passes is sparsely settled. Approximately 9,000 people live within 10 miles of the right-of-way.

Counties along the North Border route vary greatly in population density. Pennsylvania, Ohio, and Illinois are among the 10 most populated states in the country while Montana, North Dakota and South Dakota are among the 10 least populated states. In 1970 the population of the 76 counties traversed by the proposed route was 4,732,400. Four percent lived in the Western Grazing and Wheat Area, 26 percent in the Corn Belt, and 69 percent in the Great Lakes Manufacturing Belt. Of these counties, all but one showed a decline in the farm population between 1960 and 1970. Also, the population as a whole in most of the counties to be crossed in Montana, the Dakotas, Minnesota and Iowa decreased in comparison with a national increase from 1960 to 1970.

Population along the two proposed West Coast routes has increased from 1960 to 1970. The San Francisco area experienced a large population growth. Low or moderate population growth occurred in the remaining counties to be crossed by the pipeline. Population figures for 1960 and 1970 in the West Coast counties along the proposed route are shown in Table 2.OV.10-2. As along the Northern Border route, the rural farming population has decreased. Most of the area to be crossed has an extremely low population density. The San Francisco and Spokane-Couer d'Alene areas are exceptions.

Table 2.0V.10-2 Population of counties along San Francisco and Rye Valley routes

	1960	1970	Percent Change
Idaho (Boundary, Bonner, Kootenai)	50,952	56,376	+10.6%
Washington (Spokane, Whitman, Columbia, Walla Walla)	356,327	372,002	+4.4%
Oregon (Umatilla, Morrow, Gilliam, Sherman, Wasco, Jefferson, Crook, Deschutes, Klamath, Baker, Union)	197,553	207,294	+4.9%
Northern California (Siskiyou, Shasta, Modoc, Tehana, Glenn, Colusa)	155,286	177,802	+14.5%
San Francisco area (Yolo, Solano, Sacramento, Contra Coasta)	703,102	893,227	+27.0%
Total	1,463,220	1,706,701	+16.6%

Area Population Trends Without Pipeline Construction

The population of Alaska is expected to grow from 302,200 in 1970 to 419,800 in 1980, an increase of 38.9 percent.

In the study area of the Yukon and Northwest Territories, working age population is expected to increase from 13,549 in 1971 to 20,938 in 1981, an increase of 54.5 percent.

In the lower 48 States, projections by economic area are available from the U.S. Bureau of Economic Analysis. Figure 2.OV.10-1 shows the location of each economic area. The areas shown in Table 2.OV.10-3 are those containing pipeline counties; each area is named after the largest Standard Metropolitan Statistical Area (SMSA), or if none, the largest city it contains.

Along the proposed route, high population growth may be expected in the Yukon, the Northwest Territories, Alaska, and the Ft. Wayne, Indiana area between 1970 and 2000. The North will grow because it is a relatively undeveloped frontier and the Ft. Wayne area is currently undergoing urbanization. The Western Grazing and Wheat Area will lose population as farming and grazing continue to become less labor intensive.

Native Subsistence

Residents of the 13 Native communities along the proposed route in Alaska and northern Canada as well as Natives living in predominantly non-native communities, such as Inuvik and Fort Simpson, either depend entirely or partially on subsistence hunting, fishing, trapping and berry picking. Reliance upon caribou meat for food is not as vital as in the past, as every village utilizing caribou has transportation by air, barge or road. However, substantial hunts are carried out at various times of the year by residents of Old Crow, Aklavik, Fort McPherson, Tuktoyaktuk, Inuvik and Arctic Red River. While caribou are the most significant species harvested for meat, most villages rely heavily upon moose when caribou are unavailable. In addition, Aklavik people harvest from 20 to 50 Dall sheep annually and residents of Kaktovik harvest approximately 30 sheep annually. Fish also are of major importance as a food source. Subsistence catches in the Mackenzie Valley were estimated to be about 915,000 pounds in 1972. The people of Kaktovik harvest between 6,000 and 15,500 pounds of fish annually. Data (1971-1973) from Native communities along the proposed route in the Northwest Territories show that 637 of 861 males of working age, or 74 percent, were hunters and trappers (Gourdeau, 1974). Figures were not available for the community of Jean Marie River.

Social values and arts are also often intertwined with the environment. In a report for the Environment Protection Board of Canada, Gourdeau states, "The use of renewable resources in the Mackenzie region is economically most significant to one-sixth of the native population. In social and cultural terms the Land-Man relationship is still very important and constitutes the specific character of the native people."

Government

All the States traversed by the proposed pipeline have bi-cameral legislatures.

Alaska has 11 organized boroughs, 12 home rule cities, 22 first class cities and 107 second class cities as forms of local government. The

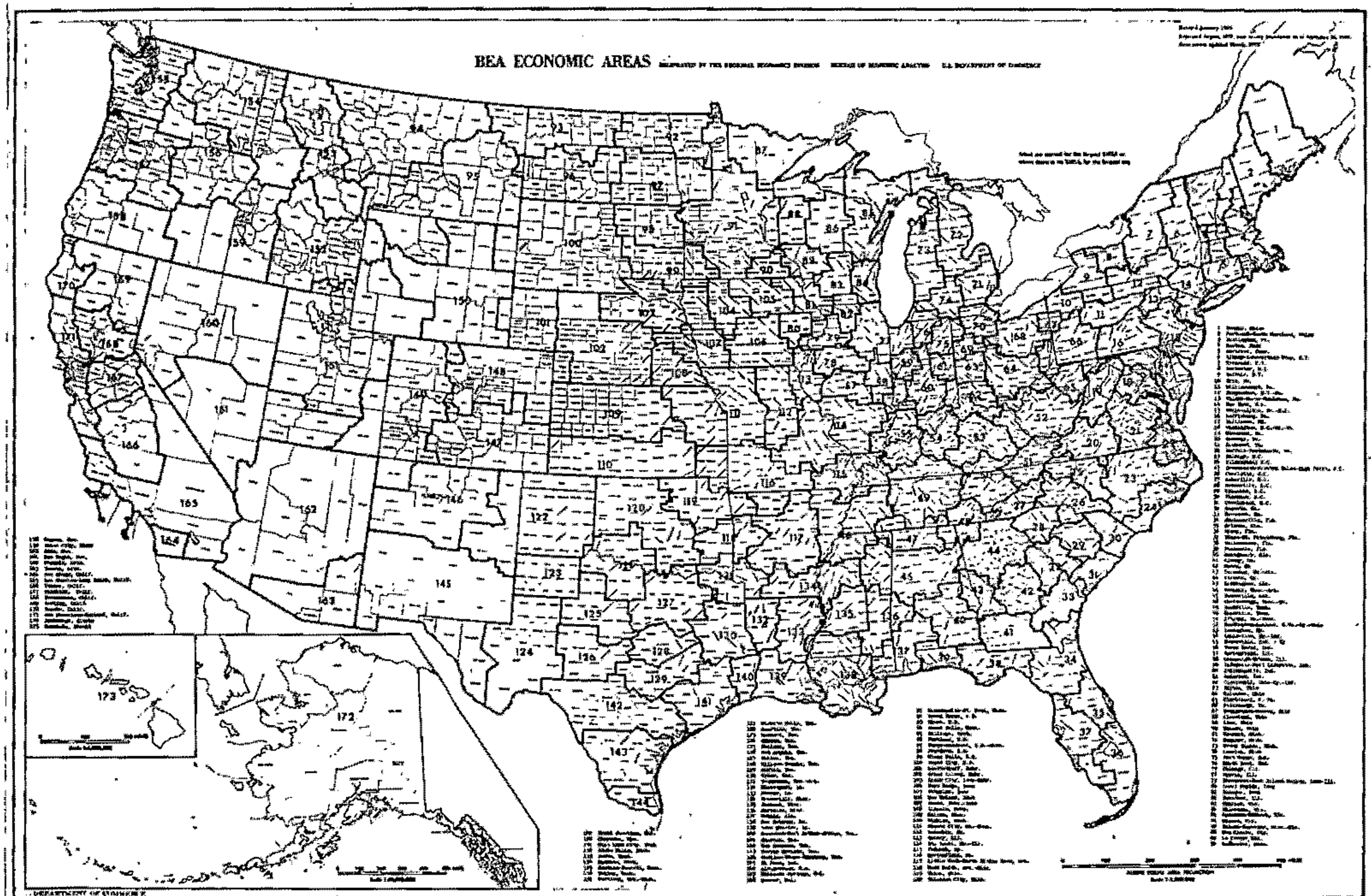


Figure 2.0V.10-1 1972 OBERS projections map

Table 2.0V.10-3 Area population trends by economic area

Economic Area	Code*	Population (1970)	% Change 1970-80	1970-90	1970-2000
Spokane, Wash.	154	687,982	3	3	3
Yakima, Wash.	156	407,607	1	1	3
Portland, Oregon	157	1,644,772	13	26	35
Eugene, Oregon	158	544,011	8	12	11
Redding, Calif.	169	179,165	3	10	14
Sacramento, Calif.	168	1,093,181	10	21	29
San Francisco, Calif.	171	5,102,971	14	30	43
Boise City, Idaho	159	266,946	2	10	15
Reno, Nev.	160	208,468	26	57	84
Las Vegas, Nev.	161	320,283	23	49	70
Los Angeles, Calif.	165	10,452,658	12	25	34
Great Falls, Mont.	094	223,407	-7	-6	-6
Minot, N.D.	093	182,383	-10	-18	-24
Bismarck, N.D.	096	144,938	-7	-7	-12
Aberdeen, S.D.	098	133,151	-11	-15	-19
Sioux Falls, S.D.	099	365,422	1	1	0
Waterloo, Iowa	105	427,118	0	-2	-5
Cedar Rapids, Iowa	080	330,715	7	15	21
Davenport-Rock Island Moline, Ia.-Ill.	079	606,414	4	6	7
Chicago, Ill.	077	8,211,480	10	20	29
Ft. Wayne, Ind.	075	599,095	11	30	44
Lima, Ohio	069	277,084	6	15	22
Cleveland, Ohio	068	4,269,961	7	12	17
Pittsburgh, Pa.	066	3,738,298	1	2	2

*BEA Economic Areas as defined in figure 2.0V.10-1 boroughs are comparable to the counties generally found in the lower 48 States. The North Slope Borough is the largest of Alaska's 11 boroughs. As a first class borough it possesses three basic powers: taxation; education; and planning, platting and zoning. Also, cities within a borough may transfer any of their powers to borough control. Kaktovik, as a second class city, may exercise all municipal powers except those granted to the borough.

The Northwest Territories in Canada has six categories of local government: cities, towns, villages, hamlets, settlements, and unorganized areas. The first four of these have established municipal boundaries.

In the Province of Alberta, local government categories include cities, towns, villages, counties, municipal districts, improvement districts and special areas. There is no typical or model community along the route in Canada.

Education

In Alaska, the average Native more than age 25 has not completed primary school; the average non-Native has completed secondary school. Unlike most other states, in which the major costs of education are borne by the government, in Alaska the primary financial burden is assumed by the State.

In the North Slope Borough, education is provided by the borough, the State, and the U.S. Bureau of Indian Affairs (BIA). The BIA is responsible for providing an education to all children having 1/4 or more Native lineage. Although all three entities are responsible for both elementary and secondary education, only elementary schools are currently provided within the region. The borough furnishes education in Point Hope, Point Lay and Anaktuvuk Pass. The BIA provides primary education in Barrow and Kaktovik. Secondary education is generally provided at large boarding schools in Oregon and Oklahoma. The use of BIA schools is slowly shifting in favor of a more local education system being set up by the boroughs.

Only 2 of the 26 Northwest Territory communities in the pipeline area in 1972-73 did not have at least some schooling facilities. They are supported by government funds and supplemented by local tax levies in the larger communities. In a 1973 survey 83 percent of the Natives in the Northwest Territories did not continue beyond the 8th grade as compared to 30 percent of the non-Natives. People with high skill levels have generally been drawn to the larger communities. Educational enrollment, however, is increasing. As is true in Alaska, many students outside major centers in the Territories must spend long periods away from home to receive education beyond the elementary level. The situation in southern Canada is similar to that of the contiguous United States. The provinces provide primary and secondary education. Most students in northern Canada who wish to continue their education beyond the secondary level must attend schools in southern Canada. Institutes of technological and vocational training and universities are located throughout Alberta.

Along the proposed North Border and two West Coast lines in the United States, educational facilities are related to the population and income of each community. The average level of education of the people along these routes is similar to the national average of 12.1 years of schooling. In the Dakotas, the average level is 9 years of formal schooling. The Idaho average is also slightly less than the national norm. In addition, the portion of population with a college education is somewhat lower in rural areas than urban areas.

Health

In Alaska, Native health services are normally provided by the U.S. Public Health Service/Indian Health Service. Private health services cannot provide adequate service because there is a low ratio of doctors to patients (97 doctors per 100,000 population) and because the immense size of the State limits access to health services. The U.S. Department of Health, Education, and Welfare has a "Health Services Development Project" in Alaska and the State also provides health services.

In Alaska's North Slope Borough, there are health service units in Barrow, Tanana, and Kotzebue. The U.S. Public Health Service maintains a health aide in Kaktovik, providing elementary medical aid.

In the Northwest Territories, the government normally provides health services. As in Alaska, isolation is again a problem. The level of services in a community depends on the size of its population. They range from a community aid, to a nursing station, to a doctor, to a hospital. In 1973 health care of some type was provided in all but 4 of the 26 communities along the proposed route. Of these, there are only 5 communities with hospitals, and one with a clinic and doctor. Health services in southern Canada are more prevalent. In Alberta a government health plan provides basic services, while private insurance plans provide supplementary services.

In terms of state-wide figures, hospital facilities along the Northern Border route appear to be fairly consistent with the national average of 420 beds per 100,000 civilian inhabitants. Facilities in Indiana and Ohio are below this mean. Less prosperous counties along the route are assumed to have a lower level of facilities. The U.S. national average for health service availability is 160 doctors per 100,000 population. The North Border counties as a whole have health service availability similar to the national average; however, this is distorted by the concentration of doctors in populous urban areas. Rural areas in Montana, North Dakota and South Dakota have low ratios of doctors to population.

Rural areas in Idaho also have a low ratio of doctors to population. In terms of State data, California is well above the national average in health care availability, while Washington and Oregon are near the national average.

Housing

Average housing in the 50 States is 62.9% owner occupied and 53.5% built before 1950. Housing unit conditions vary greatly along the proposed route.

Alaskans, especially Natives, are among the most poorly housed U.S. citizens. Over 50% of the houses in the northern region are in need of extensive repair or replacement. Housing units are small, crowded and substandard, putting them well below the national average. This results in part from the low personal income of many inhabitants and the high cost of construction.

In the study area of the Northwest Territories housing is the major economic problem. Housing is crowded and over half is in fair to poor condition. As in Alaska, the Indians and Eskimos are generally not as well housed as the non-Natives. Rising construction costs aggravate the situation. Only 7 percent of the homes in the Northwest Territories are owner occupied compared to the 1966 national average of 63 percent. Most housing here is government owned and subsidized. Housing availability improves as the route nears urban centers in Alberta. The Native population is low in southern Canada and the majority live on Indian reserves provided by the government.

The number of occupants in each housing unit is close to that of the national average all along the routes in the contiguous United States. Throughout the area of the Northern Border route and in Idaho, Washington and Oregon, housing tends to be older than the national average and more likely to be single-family, owner occupied. However, facilities in North and South Dakota are generally below the national average. As with health facilities, less prosperous counties along the route are assumed to have a lower standard of living. California counties traversed by the pipeline are also above the national average in single family, owner-occupied housing. However, housing is much newer than national averages, with several counties (Sacramento, Contra Costa, Yolo and Shasta) having little more than half the national average percentage of homes built before 1950.

2.OV.11 Land Use

This section contains information on historic land uses, current land use, transportation facilities, transmission facilities, current land use planning efforts, and land use trends.

Most of the land to be crossed in Alaska, the Yukon Territories and the Northwest Territories is presently undeveloped; Natives use some of the land for subsistence hunting and fishing. In the Canadian provinces, the proposed route would cross large areas under intensive cultivation (primarily spring wheat) and areas which are grazed.

The principal land use on the Arctic Coastal Plain is wildlife habitat. The wildlife provide for the subsistence hunting and fishing carried on by the Natives, who also trap for pelts and collect edible plants, primarily berries. Lately, the dominant land use on State land in Alaska and on the Yukon Coastal Plain has been the development of oil and gas fields, such as at Prudhoe Bay and at Richard's Island in Canada. There has been no exploratory drilling in the Arctic National Wildlife Range, which, in addition to wildlife habitat, provides limited recreation use. Sand and gravel are extracted from the bed and delta of the Sagavanirktok River south of Prudhoe Bay. There is no other mining activity on the Arctic Coastal Plain.

There are several potential ecological preserves on the Yukon Coastal Plain, one of which is contiguous with the Arctic National Wildlife Range. These are presently being studied by the Canadian Committee of the International Biological Program.

The northern parts of the Interior Plains provide for similar land use, which includes wildlife habitat, mining, and oil and gas exploration and production. These lands also support subsistence hunting, fishing and trapping. Commercial fishing is centered on Great Bear Lake. All of the above activities are supported in scattered locations and are of local importance. A few of the forests support logging. The Mackenzie River Valley is a natural transportation corridor that is gradually becoming industrialized. There are additional potential ecological preserves near Fort Norman and Fort Simpson.

South of the 60th parallel, the climate becomes more conducive to agriculture. Much of the land in northern Alberta is rolling and forested, with agriculture confined to what were formerly rolling grasslands.

Development of oil and gas fields and mining activities have gained in importance in both Alberta and Saskatchewan. South of the Peace River agriculture becomes dominant, with between 75 and 85 percent of the land devoted to crops and grazing. The principal crop is spring wheat. In southeastern Alberta and southwestern Saskatchewan 35 to 50 percent of the total land area is in crops with the rougher terrain utilized for rangeland.

A number of recreation areas operated by the Canadian Forest Service are located in eastern Alberta. The proposed corridor traverses or passes near 5 of these, as well as three Provincial parks. There is also an Indian reserve near Calgary.

As shown in Table 2.OV.11-1, some 90 percent of the land traversed by the proposed Northern Border route is agricultural. As it enters the United States at a point near Morgan, Montana, the proposed pipeline enters the Great Plains Province. This area once supported extensive gently rolling grasslands, which came into agricultural use in the last years of the 19th century. The production of spring wheat by dry farming methods dominates the agriculture of this region; cattle are grazed where rougher topography and thinner soils are found. Feed grains (including corn), small grains (including barley, oats, and rye), hay, and flax are also raised, along with sugar beets and potatoes.

Most of the land is unirrigated. However, the proposed route would cross two Bureau of Reclamation irrigation projects, the Buford-Trenton Project near the Montana-North Dakota boundary, and the Heart Butte Unit of the Missouri River Basin Program in south central North Dakota. The route would also cross the Federally-owned Oahe Reservoir in North Dakota.

The land crossed by the route in Montana and the Dakotas also includes 121 miles of prairie pothole country, important as habitat for migratory waterfowl and shorebirds. Both the U.S. Fish and Wildlife Service and their State counterparts have acquired scattered wetland areas in the Great Plains area in fee simple or as easements in order to protect habitat for migratory shorebirds and waterfowl.

The proposed route would cross the Fort Peck Indian Reservation in Montana for 84 miles. The Bureau of Land Management, besides managing scattered lands for a total of 19 miles along the proposed route in Montana and North Dakota, is responsible for management of Federal subsurface mineral rights under segments of prairie land for a total of 115 miles along the proposed route. The Little Missouri National Grasslands, managed by the Forest Service, also occurs in scattered tracts in North Dakota. It is possible that Federally managed areas in the North Dakota Badlands could receive increased recreation use in the future.

Coal, oil, and natural gas are extracted in Montana and North Dakota; some sand and gravel extraction also occurs near this part of the Northern Border route.

The proposed route next passes through the Central Lowlands Province, which is one of the outstanding grain-producing regions of the world. This area was settled and converted to agricultural use during the 19th century. Virtually all the land crossed is agricultural, and all but 15 percent of it is cropland; from Indiana through central Ohio, some 90 percent of the land is agricultural. The land is gently rolling to flat--generally flatter east of the Mississippi River. Scattered woodlots are also seen. Corn, soybeans, oats, and other feed grains are the most widely grown crops. Hay and winter wheat are also raised along with beef, cattle and hogs. Some land is in pasture. Near large cities some dairy production is found, and truck and canning crops are grown in the area near the Great Lakes. Moving

Table 2.0V.11-1 Land uses along Northern Border route

Land Use	Miles
Urban (Residential, Industrial, and Commercial)	4
Agriculture (Cultivated and Range)	1,470
Woodland	73
Rights-of-Way (Roads, Railroads, and Utilities)	27
Waterways and Flood Plains	24
Total	1,598*

*Not corrected for elevation.

from west to east, average farm size declines. Urbanization is gradually removing some land from agricultural use in the eastern part of the Central Lowlands Province, especially along the part of the proposed route between Davenport, Iowa and Chicago.

Recreation areas developed around lakes and rivers, along with State parks, are important regional recreation resources in the Central Lowlands area. The proposed route would cross several of these. (See also 2.OV.13 concerning Recreational Resources.) Although the proportion of Federal lands along this portion of the Northern Border route is even smaller than in the Great Plains, the proposed pipeline would cross Federally-owned land at the Mississippi River crossing south of Clinton, Iowa. It would also cross the Salamonie Reservoir in Indiana and the Delaware Reservoir in Ohio; both are U.S. Army Corps of Engineers projects with recreation facilities now operated by the States.

Although oil and gas have been extracted in Illinois, Indiana and Ohio, production is now declining. Coal is still mined in Illinois near the proposed route. Sand and gravel, limestone, dolomite, clay, and shale are mined along the route through the Central Lowlands.

Entering the Appalachian Plateau Province, the proposed route passes from sharply rolling terrain with scattered groves of trees, into a more rugged forested area of ridges and valleys. Nearly half the area is in forest; sale of timber is an important source of income on some farms. Most of the remaining land is farmland, particularly in the valleys, although much farmland along the Ohio River has recently been diverted to industrial uses. Hay and some grain for dairy cattle and other livestock are the major crops; some of the farmland is in pasture. A variety of fruits and vegetables are also grown. The last few miles of the route, which terminates at Delmont, Pennsylvania 20 miles southeast of Pittsburgh, pass through several residential and recreational areas, including two wooded parks of regional importance.

Coal production is important in the Allegheny Plateau Province. Oil and natural gas are also extracted in this area, as are sand, gravel, clay, shale, crushed rock, and building stone.

Twenty-five urban areas of 50,000 people or more are found within a 100-mile corridor along the proposed Northern Border route, most of them east of the Mississippi River. (See Table 2.OV.11-2.) The route would pass just one mile north of Waterloo, Iowa. Many smaller industrial towns also lie near the route as it moves into the eastern United States.

From Alberta the Kingsgate laterals proceed through the Rocky Mountain Province of British Columbia and Idaho. Much of this land is forested and utilized in timber production and as wildlife habitat and watershed. There are three Provincial forests in this area of British Columbia.

Land uses along the entire route proposed for the West Coast leg are approximately 46 percent agricultural (croplands and pasture), 30 percent conservation (rangeland grazing and watershed), and 23 percent forest. Lands in the area of the proposed pipeline were converted to agriculture in the mid-19th century to meet the needs of the mining towns; use of irrigation began in earnest in the 1880's.

The proposed San Francisco route coincides with the route of the proposed Los Angeles leg for the first 206 miles from the Canadian Border to a point just south of the Snake River crossing in Columbia County, Washington except for a reach through the Moyie River Valley. The proposed route enters the United States near Eastport, Idaho and first passes through

Table 2.OV.11-2 Urban areas of 50,000 population or more within 100-mile corridor along Northern Border route

Sioux Falls, South Dakota	72,488
Waterloo, Iowa	75,533
Cedar Rapids, Iowa	110,642
Davenport-Rock Island-Moline, Iowa, Illinois	194,872
Peoria, Illinois	126,963
Bloomington-Normal, Illinois	66,388
Chicago, Illinois	3,336,957
Gary-Hammond-East Chicago, Indian	330,187
South Bend, Indiana	125,580
Lafayette-West Lafayette, Indiana	64,112
Indianapolis, Indiana	744,624
Anderson, Indiana	70,787
Muncie, Indiana	69,080
Fort Wayne, Indiana	177,671
Lima, Ohio	53,734
Dayton, Ohio	243,601
Springfield, Ohio	81,926
Columbus, Ohio	539,677
Mansfield, Ohio	55,047
Canton, Ohio	110,053
Steubenville-Weirton, Ohio, West Virginia	57,902
Wheeling, West Virginia	48,188
Pittsburg, Pennsylvania	520,117
Johnstown, Pennsylvania	42,476
Altoona, Pennsylvania	62,900

Source: United States Census 1970.

the Kaniksu National Forest. The major land use along the first part of the route through Idaho, along the Moyie and Kootenai Rivers, is forestry and watershed. However, mixed forests and croplands are found as the pipeline moves down in a southwesterly direction from the Rocky Mountains into the rolling hills of the Columbia Plateau. Some livestock grazing and dairy production also occur in this part of Idaho.

In Idaho, land ownership along the proposed route is generally private, except for the first 20 miles through the Kanisku National Forest. The proposed route would pass very close to a number of established camping and recreation sites in northern Idaho. The route would pass within 1 mile of the residential outskirts of Sandpoint and Bonner's Ferry, both in Idaho. Reflecting a statewide trend, residential developments are growing rapidly around Idaho's Pend Oreille and Cocolalla Lakes; the proposed route would pass within one-eight to one-half mile of such developments. Mixed agricultural and residential land use dominates the 15 mi. of the corridor east of Spokane.

The proposed route continues in a southwesterly path through the rolling hills of Washington. Dryland farming is the principal land use in this area; crops include wheat, barley, and green peas. As the route approaches the Oregon border, livestock grazing is also evident. In north central Oregon both farming and grazing are found, but grazing accounts for more of the land use as the route heads south, a trend which has intensified in recent years due to decreased annual rainfall. There is very little residential or industrial use along this part of the pipeline. In Washington and north central Oregon, most of the land to be traversed is private. The U.S. Bureau of Land Management manages scattered small parcels, notably several river canyons. The route also crosses 20 miles of the Crooked River National Forest. Fishing and hunting are popular in this region, and heavy recreation use is found above and below the pipeline's proposed crossing of the Snake River in Washington.

The proposed route passes within 3 miles of Bend and Redmond, both in central Oregon; it passes near several recreation areas associated with the lava beds near Bend. The route then passes south through the Deschutes and Winema National Forests in south central Oregon and the Modoc, Shasta and Lassen National Forests in north central California, all within the Cascade, Modoc, and Basin and Range Provinces. The predominant land use along this part of the proposed route is forestry. In the lava country of the Modoc National Forest, livestock grazing and conservation use predominate. Between 5 and 10 percent of the land along the route is irrigated and used to grow potatoes, grain, seed crops, and hay for pasture. Over 50 percent of the land to be crossed along this part of the route is administered by the Federal Government, including the five national forests and some lands managed by the Bureau of Land Management. The rest of the land in this area is in privately owned farms and ranches. The route would pass near a number of established camping and recreation sites in south central Oregon. Intensive recreation use is increasing in the forested areas of northern California; development of recreational or second homes is also increasing in these areas. Heavy recreation use is found above and below the proposed pipeline crossing of the Pit River near Lake Britton in northern California. Hunting and fishing are also very popular along this part of the proposed route.

The proposed route decends into the Central California Valley where the most important land use is agriculture; a variety of truck farm crops, fruits, nuts, and small grains are raised. A substantial amount of livestock grazing is also found, as well as dairy and poultry production near large cities. The agricultural area generally lies to the east of the proposed route; most of the grazing and conservation use is found on the mountain slopes to the west of the proposed line. Most of the land to be crossed is privately owned.

The proposed route generally parallels a string of communities down the Central California Valley, and would run within 1 to 4 miles of several of them. It would pass near a rural/urban section of Burney, California. It would cross industrial/commercial land use areas of Red Bluff, California and then cross an area that is changing from agricultural to industrial/commercial near Willow, California. In Winters, California, the proposed route is adjacent to a residential subdivision, although further subdivision development has slowed. The termination point in Antioch, California is in an industrial/commercial area. Table 2.OV.11-3 lists all communities within 5 miles of the proposed route having populations of 2,500 or more.

Along the entire San Francisco leg of the proposed pipeline, there are nearly 600 dwelling units and about 40 industrial establishments (including existing pipeline compressor stations) within one-eighth mile of the right-of-way centerline. Several communities are located near enough to compressor stations that the inhabitants may react to the noise levels of construction or operation: Eastport, Idaho; Diamond Lake Junction, Oregon; residences south of Bonanza, California; Tionesta, California; Burney, California; and Rawson, California.

The proposed route of the Los Angeles (Rye Valley) leg coincides with the proposed San Francisco route for 206 miles from the Canadian border to a point just south of the Snake River crossing in Columbia County, Washington. Land uses along the route through Idaho and Washington have therefore been discussed above in conjunction with the San Francisco route.

The proposed Los Angeles leg turns south and enters Oregon, passing through rolling croplands to the foothills and western slopes of the Blue Mountains in northeastern Oregon. Some livestock grazing and timber harvesting also occur in this area.

The proposed route crosses small portions of the Umatilla National Forest and the Wallowa-Whitman National Forest and travels 12 miles through the Umatilla Indian Reservation; most of the remaining land crossed in this area is privately owned. Hunting and fishing are popular in northeastern Oregon, and family recreation uses such as camping and hiking are increasing there.

Transportation Facilities

In Alaska, aircraft are heavily used for both local travel and travel to locations distant from the Arctic Coastal Plain. Major private airstrips are located at Prudhoe Bay but their use is being discouraged in favor of a main state-owned airport at Deadhorse. At present there are 16 airports and 4 heliports open to the public, mostly near Prudhoe Bay. Two military-only airports are also in the vicinity. All of these are within 30 miles of the route in Alaska. An additional 6 airfields and 14 helipads are planned. The use of the private airstrips at Prudhoe Bay is being discouraged in favor of a main State-owned airstrip at Deadhorse. Daily commercial service is available at Barrow, located on the seacoast to the west of the area immediately influenced by the proposed gas pipeline.

Approximately 100 miles of local private service roads are found in the Prudhoe Bay area; the rest of the North Slope Borough, which covers a large portion of northeastern Alaska, is virtually roadless. In the Arctic oil and gas fields, snow and ice roads and low-ground-pressure vehicles are

Table 2.0V.11-3 Communities of 2,500 population or more within five miles of the proposed West Coast routes

State / Community	Approximate 1970 Population
Idaho	
Bonner's Ferry	2,800
Sandpoint	4,000
Coeur d'Alene	16,200
Washington	
Spokane	170,000
Opportunity	16,600
Walla Walla	23,600
College Place	4,500
Oregon	
Hermiston	5,000
Redmond	3,700
Bend	13,700
Milton-Freewater	4,100
La Grande	9,600
Baker	9,300
California	
Red Bluff	7,700
Corning	3,600
Orland	2,900
Willows	4,100
Vacaville	21,700
Antioch	32,100*

* 1973 Figure

widely used. In Fall 1974, the 400-mile-long North Slope Haul Road, an all-weather gravel road from the Yukon River to Prudhoe Bay, was completed by Alyeska. When a bridge across the Yukon is completed in 1976, this road will connect Prudhoe Bay with the existing State highway system in southern Alaska.

The Beaufort Sea is navigable about four months each year. At present there are no deepwater ports on the sea, but Prudhoe Bay has port facilities to accommodate barges bringing equipment to the oil and gas fields. River travel in the area is negligible.

Although there is presently no rail service to the Prudhoe Bay area, the Alaska Railroad has considered extending the existing railroad net northward to Prudhoe Bay from Fairbanks. The route would generally follow the Trans-Alaska Pipeline.

The area in Canada to be affected by the proposed pipeline route is served by major air carriers and by bush pilots. In the Northwest Territories, usable airstrips presently exist at Inuvik, Norman Wells, Fort Simpson, and Hay River. There are also airstrips that would be improved for use at Fort Norman, Wrigley, and Fort Good Hope, all in the Northwest Territories (N.W.T.).

Highway access to the proposed route through Canada is presently limited, although about 30 trucking companies operate between Edmonton, Alberta; Fort Simpson, N.W.T.; and Yellowknife, N.W.T. When completed, the Dempster Highway will connect Whitehorse in the Yukon Territory with Inuvik. A portion of the Dempster Highway that would parallel the proposed pipeline in the Mackenzie Delta between Fort McPherson, N.W.T. and Arctic Red River, N.W.T. will soon be open (see Figure 2.OV.11-1). Construction between Arctic Red River and Inuvik is proceeding.

The Dempster Highway is already open between Whitehorse and Dawson, Yukon Territory; construction is proceeding between Dawson and Fort McPherson with the first 290 miles north of Dawson already completed. Any highway access to the portion of the proposed pipeline between the Alaska-Canada border and the Mackenzie Delta would require extensive construction of access roads from the Dempster Highway.

Although planning is proceeding on the proposed Mackenzie Highway, which would parallel the proposed route within a few miles connecting Travaillant Lake Junction, N.W.T., Arctic Red River, and Inuvik with Fort Simpson, N.W.T., to the south; the pipeline development would precede construction of the highway. Access to the pipeline segment from Fort Simpson south to Peace River, Alberta, would be more difficult; extensive access roads would have to be constructed from existing highways east of the route which connect Fort Simpson with Hay River, N.W.T., and Hay River with Peace River. For the pipeline segment between Peace River and Calgary, Alberta, access roads would be needed from the existing Peace River-Edmonton (Alberta) and Edmonton-Calgary highways. The Alaska Highway also crosses the proposed route south of Peace River. In southern Alberta, the Trans-Canada Highway runs east-west near the Monchy Delivery Line. The Kingsgate Delivery Line would be somewhat accessible from highways connecting Calgary with Fort McLeod, Alberta and Fort McLeod with Kingsgate, British Columbia.

Besides using trucks to transport materials, the Applicant would use river barges and railroad transportation. A railroad line presently extends north as far as Hay River, located near the Great Slave Lake in the southwestern part of the Northwest Territories. Waterway transportation is already widely used in Canada and barge service operates during the summer months between Hay River and the Beaufort Sea via a series of rivers and

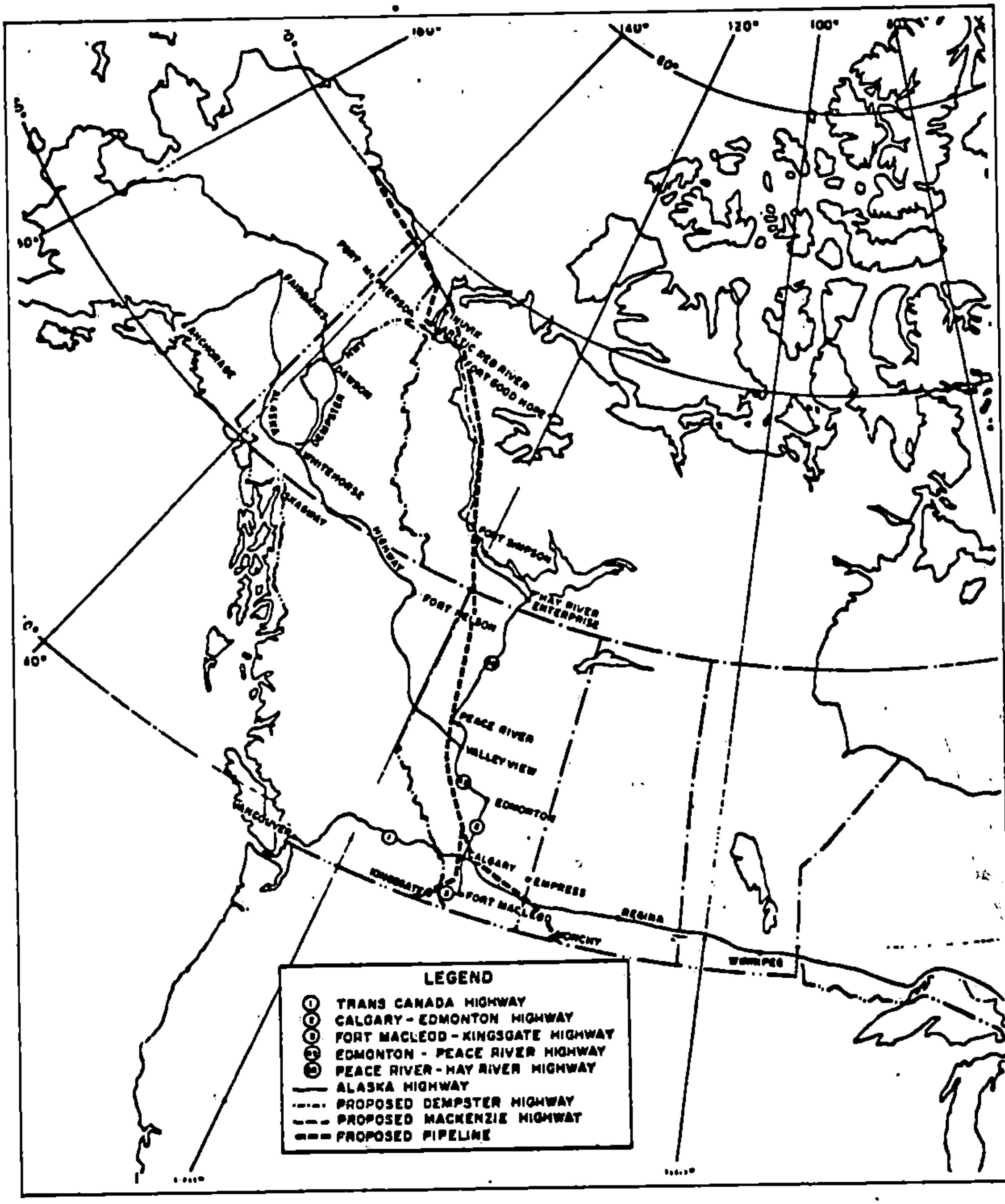


Figure 2.0V.11-1 Western Canada showing locations of existing major highways

lakes. Barges would be used to transport several million tons of pipeline materials, especially to pipeline construction sites north of Fort Simpson, N.W.T.

Commercial air service to major cities and towns along the proposed Northern Border pipeline is adequate. Commuter-type service to the larger rural communities from major cities and between rural communities is regionally available. There are also many local airfields along the route for use by charter or private planes.

The proposed pipeline would cross 99 State highways, 39 U.S. highways, 15 interstate highways, and numerous county roads. The availability of highways and roads, and thus available access to the proposed route, generally increases from west to east. Because existing roads are so infrequent in the less populated areas of Montana and North Dakota, more than 50 percent of the Applicant's temporary roads would be built in these States.

The proposed Northern Border route would cross 12 navigable rivers or streams. There are two crossings of the Missouri River in North Dakota; the rest of the crossings are at the Mississippi River and eastward. All the navigable streams carry recreational boat traffic. Commercial traffic is limited to the following rivers, with their average monthly tonnages shown: Mississippi, 2 million tons; Illinois, 2.5 million tons; Monongahela, 1.7 million tons; and Ohio, 2.5 million tons.

The proposed route crosses 99 railroad lines. Rail access is limited in Montana and in western North and South Dakota. In the mid-State grain producing areas, however, there are numerous railroad lines, many converging in Chicago. An even heavier concentration of trackage is found along the eastern part of the Northern Border route; many emanate from the major population centers of Cincinnati, Columbus, Toledo, Cleveland, and Pittsburgh.

Aircraft facilities are generally available near the proposed West Coast routes. An adequate number of highways or paved roads are found all along the proposed route; the smallest proportion of roads is found in the Southern Cascades area of northern California. The proposed pipeline would parallel U.S. 97 for about 170 miles through central Oregon. It would parallel U.S. 5 and 505 for approximately 115 miles through the Central California Valley. The Moyie River Road, a major artery at the head of the proposed route in northern Idaho, has severe bridge weight limits.

Navigable rivers in the area influenced by the proposed pipeline include the Snake River between Pasco, Washington and Lewiston, Idaho; the Columbia River from Pasco, Washington to the Pacific Ocean; the Walla Walla River in Washington and the Sacramento and San Joaquin Rivers in California. In northern Idaho many lakes, such as Coeur d'Alene Lake and Pend Oreille Lake, and several rivers, such as the Pend Oreille, are used for transporting logs.

The proposed gas pipeline would cross a large number of major railroads all along the route; the route runs parallel to a number of these lines for substantial distances.

Transmission Facilities

There is no electric power service grid in the Alaskan Arctic; presently, all electric power in Kaktovik and the Prudhoe Bay area is produced by local power generators. Similarly, no regional water supply system is available; existing settlements take their water directly from nearby water bodies.

The oil and gas used in the Prudhoe Bay area are locally extracted; a small oil refinery at Prudhoe processes the crude oil for local use.

Radio and radio-telephone are the primary means of communication in the Alaskan Arctic; the communications system is generally oriented toward industry and defense. Private industry is now establishing an extensive radio network, including linkage with satellite facilities, to serve the Prudhoe Bay area.

Various electrical power sources are used in the Canadian provinces. In Alberta, for example, oil, gas, coal, and hydroelectric generators are all used to produce electricity; communities in more mountainous areas in particular use hydroelectric power.

In the permafrost zone of northern Canada, public water supply systems rely on surface water sources; south of the permafrost zone, both surface and groundwater may be used. In the Territories, many small communities use hand-carried or informal water delivery systems. In some of the larger growing communities, such as Inuvik, Hay River, Norman Wells, and Yellowknife (all in the Northwest Territories), water is treated and piped or commercially delivered, and sewage systems have been established. However, in these communities use of facilities has nearly reached or exceeded maximum capacity; in some communities, poor ground conditions also contribute to sewage system problems. Generally, irrigated agriculture is not practiced in the area crossed by the proposed route.

Several major gas pipelines now exist in the area of the proposed route. (See Figure 2.OV.11-2.) One gas line of the Alberta Gas Trunk Line Company Limited originates in northeastern Alberta; it runs southwestward, crossing the proposed route several times near the center of the province before it heads eastward, paralleling the proposed Monchy Delivery Line as far as the Alberta-Saskatchewan border. Here it delivers gas to Trans-Canada Pipeline Limited, which distributes gas as far as eastern Canada and the Great Lakes region of the United States; the proposed Monchy Delivery Line would have a connection with the Trans-Canada line.

A second Alberta Gas Trunk Line Company Limited gas line would generally parallel the proposed pipeline from a point in northern Alberta to Caroline Junction, and would parallel the proposed Kingsgate Delivery Line part of the way to Kingsgate. Near Fernie, British Columbia, the Trunk Line gas line delivers gas to Alberta Natural Gas Company Limited, which would parallel the proposed Kingsgate Delivery Line the rest of the way to Kingsgate, and connect with it; the Alberta Natural Gas Company Limited line now makes deliveries to Pacific Gas Transmission Company at Kingsgate. The second Alberta Trunk Line Company Limited line ends at the Canada-United States border with a delivery to the Montana Power Company.

To the west of the proposed route, the West Coast Transmission Company Limited gas pipeline extends from near the northern British Columbia border to a delivery point at the British Columbia-Washington State border with Northwest Pipeline Corporation.

Petroleum pipelines are also numerous in Alberta and Saskatchewan, especially in Alberta; many lines run close to and in places parallel the proposed gas pipeline. The potential for future development of a Mackenzie Valley oil pipeline is presently being studied.

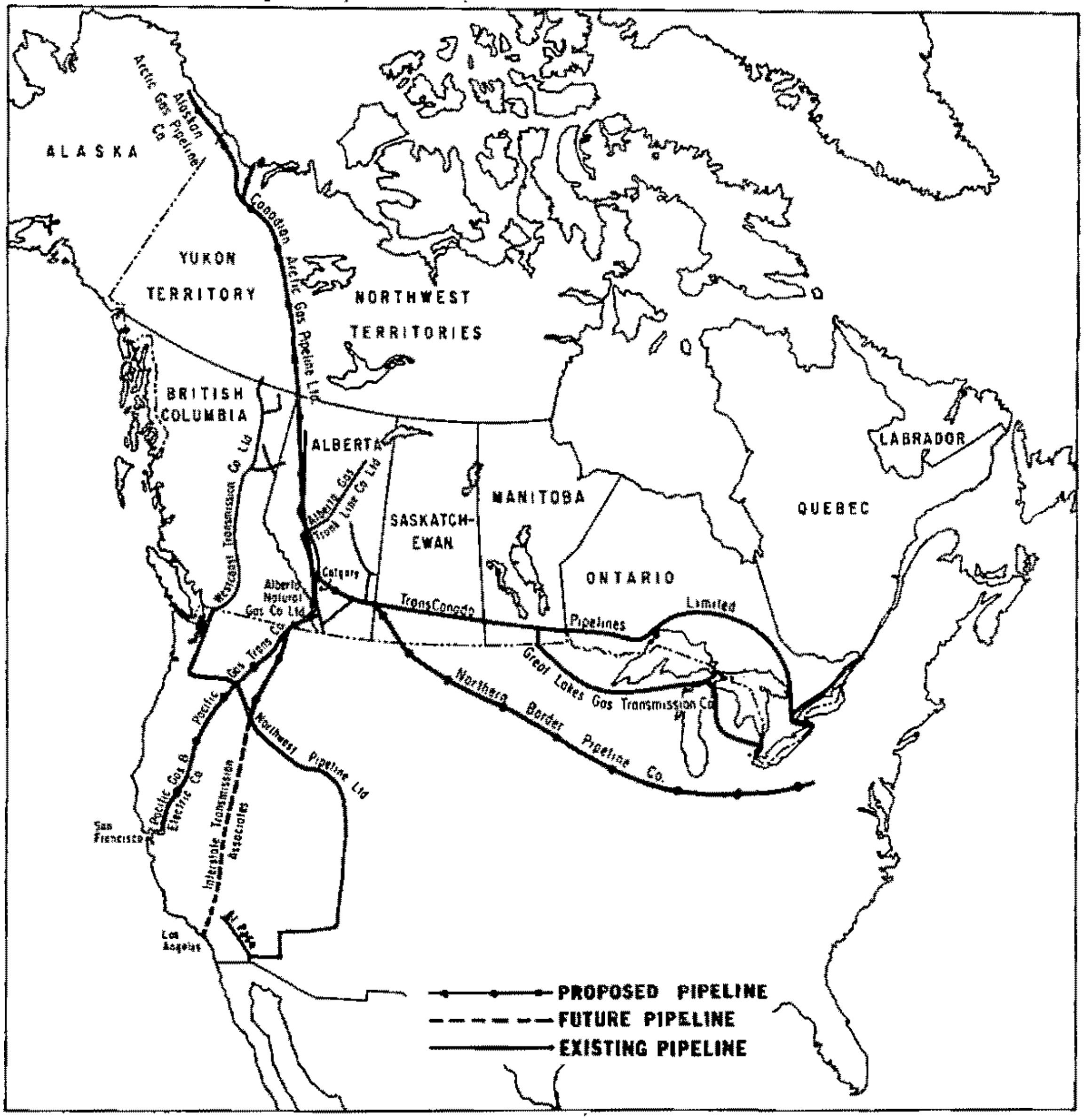


Figure 2.OV.11-2 Proposed Canadian and Alaskan pipelines for Arctic gas and connections to southern Canadian and U.S. pipelines

Where public communication networks exist in Canada, they could be used in constructing the proposed pipeline. However, the Applicant also expects to install a microwave radio system with more than 80 communication sites, a company phone system, and a mobile radio system.

The proposed Northern Border route would intersect 36 major power transmission lines; the density of powerlines generally increases along the route from west to east. The proposed route would share existing pipeline and electric powerline rights-of-way in Iowa, Illinois, Ohio, West Virginia, and Pennsylvania; no shared right-of-way is longer than 5-1/2 miles and the total shared right-of-way is 23 miles.

There is little irrigated agricultural land along the proposed Northern Border route. About 4 miles of irrigated lands of the Buford-Trenton Irrigation Project are crossed in North Dakota, and a larger section of the Bureau of Reclamation's Oahe Irrigation Unit in South Dakota. The latter is still in the planning stage. In the middle portion of the Northern Border route which is within the Upper Mississippi River Basin, groundwater is the primary water supply source for most communities. Many communities along the Northern Border route to the east and west of this area obtain public water supplies from surface water.

The proposed gas pipeline would cross 29 major natural gas pipelines along the Northern Border route. It crosses two primary distribution lines in Montana and western North Dakota. It makes deliveries to other lines near Aberdeen, North Dakota; Fairmont, Minnesota; Mason City, Iowa; Mendota, Illinois; Kankakee, Illinois; Rensselaer, Indiana; Berne, Indiana; Mt. Vernon, Ohio; Canonsburg, Pennsylvania; and Delmont, Pennsylvania. A large number of gas lines are crossed in central Ohio, northern West Virginia, and western Pennsylvania as major distribution lines bring natural gas across the country from gas fields in the Southwest.

The proposed Northern Border route would cross 35 major crude oil, liquefied natural gas, and petroleum products lines. A large concentration of these lines are crossed at the eastern end of the route because they originate from oil fields in eastern Ohio, West Virginia, and western Pennsylvania.

There are numerous major and minor electric transmission lines all along the West Coast leg of the proposed pipeline; the route would parallel existing powerlines for a total of 160 miles in south central Oregon, the Modoc National Forest (northern California), and the Central California Valley. Several electric transmission facilities are passed just east of Spokane. Most electric power in the Pacific Northwest is hydroelectric power produced by the Bonneville Power Administration. Northern Idaho residents are also facing a proposal for installation of a 500-kV (kilovolt) electric transmission line from Hot Springs, Montana to Spokane. In the San Francisco area, geothermal steam is also used to generate electricity.

The proposed pipeline would cross many irrigation canals and ditches all along the route. Most public water supplies in Idaho and Washington come from surface water. Since surface water is limited along much of the proposed route through Oregon and California, most public water supplies come from groundwater. In the Central California Valley, some communities along the route depend at least partly on local surface water; these include Sacramento and many communities just north and east of the San Francisco peninsula. The peninsula itself receives water from the Tuolumne River in the Sierra Nevadas via the Hetch Hetchy Aqueduct.

The proposed 42-inch outside diameter gas pipeline would parallel the existing 36-inch outside diameter gas pipeline of the Pacific Gas

Transmission Company (PGT) and the Pacific Gas and Electric Company (PG&E) from the Canadian border near Kingsgate, British Columbia to Antioch, California, with the exception of a 21.4-mile segment through the John Day River Canyon in north central Oregon. The proposed pipeline would cross two natural gas pipelines in Washington and Northwest Pipeline Corporation's 22-inch gas pipeline in Oregon. In California, numerous small gas lines owned by PGT would be traversed.

The proposed pipeline would cross three oil product pipelines in Washington. A microwave radio system now used between facilities along the existing Pacific Gas Transmission Company pipeline would serve the new pipeline as well.

In Oregon, most public water supplies in the area traversed by the proposed pipeline come from groundwater. The Los Angeles gas pipeline would cross the Joe West Reservoir site in northeastern Oregon.

In Oregon, the proposed gas pipeline would parallel an existing gas pipeline of the Northwest Power Company for 88 miles from Meacham to Rye Valley. There is one oil products pipeline in the vicinity of the proposed gas pipeline in northeastern Oregon.

Land Use Planning

Authorities with responsibility for land use planning in the area of Alaska traversed by the proposed gas pipeline include the North Slope Borough, the State of Alaska, the Joint Federal-State Land Use Planning Commission, and the U.S. Fish and Wildlife Service acting for the Secretary of the Interior. The North Slope Borough has mandatory responsibility for planning, platting, and zoning, but so far such plans are in the formative stages only.

Until recent years, land ownership in northeastern Alaska was almost exclusively Federal. However, substantial acreages are now being selected by and transferred to the State of Alaska under provisions of the Alaska Statehood Act. The State of Alaska has already selected lands in the Prudhoe Bay area and classified a large portion of them as resource management lands; most of these resource management lands are leased for oil and gas exploration.

Under the Alaska Native Claims Settlement Act, Native corporations formed all over the State, including the Kaktovik Village Native Corporation and the North Slope Regional Native Corporation, will be able to acquire lands. The lands to be selected by the Kaktovik Village Native Corporation for corporation use could include up to 108 acres that are now part of the Arctic National Wildlife Range. The North Slope Regional Native Corporation selections are expected to include some State lands in northeastern Alaska.

The Alaska Native Claims Settlement Act also provided for establishment of the Joint Federal-State Land Use Planning Commission. In August 1973, the Commission submitted recommendations to the Secretary of the Interior on the use of 80 million acres of Federal lands identified for potential addition to the national park, forest, wildlife refuge, and wild and scenic rivers systems. The Commission is also authorized to undertake a process of comprehensive land-use planning, but a statewide land use plan has not been issued.

The Secretary of the Interior has proposed that the Arctic National Wildlife Range be enlarged and included in the National Refuge System; the proposal includes a requirement for the issuance of permits for mineral exploration and development. (For the location of these lands, see the Alaska Volume.) The Secretary has also recommended that suitability of the enlarged Arctic National Wildlife Range for inclusion in the Wilderness System be studied.

Besides the expansion of the Arctic National Wildlife Range, the future may also see the establishment of several new national parks within the North Slope Borough. Expanded exploration and development of oil and gas can also be expected. Whether Prudhoe Bay, whose residents now are mostly temporary, will emerge as a permanent population center is uncertain. In view of the proven and speculative oil and gas reserves in the area, a fluctuating work force could be in the area for 25 years or longer.

In Canada's Yukon Territory and Northwest Territories, government entities that could become involved in land use planning include the Federal and the territorial governments. The territorial governments have legislative powers similar to those of provincial legislatures, but all natural resources except game are still the responsibility of the Federal Government. In British Columbia, Alberta, and Saskatchewan, both the Federal and provincial governments could become involved. However, there is no indication in the Applicant's materials that comprehensive land use planning is taking place.

Both the Federal and territorial governments are examining sites for possible designation as national or territorial parks. The proposed Nahanni National Park would lie west of the proposed route in the vicinity of the Liard River in southwestern Northwest Territories; a national park at Toker Point on the Arctic Coast 50 miles northeast of the proposed route is also being considered. Proposals have also been made for a Yukon Wildlife Range adjoining the Arctic National Wildlife Range at the Alaska-Canada border, and the proposed pipeline route would run through it.

According to the Applicant, no marked changes are foreseen in the level of activity in trapping, hunting, fishing, agriculture, forestry, commercial fishing, mining, or oil and gas development through 1985.

Government entities with responsibility for land use planning along the route of the proposed Northern Border gas pipeline include the States, counties, and localities. The Fort Peck Tribal Council could become involved in land use planning; Federal agencies with management responsibilities along the Northern Border route could have some effect, but the Federally-managed acreages here are small. Soil conservation districts are concerned with protection and conservation of natural resources on a county or watershed basis and prepare both long-range and annual plans. Special purpose districts such as irrigation, water, drainage, and weed control districts have also been formed in many areas.

Table 2.OV.11-4 shows that the States along the proposed Northern Border route have completed statewide comprehensive outdoor recreation, historic preservation, economic development, and water plans. Most of the States are also developing their programs to identify flood plain areas that should be protected and designated for uses such as open space, parks, and recreation. Generally, the counties along the route are now in the process of developing future land use plans and county zoning regulations, and approximately one-fourth of the counties have issued a land use or zoning plan. A few cities and towns near the proposed pipeline also have a land use or zoning plan.

The Little Missouri River in North Dakota and the Wapsipinicon River in Iowa are being studied for potential addition to the Wild and Scenic River

Table 2.OV.11-4 State comprehensive plans completed or in preparation along proposed Northern Border pipeline

State	State Comprehensive Outdoor Recreation Plan	State Historic Preservation Plan	State Economic Development Plan	State Water Plan
Montana	Completed	Completed	Completed	Completed
North Dakota	Completed	Completed	Completed	
South Dakota	Completed	Completed	Completed	In Preparation
Minnestoa	Completed	Completed	Completed	
Iowa	Completed	Completed	Completed	Completed
Illinois	Completed	Completed		Completed
Indiana	Completed	Completed		Completed
Ohio	Completed	Completed		Completed
West Virginia	(Route crosses 8 miles only)			
Pennsylvania	Completed	Completed	Completed	In Preparation

System. The State of Indiana is studying the possibility of designating the Wabash River as a scenic river.

In the future, the agricultural land use which now predominates in Montana, North Dakota, South Dakota, and Minnesota is expected to continue. More marginal land may be brought into spring wheat production. Some economic development planning is underway at the Fort Peck Indian Reservation in Montana. The scarcity of water west of the Missouri River is a factor limiting future industrial developments; however, if coal gasification becomes a reality in the future, eastern Montana and western North Dakota would experience a population increase with conversion of grazing lands to plant sites and urban/suburban housing developments. Large land areas would be used as mining sites. Water availability may become critical in these areas.

In Brown and Spink Counties in northeastern South Dakota, a proposed Bureau of Reclamation irrigation project could convert as much as 495,000 acres of nonirrigated range and cropland to irrigated cropland.

In the mid-America grain producing segment of the proposed route, agriculture is likely to remain the primary land use, but population growth is expected to place demands on agricultural lands near population centers.

In the eastern Ohio-West Virginia-southwest Pennsylvania segment, where most lands are used for agriculture or forestry, future land use is expected to follow the existing pattern with some increase in urban usage. Recreation demands by urban populations may accelerate the use of flood plains for recreation. Pennsylvania is presently preparing a State Land Use Plan. In addition, many cities and subdivisions have zoning regulations in effect. Ohio has already adopted a State Transportation Plan.

Governmental entities with responsibilities for land use planning in the area surrounding the proposed West Coast leg include the governments of the States and counties through which it passes. Planning by the U.S. Forest Service and the U.S. Bureau of Land Management also affects developments on the proposed route. In all the States traversed--Idaho, Washington, Oregon, and California--comprehensive land use plans and zoning have been or are being developed. This planning and zoning does not specifically address the question of transmission or utility corridors.

The State of California Code requires each county to include in its comprehensive land use planning elements for land use, circulation, housing, conservation, open space, seismic safety, fire and geologic hazards, transportation noise, and scenic highways. Most California counties have zoned Federal lands along the proposed route as open space; most other lands along the route have been zoned for open space, agriculture, or recreation.

Recreation land use is highly important along the proposed San Francisco leg. Segments of the John Day River in Oregon, the Moyie and Kootenai Rivers in Idaho, and the Sacramento River in California have all been identified as potential additions to the Wild and Scenic River System. The Owyhee River in Oregon is also being studied for potential inclusion in the system. The Snake River Gorge in Washington has been identified in the Washington State Recreational Trails Program as a hiking and horseback riding trail and water trail. The Grande Ronde and Malheur Rivers have been designated by Oregon as needing study for inclusion in the State Scenic Waterways System. The Bureau of Land Management is considering an area of the public lands mile east of the proposed route in northern California for designation as a primitive area; adjacent to this area to the west is a 28,000-acre nondesignated roadless area of equal value administered as part of the Shasta National Forest.

In the future, continued expansion of recreational and recreational/residential development in northern Idaho is expected. This is occurring on private lands with the subdivision of rural-type recreation property along streams and lakes. In the nonurban areas of Washington and north central Oregon, population growth is expected to be slow and little change in prevailing agricultural land use is anticipated. With increased irrigation, some areas now in grazing and conservation use could be converted to agricultural use.

The Blue Mountains in northeastern Oregon are expected to show increased recreational use. Growth of La Ronda will probably continue. In the remainder of eastern Oregon, the present mix of grazing, farming, and timber harvesting will probably persist.

In the portions of south central Oregon and California affected by the proposed route, continued residential expansion around existing population centers is anticipated. Bend, Oregon and Burney, California will probably experience continued subdivision growth. Continued expansion of industrial/commercial use near Red Bluff and Willows, California is also expected.

In north central California, the development of recreational homes is expected to continue. It is also possible that timber harvesting will increase again there, as it has in northern Idaho.

It is possible that the Rio Vista Gas Field in the Central California Valley could be developed in the future; utilization of geothermal resources in the lava beds of northern California and central Oregon is also a possibility.

2.OV.12 Paleontological, Archaeological, and Historical Resources and Unique Areas

Table 2.OV.12-1 lists all historical and archaeological sites along the proposed route which have been identified as sites listed on the National Register of Historic Places or a State Register. The State Historic Preservation Offices of the States through which the proposed pipeline would pass have been consulted in identifying these sites. Not all known historical and archaeological properties have been evaluated for National Register status. Properties are continually added to the Register, and unknown properties may be of a quality meriting nomination for Register status. Therefore, additional National Register properties which could be affected by the proposed route may be identified in the future.

Paleontological Resources

Only a few known sites containing fossil remains of plant and animal life from earlier geologic periods would be crossed by the proposed route. There is, of course, the possibility of discovering additional sites during future investigations or excavations. Outcrops of fossil-bearing bedrock have been found along Fire Creek in Alaska. However, no currently known sites are near the proposed crossing. The Kingsgate Delivery Line in Canada traverses significant areas of bedrock where fossil remains could be found, but the area has not been surveyed to date. In the vicinity of the Snake River in Washington two paleontological sites, one 3 miles from the proposed route and the other 1.6 miles from it, are known. No sites are currently known along the Northern Border route, but fossiliferous bedrock is exposed in spots along the route in central Illinois, eastern Ohio, West Virginia, and Pennsylvania. Bedrock is also generally exposed at the base of river

Table 2.0V.12-1 Historical and archeological sites along proposed route which are listed or eligible for listing on National Register of Historic Places or State Register

Location	Description	Distance from Pipeline (Miles)
Alaska		
Flaxman Island, mouth of Canning River	Leffingwell Camp	Not Given
Illinois		
LaSalle County, Starved Rock State Park	Starved Rock	near
La Salle	Illinois-Michigan Canal	0
Indiana		
Rensselaer	St. Joseph's Indian Normal School	1½
Ohio		
Wapakoneta	Auglaize County Courthouse	2
Homer	Dixon Mound	½
Morgan Center	McLaughlin Mound	1½
Warrenton	Speedway Mound	1
West Virginia		
Bethany	Old Main, Bethany College	½
Bethany	Pendleton Heights, Bethany College	½
Bethany	Alexander Campbell Mansion	½
Pennsylvania		
Canonsburg	Roberts House	2
Idaho		
Bonner's Ferry	Site of first ferry across Kootenai River (1826)	1
Sandpoint	Railroad depot	1½
Washington		
Idaho-Washington border at Liberty Lake to Washington-Oregon border at Walla Walla	Kentucky Trail (1864-1872). Pipeline intersects route of Kentucky Trail approximately 1 mile northwest of Rosalia	0-5

Table 2.OV.12-1 continued

Location	Description	Distance from Pipeline (Miles)
Washington (cont.)		
Rosalia	Steptoe Battlefield. Col. Steptoe defeated by the Indians (1858)	1
Rosalia	Historic properties in town	1
Approximately 2 miles south of La Crosse	Texas Road (1865-1880)	0
Lyons Ferry	Mullen Road (1859-1880)	1½
Lyons Ferry	Marmes Rockshelter	1
Snake River pipeline crossing	Lewis and Clark Trail (1804-1805)	0
Starbuck	Properties in town	3
Touchet River Crossing	Lewis and Clark Trail (1805-1806)	0
Waitsburg	Historic properties in town	5
Spokane County	Turnbull-Pines Rock Shelter	Near
Spokane County	Horse Slaughter camp	Near
Oregon		
Morrow County	Oregon Trail (crosses ROW at 45°)	0
Milton-Freewater	Fremont's Route	0
Deadman's Pass	Whitman Route	0
La Grande	Oregon Trail	0-1½
California		
Modoc County	Bloddy Point 1850 Indian/Settler Battle	2
Lava Beds Nat'l Monument, Modoc County	Fern Cave	Not Given
Lava Beds Nat'l Monument, Modoc County	Petroglyph Point	Not Given
Shasta County	Fort Crook Site	1
Lassen Volcanic National Park, Shasta County	Loomis Visitor Center, bldg	Not Given

Table 2.OV.12-1 continued

Location	Description	Distance from pipeline ----- (Miles)
California (cont)		
Shasta County	Lake Britton Archeological District	0
Shasta County, near Inwood	Noble's Emigrant Trail	0
Fall River Mills	Lockhart Ferry Site	Not Given
Orland, Glenn County	Site of Swift Adobe, early homestead	5
Maxwell, Colusa County	Swifts Stone Corral, early homestead	2
Winters Area, Solano County	University of California Experimental Farms	Not Given
Vacaville, Solano County 2 miles south	Vaca-Pena Adobe Hdqs. building, Vaca Grant Ranch	4

valleys. Wherever limestone or shale is encountered, fossils are likely to be found.

Archeological Resources

Archeological evidence indicates that some 25,000-30,000 years ago, prehistoric people who had crossed the Bering Strait and the North Slope of Alaska used the Mackenzie River Valley as a southern migration route during an interval in the glacial period when it was ice-free. The proposed pipeline follows this prehistoric migration route. The best existing evidence of this is a site on Old Crow River in northern Canada near the proposed interior route crossing. This area served as a travel route for subsequent migrations as well. Most evidence for prehistoric habitation dates back to about 12,000-13,000 years ago, after the glaciers receded. This generally holds true all along the proposed route, although some evidence along the San Francisco route suggests occupation may have occurred there as much as 20,000 years ago.

Along much of the route, relatively little actual archeological investigation has taken place. However, an archeological survey and excavations were performed along the Sagavanirktok River in conjunction with the Trans-Alaska Pipeline System project. Two sites are known along the route in the Arctic National Wildlife Range. Also, there are reportedly archeological and historical sites at Camden Bay and Demarcation Bay where facilities for the proposed project are to be set up. In Canada, about 15 general historical and archeological areas have been investigated in the North. As part of a salvage proposal included in the present application of Canadian Arctic Gas Pipeline Limited, 79 potential sites have been identified along the proposed route, all of them north of 60° North latitude (Millar, 1974).

In the Alaskan and Canadian Arctic, prehistoric people were nomadic hunters and traders. Eventually they began fishing, both along the coast and along the inland rivers, streams, and lakes. Evidence such as stone shelters, stone fences (which served as caribou hunting blinds), limestone caves, and changes in tundra vegetation where dwellings stood can be found. A seasonal campsite, an old village site, an abandoned trading post, trade routes, and a general area which served as a trade meeting site are examples of known, potentially important archeological sites along the right-of-way.

In the Canadian provinces and lower 48 States the earliest prehistoric inhabitants were nomadic big game hunters. Gradually most groups became village based, traveling shorter distances to fish, hunt, or gather food and materials. The tools and weapons used by different groups varied in design. After prehistoric groups became more settled, agriculture and the production of additional implements and objects of art developed. Most settlements were located along rivers, streams, lakes, and other water sources. Villages varied in their permanency. Differing culture groups came together at least twice in southwestern Saskatchewan. This meeting area may contain evidence of cultural changes. Some groups, such as Midwestern Plains Indians, had to become hunters again because pursuit by other Indians and later by whites forced them to move constantly. Use of the horse reached the Plains in the 1700's and provided new mobility for these people.

Along the proposed San Francisco and Rye Valley routes a large number of archeological sites have been located. Many were identified in conjunction with the construction of the Pacific Gas Transmission Company/Pacific Gas and Electric Company gas pipeline that was completed in 1961. Archeological sites include villages, campsites, fishing camps, water source camps, cave and rock shelters, burial sites, sleeping circles and middens. Scattered flakes, grinding stones and cooking stones have been found. The Marmes Rock Shelter on the Palouse River in Washington contains the earliest known burial site in the northwest. It is located 2 miles from the proposed route. Very little excavation has been done in eastern Oregon, though the area is believed to have been relatively heavily populated by prehistoric groups.

Much of the proposed Northern Border corridor has not been surveyed to date. However, surveys have been carried out in the Upper Missouri River Basin as part of the Smithsonian Institution River Basin Survey. A small number of known archeological sites have been identified along the proposed route. They include 3 in North Dakota, 5 in Illinois, 3 in Ohio and 4 in Pennsylvania. Others are known in the broader study area surrounding the route. Little is known about the prehistoric inhabitants of the Plains. Most knowledge derives from special use sites and isolated artifacts. River banks may have supported semi-permanent villages, and caves were often inhabited. Tepee rings, bison kills, boulder effigies, some wooden structures, and vision quest sites are examples of archeological features found in the Plains region. As the proposed route enters the Mississippi River Basin, burial mounds which may be 2,000 years old are encountered. They are typified by elaborate grave goods, often made from exotic materials. Artifacts such as stone and copper implements, pottery, and spear points have been found. Small permanent villages existed along major Illinois rivers. A later influence in this area has many traits which may have Mesoamerican origin. One site in Illinois, the Little Beaver Site, has been given high priority by the Illinois Archeological Survey and is reported by the Applicant to be in the path of the proposed pipeline. As in the Mississippi River Basin, Ohio and Pennsylvania have rich archeological resources. A number of sites have been identified through professional investigations. The majority of sites discovered have been mounds, burial sites, and a few campsites.

Historical Resources

Although the Russians entered Alaska as early as 1741, the Arctic region did not gain historical significance until 1826 when Sir John Franklin explored the eastern Alaskan Arctic coast. Contacts and trade between Natives and foreigners began in earnest during the 1840's when whaling vessels reached the Beaufort Sea (Humphrey et al., 1974). By this time three cultural patterns of geographic settlement among Arctic Eskimos had developed. The Nunamiut were inland nomadic hunters, following the migratory patterns of the caribou. Taremiut, on the other hand, lived along the coast depending mainly on sea mammals for existence. The third group, the Thule Eskimo, depended upon both inland hunting and sea mammals. Trade with the foreigners disrupted the Native trading patterns and attracted more Eskimos to the vicinity of the whaling camps on the coast. Prominent land points along the Beaufort Sea played a vital role throughout the historic record of man in the Arctic. Eskimo villages, bases for English explorers, Hudson's Bay trading posts, semi-permanent settlements for hunting, and camps for Russian and American whalers could be found there at various times. Leffingwell Camp, built for a scientific expedition, on Flaxman Island at the mouth of the Canning River is on the National Register of Historic Places. Russian fur traders settled a little farther south.

Historically, the study region in northern Canada was inhabited by two basic cultural groups: the Inuit (Eskimo) of the Arctic coast and tundra area and the Athabascan Indian groups of the sub-Arctic interior. Both were semi-nomadic hunters. Europeans penetrated Alberta setting up fur trading posts in the late 1700's and early 1800's. Opening of the fur trade on a large scale in 1789 in the interior region of the Northwest Territories brought disease and cultural change to the Indians. Some self-sufficiency was lost as they became more and more dependent on white man's trade goods. New trade patterns moved north to the Inuit in the 1840's when a Hudson's Bay trading post was built at the head of the Mackenzie River Delta. Whaling vessels entered the Canadian Arctic coastal region in 1889. A gold rush in 1896 in the Yukon brought more whites into the northern region.

History in the Alberta plains developed late due to hostility of the Indians to fur traders. Extensive exploration did not occur until 1857-1860. By the end of the 1800's Alberta was beginning to become industrialized. The completion of the railroad to Calgary in 1883 helped to increase urbanized manufacturing and mining in the area. Nevertheless, before World War II the economy of Alberta was predominantly agricultural. Most of the land is still used for farming, but urbanization has been rapid since the war. In the sections of Alberta and British Columbia to be crossed by the proposed route there are a number of structures associated with the history of mining and railroad construction, such as early cabins, camps and mines. These are in need of further investigation and preservation. The Rocky Mountain foothills area is of considerable historic value (Millar, 1975). The proposed route would also cross two designated historical sites in Saskatchewan.

In the lower 48 States the different parts of the country to be crossed by the proposed route have similar patterns of historical development. As the French Canadian traders and trappers entered the Midwestern Plains beginning in the middle of the 18th century, so the Spanish and French sought to extend their influence in the Mississippi and Ohio River Valleys. In the Pacific Northwest the early explorers were mostly British and American fur traders, while Spanish/Mexicans ruled in California. Governmental explorers and fur traders opened routes to the West for others. Miners, followed by farmers and ranchers, settled the Plains and the far West. Battles between the military and Indians increased in the mid-19th century, especially in the Plains and the Pacific Northwest. The development of river travel, railroads, and the East-West trades expanded the Nation. In the Ohio River Valley canals and railroads facilitated the establishment of farms.

Types of historical sites to be found along the proposed Northern Border route include fur trading posts, historical Indian villages and camps, military forts, battlefields, dugouts, sod houses, homesteads, train depots, civic buildings, and canals. Some sites have been identified along the route. In North Dakota the Fort Bouis Fur Post may be in the path of the proposed line. In Illinois, Starved Rock is passed within the park boundaries and the Illinois-Michigan Canal is crossed by the current proposed route. Both are on the National Register of Historic Places. In Ohio the proposed route would cross the Miami and Erie Canal one mile from a lock. Another segment of this canal is presently on the National Register, and since canal portions containing locks are often added to State Registers, this portion may be designated in the future. One site a 1/2 mile from the line in West Virginia is on the National Register of Historic Places and another is considered worthy of nomination. There are no sites along the route in Pennsylvania that are currently on the Register, but this area is so rich in history that new sites may be revealed.

In the West, many towns, battlefields, and ferries are historic sites. Old trails and roads are one of the principal historical resources. The proposed route would cross or parallel the Kentucky Trail, the Texas Road, the Lewis and Clark Trail, Marcus Whitman's route and John Fremont's route in Oregon, the Oregon Trail and Nobles Emigrant Trail. The proposed route to Rye Valley would roughly parallel visible portions of the Oregon Trail for 65 miles from Meacham to Rye Valley. (This is also the route of an existing gas pipeline.)

Unique Areas

In Alaska, 5 areas have been nominated by the Joint Federal-State Land Use Planning Commission for analysis as Science Research and Natural Areas; they are:

Prudhoe Bay
Jago River
Neruokpuk Lakes
Shublik Springs
Beaufort Lagoon

These would be for studies of unique vegetational and animal features. Also, the National Park Service is considering designation of 11 areas in Alaska as Natural Landmarks in order to preserve distinctive geological and ecological classes. They are:

Flaxman Island
Sagavanirktok River
Kadleroshilik River and Plain
Kadleroshilik Mound
Fire Creek
Sadlerochit Springs
Jago River
Clarence Plain
Demarcation Bay
Icy Reef

Most sites of both groups are within the Arctic National Wildlife Range, which is the only remaining largely undisturbed continuum of arctic ecosystems and vegetation types from the Arctic Ocean to the interior of Alaska. One of the specific objectives for establishing the Arctic National Wildlife Range was to preserve wilderness values which are quickly diminishing elsewhere in the United States. The intent for setting this area aside as a special area was to eventually designate it as a Refuge, where values have more legal protection. This has not been done yet, though it has been studied for inclusion in the National Wilderness Preservation System. Congress makes the final designation.

An area adjoining Alaska's Arctic National Wildlife Range in the Yukon is proposed as the Canadian portion of an International Arctic Wildlife Range. Within this a 2,140 square mile Firth River area is proposed for establishment as an Ecological Reserve under the International Biological Program. The area contains archaeological sites and unique vegetational and wildlife features. Two other preserves are proposed in the Mackenzie Delta and Fort Norman areas under the same program.

Several areas also exist along the Northern Border route. Rare native prairie lands are preserved in Ordway Memorial Prairie in South Dakota. The route currently crosses part of this Prairie. In Illinois unique areas are designated as Nature Preserves by the Illinois Nature Preserve Commission and are protected from alteration by Illinois law. The route south of the Illinois River would cross through the recently dedicated portion of the Starved Rock State Park Nature Preserve. This area contains rare vegetation and unique geologic features. Pecumsaugan Creek Nature Area, potentially crossed north of the Illinois River, also has the qualities of a unique area, but has not yet been designated as such.

Camas Meadow, 2 miles north of Spangle, Washington, is a potential Natural Landmark. It is a 5 acre remnant of a formerly extensive camas meadow used by the Indians.

2.OV.13 Aesthetic and Recreational Resources

Aesthetic Resources

Much of the Arctic Slope of Alaska and the Yukon Territory is largely wilderness. Within the Arctic National Wildlife Range in Alaska, primitive or wilderness values are good to high quality. Studies are underway which may result in a recommendation that Congress include large areas of the North Slope in the National Wilderness System. Also, the Canadian north is largely inaccessible, unpopulated and unexplored. However, much of the proposed route follows the Mackenzie Highway right-of-way. A variety of unusual landscapes exists throughout the Arctic. The terrain and vegetation combine to create almost limitless vistas. The extreme sensitivity of the environment makes a balance with nature critical. Due to the severe climate and short growing season, the growth and recovery of vegetation and wildlife is slow.

The pipeline route goes through five Alberta and three British Columbia provincial forests. Between Caroline Junction, Alberta and Monchy, Saskatchewan, where the pipeline route branches to the east on its course to Delmont, Pennsylvania, the corridor enters into a country similar to northern Montana where rolling prairie predominates.

A variety of landscape types would be crossed throughout the contiguous United States. Grass-covered plains crossed occasionally by rivers and streams are the principal landscape features west of Minnesota along the Northern Border route. The rolling grasslands give the visitor the impression that the region is largely undisturbed by man. The blue sky and clear air that are striking characteristics of the area are rapidly disappearing elsewhere. The North Dakota Badlands are a fairly unique topographical feature along the route. Scattered lakes in South Dakota, Minnesota and northern Iowa add color and diversity to the environment. The midwestern checkerboard and the rugged forested foothills of the eastern portion of the route each have their own picturesqueness. In the cornbelt occasional patches of woods and marshy areas are unplowed lands that provide cover for wildlife. There is little diversity of topography within each area, though scattered significant features such as bluffs and river valleys exist throughout the route.

These special features have been singled out for providing contrast to the countryside or for being the most attractive area in their respective regions. A list is presented in the North Border volume (2.1.3.13) for the Northern Border route. West of Leola, South Dakota the recently designated Ordway Memorial Prairie is an example. This is a 7,600-acre area of native prairie lands with sufficient unique characteristics to have been acquired by the Nature Conservancy. It is crossed by several miles of the current proposed route. Little Missouri Grasslands and Theodore Roosevelt National Memorial Park located in the North Dakota Badlands near the route are also sufficiently unique and scenic to be possibly worthy of national recreation designation. Other areas, such as the Killdeer Mountains and many stream crossings, are picturesque and provide the sites for the limited existing recreation activity other than hunting. In the Midwest, the most important area along the route in terms of aesthetic and recreational values is the Illinois River crossing where the Starved Rock Nature Preserve and State Park are located.

Ridges and valleys, canyons, cultivated fields, forests and meadows are all traversed by the two proposed West Coast lines. Ridges create scenic vistas as along the Moyie River Valley. As the route continues south the mountains change from foreground to background components in scenic views. This route follows an existing right-of-way which would be widened by 25-50 feet in most areas. Where both the San Francisco and Rye Valley lines parallel the existing route (206 miles) the strip will need to be wider. The cleared swath of the present pipeline in the low wooded ridges and valleys, as in the Moyie Valley, is readily seen and is a serious detraction to the natural qualities of the region.

Areas of special interest along the two West Coast lines are mainly located in Oregon and along the San Francisco route in California. The proposed San Francisco route in Oregon passes near lava beds outside of Bend. Two designated areas receive most of the visitation. They are the Lava River Caves State Park and Lava Butte Interpretative Center. More than 150,000 visitors per year come to these two sites. The State park is within 400 feet and the interpretative center is within 3/4 of a mile of the proposed route. In California there is a tract of land associated with the Baker Cypress Area that meets the criteria for designation as a primitive area.

In addition, the natural qualities of several of the rivers to be crossed by the proposed routes are being studied or are on study lists for inclusion in the National Wild and Scenic River system. This includes the Little Missouri (North Dakota), the Wapsipinicon (Iowa), the Moyie (Idaho), the John Day (Oregon) and the Sacramento near Red Bluff (California).

Recreation Use and Resources

There are currently no designated recreation sites along the proposed Arctic corridor. However, there is great outdoor recreational potential. Opportunities exist in this area for certain outdoor activities that are not easily obtained elsewhere in North America. As access improves and knowledge of the area grows it is likely that more people will visit the region because of its wilderness character, unique scenery and hunting and fishing opportunities. The Canadian Federal and Territorial governments are examining areas north of 60°N for potential national and territorial parks. Typical recreation activities currently engaged in are hunting (65 percent of use), fishing, hiking, camping, mountain climbing, nature study, photography and river floating. Many species of migratory animals and birds seasonally inhabit the North Slope. The abundance of different species diminishes in the winter when construction would occur. Cross-country skiing is a winter activity, but winter recreational use is minimal. The short summer season, harsh climate, mosquitoes and high cost of housing and transportation are limiting factors for visitors.

In Alberta the pipeline route goes through the Chain Lakes Provincial Park and passes near two other parks (one in Saskatchewan). Hunting and fishing are major recreation activities throughout the corridor area in Alberta, British Columbia and Saskatchewan. Most big game species and upland birds that occur in western Canada are found along the corridor. Several rivers also have recreational floating, including whitewater canoeing, potential. Those that are best known also have historic values. Perhaps the most famous is the Rat River which served as a canoe route to the Yukon gold mining areas.

Recreation sites along both the Northern Border and West Coast lines often follow stream courses or are located near lakes and reservoirs. Most of those that lie directly in the path of the pipeline are in the Midwest and the Ohio Basin and are State managed.

Ten designated parks and recreation areas as well as 12 trails and recreational or scenic waterways would be crossed by the Northern Border route. Hiking, picnicking, swimming and boating are typical activities within the parks and recreation areas. A list of the parks crossed appears in the North Border volume (2.1.3.13). Recreational trails and waterways in the Great Plains and Midwest are rapidly increasing in popularity. Currently trails for recreational purposes are more common in the east, especially near urban areas. Shade, water and scenic views are usually prevalent in these linear recreation areas. The trails and waterways crossed by the Northern Border pipeline vary from historical trails as the Lewis and Clark route which is being studied for inclusion in the National Trails System, to abandoned railroad rights-of-way, to historic canals and rivers designated for canoe routes. Most of these areas are in various stages of being designated as official park and recreation areas. The Illinois & Michigan Canal already has State park status. The Wabash River in Indiana is a candidate for designation as a State Recreation River System. There are many more stream corridors, canals and scenic areas that have potential for recreational use.

No State parks would be crossed by the West Coast Lines, but 10 National Forests as well as recreational waterways and trails would be traversed. Lists are presented in the West Coast Vol. (2.1.4.13 and 2.1.5.13). Hiking, nature study, fishing and hunting are the major recreational activities on the public lands. Several recreational lakes, such as Pend Oreille and Coeur d'Alene (Idaho), are in the vicinity of the proposed pipeline. In addition, Upper Klamath Lake (Oregon), Tule Lake (California) and Clear Lake (California) attract hunters and viewers interested in waterfowl from all over the United States. None of the lakes will be directly crossed by the pipeline and no facilities will be directly affected unless wildlife is scattered or access is temporarily interrupted, as at Black Butte Lake in California. Since so much of the countryside along or near the corridor is public land, campgrounds and picnic areas frequently occur.

The pipeline crosses many trails of historical and recreational interest in eastern Washington and Oregon. The most important one along the Rye Valley route is the Oregon Trail. Considering the entire route of the Oregon Trail the segment crossed by and parallel to the pipeline corridor probably offers the best potential for establishing scenic interpretative hiking and horseback riding trails in areas of visible ruts. Much of the route here, as well as the adjacent landscape, appears virtually untouched since the passage of the last emigrant wagon. However, an existing pipeline does follow this route. Along the San Francisco route the Pacific Crest Trail in California has been designated a National Scenic Trail. In addition, boating is popular on many of the rivers and streams to be crossed.

Recreational and aesthetic values along the proposed West Coast routes are important to a large tourist business and, in the Coeur d'Alene area, to a booming retirement industry. At the present time population is small along the route except in the Spokane-Coeur d'Alene area and near San Francisco. As more people come to these and other areas along the proposed route, more recreation areas are certain to be established. Private landowners, especially in Idaho and California, are already converting their lands for recreational use.

2.OV.14 Air Quality

General

The dispersal or concentration of pollutants depend to considerable extent on factors of climate and micrometeorology, that is, local atmospheric conditions, and to some degree also on topographic setting. These conditions often determine the degree to which sources of pollution and the pollutants produced actually present a problem in the degradation of the environment. High winds, for example, disperse atmospheric pollutants to lower concentrations that are no longer objectionable, whereas long periods of calm permit the buildup of pollutants. Wind directions determine where concentrations of pollutants will occur with respect to the sources of pollution. Irregularities in topography can hamper the ability of the winds to act as dispersing agents by precluding the development of near ground open wind paths, or can channel winds to produce good pollution dispersal.

A climatic feature typical of the Arctic and other cold regions that has an important bearing on air pollution is the ground-surface-based air temperature inversion that is caused by the negative radiation balance over the ground and especially over vast snow and ice surfaces present during the greater part of the year. This feature is particularly prevalent on winter mornings. In this situation a mass of dense cold air, as much as several thousand feet thick, is trapped beneath an overlying layer of warm air, and very little mixing occurs. Thus, if pollutants are added to this stable mass of air they remain where they are and their concentrations build up to levels that may greatly exceed those that would develop under conditions of normal temperature gradients with concomitantly greater air-mixing and pollutant-dispersing possibilities.

A contributing factor to air quality problems at the high latitudes is the occurrence of ice fog, in which the principal component is ice particles, although the presence of other materials, such as hydrocarbon nuclei, greatly enhance its formation. Ice fog causes a reduction in visibility by high concentrations of suspended ice particles formed by the condensation of water vapor onto hydrocarbon nuclei. The amount of water vapor that can be held in air decreases drastically as the temperature of the air decreases. Under sufficiently cold conditions almost any water vapor emitted into the air by the combustion of fuel, which also produces the hydrocarbon nuclei, will immediately form ice fog. In general, ice fog can occur at temperatures of -22°F, is increasingly likely to form with further reduction in temperature, and at -40°F it is almost certain to form.

Topographic settings such as river valleys or basins confined by surrounding mountains, common settings for human habitation, can greatly enhance the development and persistence of both temperature inversions and ice fog.

There are both natural and artificial (man-made) sources of pollution, but most of the common sources in developed areas are man-made. Among the major sources of gaseous and particulate pollutants are power plants, heavy-industry plants, automotive traffic, urban residential concentrations, and agricultural fields. Man-caused forest fires and intentional fires for land clearing and trash disposal are other artificial sources. Natural sources include exposed areas of loose fine-grained soils and geologic materials subject to wind erosion; naturally caused forest fires; and volcanic eruptions.

Pacific Gas Transmission Company already operates 16 compression station turbines along existing pipeline largely within the proposed right-of-way. The nitrogen oxide emissions range from .43 to 1.1 tons per day, and carbon monoxide emissions are calculated to range from .55 to 2.0 tons per day. Measurable quantities of sulfur dioxide and particulate matter are not emitted from the existing stations.

Air Quality along the Proposed Route

Air quality in the Arctic has been monitored only at a few locations. At Prudhoe Bay condensation nuclei range from a background reading of 300 to 500 nuclei per cubic centimeter to 20,000 nuclei per cubic centimeter. High values are associated with the Prudhoe Bay oil development installations. At Barter Island fog may be expected to occur on at least 74 days each year, and visibility is less than 1 mile for about 118 days each year.

Data on air quality along the proposed pipeline route through Canada is generally lacking. Man-caused pollutants are minimal and probably consist mainly of vehicle emissions and dust from agricultural areas. Natural pollutants include such things as smoke from forest fires and seasonal pollen clouds from coniferous trees. In a few areas of southeastern British Columbia and adjoining Alberta, smoke from combustion of coal is an obvious pollutant.

Air quality generally declines from west to east in the 20 Air Quality Control Regions along the proposed route. The zones of most intense air pollution correspond to areas of highly developed industrialization. An emission density ranking of five polluting substances (particulates, sulfur dioxide, carbon monoxide, hydrocarbons, nitrogen oxides) with population density shows that all portions of the proposed route west of the Iowa-Minnesota area are relatively unpolluted. Severely polluted areas along the proposed route include the regions around Chicago, Columbus, Wheeling, and Pittsburgh. Only air particulates have been measured by all the States.

The western one-half of the proposed route receives air pollution from natural sources and plant combustion sources. There is good correlation between occurrence of sulfur dioxide and particulates with power plants and heavy industry, between hydrocarbons and carbon monoxide with automotive traffic, and nitrogen oxides with total combustion sources. At times, nitrogen oxide concentrations exceed the National Standard of 100 g/m^3 (micrograms per cubic meter). Periodic wind-generated dust appears to increase particulate concentrations in excess of 800 g/m^3 in the farthest western part of the proposed route.

Excessive particulate concentrations occur locally in the eastern segment and sulfur dioxide concentrations greater than the National Standard, 80 g/m^3, are observed along the route in parts of West Virginia.

The climate west of Indiana is highly favorable for dispersion of air pollution. Wind speeds are high and stagnant inversion layers do not occur except at the crossing of the Mississippi River. By contrast, the climate to the east of Indiana is conducive to stagnant inversion layers owing to generally low wind speeds in combination with mountainous terrain.

The San Francisco leg passes through 7 Air Quality Control Regions. In Idaho and Washington, air concentrations of particulate matter periodically exceeded the primary Federal standards in 1972, the last full year for which data was available; however, concentrations increased in 1973. Naturally blown soil particles and lumber refuse burning are major contributors to high particulate matter concentrations; lumbering and saw mill activities also increase nitrogen oxide concentrations.

Spokane, Washington, and Sacramento, California, are the two areas along the proposed route that may be classified as "industrial." In both cities substantial automotive traffic results in nitrous oxides, hydrocarbon, and carbon monoxide emissions. Primary Federal standards for carbon monoxide and sulfur oxides were exceeded in 1972 and 1973 in the Spokane area.

In portions of the Central California Valley, secondary Federal standards for particulate matter and primary Federal standards for carbon monoxide and hydrocarbons were exceeded. The hydrocarbon concentrations in California are very high at all measuring stations, at times exceeding 10,000 micrograms per cubic meter.

PGT states that nitrogen oxide and carbon monoxide emissions from the 16 existing compressor station turbines are small compared to local industries, such as pulp and saw mills. Measurable quantities of sulfur dioxide for which data was available; however, concentrations decreased in 1973. Naturally blown soil particles and lumber refuse burning are major contributors to high particulate matter concentrations; lumbering and saw mill activities also increase nitrogen oxide concentrations.

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The Applicant states that nitrogen oxide and carbon monoxide emissions from the 16 existing compressor station turbines are small compared to local industries, such as pulp and saw mills. Measurable quantities of sulfur dioxide and particulate matter are not emitted from the existing stations.

The potential for air pollution due to air inversions is high all along the proposed San Francisco route; in parts of California, there is a potential for 80 days or more when air pollution can occur.

The Rye Valley leg passes through seven Air Quality Control Regions. The first 206 miles of the route with exception of about 22 miles coincides with the San Francisco route through Idaho and Washington, and discussion of that segment will not be repeated here.

In portions of eastern Oregon secondary Federal standards for particulate matter were exceeded in 1972, the last full year for which data was available. These particulates are primarily wind-blown dust.

Although there is a high likelihood of night air inversions along the proposed route, wind movements averaging 5 to 10 miles per hour prevent extended periods of air stagnation. However, in parts of Nevada there is a potential for 80 days or more when air pollution can occur. Inversions can be expected to exist much of the time, especially during the winter months, in mountain valleys similar to those where proposed compressor station sites 1, 5, 7, and 9 would be located, and can be expected some of the time at the other compressor station sites.

2.OV.15 Environmental Noise

There are several means for evaluating ambient sound levels. For the purpose of evaluating environmental impact, the U.S. Environmental Protection Agency is beginning to use the Day-Night Average Sound Level (Ldn). The Ldn is the 24-hour energy average of the sound level when the instantaneous level in decibels (dB) is measured with an A-weighting (dBA). The A-weighting makes a sound level meter "hear" similarly to the human ear. Where data are available, this measure (Ldn) is used to evaluate the impact of noise on humans. For impact on wildlife, maximum A-weighted sound levels are used.

The pipeline route has been chosen to avoid human populated areas. In the context of noise, avoidance will be achieved if any noise-making activities are more than 10,000 feet from any receiver. In certain cases there are human populations at lesser distances and the masking sound caused by the ambient levels plays an important role. The ambient sound levels along most of the total proposed route are typical of that existing in rural areas. The sound is primarily natural, being that of wildlife, wind and water flow. Occasionally, man-made sounds intrude, such as an overflying aircraft, a distant truck, or agricultural machinery in farmlands.

Data are not commonly available on remote or rural ambient sound levels, and those levels available vary from mile to mile. To permit a general assessment of the impact, broadly averaged ambient levels have been abstracted from a number of sources and are presented in Table 2.OV.15-1 below. The ranges of values shown are those that would be expected along the relevant parts of the pipeline route. There will be certain exceptions such as locations near a highly turbulent river or a highway. Since the West Coast lines are proposed to be partially alongside existing lines, there will be existing compressor station noise that must be considered as part of the local ambient noise. These data are not presented here but deferred to section 3.OV.15.

The ability for sound to propagate from a sound source to a receiver will determine how far a sound can travel before it mixes with the previously existing ambient levels. There are a number of factors which determine the attenuation of sound levels with distance: (1) spreading of the sound--6 dBA reduction per doubling of distance; (2) temperature gradients--reduction or addition and fluctuation; (3) wind gradients and direction--reduction or addition and fluctuations; (4) humidity--reduction particularly at high frequencies; (5) surface growth--reduction; and (6) topographic changes--hills produce shielding and therefore reduction. Because the pipeline route covers a wide variety of climatic and topographic zones and because the specific sites of interest (compressor stations) have not yet been chosen, an estimated attenuation characteristic was developed and is shown in Table 2.OV.15-2.

This table (2.OV.15-2) would apply for a compressor station, without a strong pure tone, generating sound over a flat grassy field during a calm day. Propagation upwind, through forests, or over hills can be expected to provide greater attenuation. Propagation downwind, during early morning hours, or over hard surfaces can be expected to provide less attenuation. A measurement was made at a typical turbine compressor station under the stated conditions and the observations agree sufficiently well to expect the attenuation estimate to provide a reasonable estimate of the range of compressor station noise influence.

Table 2.OV.15-1 Ambient sound levels

Environment Type	Day-Night Average Sound Level
Undeveloped - remote	25-30
Undeveloped - near natural sources of sound	30-40
Rural - desert	30-40
Rural - agricultural	35-55
Rural - near man-made sources of sound	50-65

Table 2.OV.15-2 Sound attenuation with distance

Distance (ft)	100	200	400	450	650	800	1,000	1,050	1,450	2,000	4,000
Estimate (db)	0	6	12	13	17	19	22	23	27	32	41
Observed (db)	-	-	-	12	18	-	-	24	26	-	-

2.OV.16 Hazards

Earthquakes

The recorded history of earthquakes in North America is limited to approximately the last 150 years. Statements on expected seismic activity are generalized from the incomplete data of this relatively short period. All four seismic risk zones (0-3 in increasing intensity) are present along the proposed pipeline route; recorded ground shaking, strong enough to be felt, has occurred all along the proposed route.

The two areas of greatest potential seismic activity are the northern end of the Canadian segment, and the southern end of the West Coast leg. Although no faults with surface expression are presently known to be active along the Canadian segment, there has been a persistent concentration of seismicity along 180 miles of pipeline route in the Yukon/Northwest Territories border north of 65 degrees N. Since early 1960 at least two earthquakes of magnitude 5.0 or greater on the Richter scale have occurred within 50 miles of the proposed route on the western edge of the Mackenzie Valley. The maximum expectable earthquake in this region is magnitude 7.0 on the Richter scale.

The West Coast leg of the proposed pipeline traverses areas of known faulting, but in most areas the faults are apparently inactive. Further studies will be needed to verify this. However, the route would cross the Wallula Gap fault, south of the Walla Walla River in Oregon, where faulting has occurred recently (within the past 35,000 years.) In addition, the pipeline would cross the Central Valley of California in Yolo and Solano Counties for approximately 100 miles, an area of high seismicity where earthquakes of intensity of about 7 on the Richter scale have occurred just north of Vacaville, along the proposed alignment.

Seismic risk zone 2, an area of expected moderate damage, is crossed by the pipeline for approximately 120 miles near Anna, Shelby County, in west-central Ohio.

The remainder of the proposed route, or about 4,350 miles (about 92 percent), lies within seismic risk zone 0 (no expected damage) and zone 1 (minor expected damage). Movement along active faults will cause disruption of the ground surface which, if it occurs within the area of the pipeline, could cause the line to rupture.

Landslides and Related Mass Movements

Landslides can be described as the downslope movement of a mass of rock and soil by gravity along a concave surface generally lubricated by water. The movement can be fast or slow depending on the type of soil or rock that is sliding. The initial force which starts a landslide can be caused by: 1. steepening a slope, 2. overloading the top of a slope with fill material, 3. removal of the toe or foot of a slope, and 4. increasing the water on a slope by rerouting surface drainage. Each of these singly or in combination can activate a slope failure. These actions are generally man-induced during construction, although the removal of the toe of a slope can be accomplished by running water. Slides of pre-historic age can thus be re-activated by the eroding action of flood water. In addition, vibrations such as those that accompany earthquakes can activate a slide on an otherwise stable slope.

In general, slopes 10 percent or less can be considered stable (in permafrost area slopes as low as 3 percent can slide through the process of solifluction, deep creep, skin flow or thaw consolidation); slopes over 10 percent will not necessarily slide, but care should be taken to examine the slope carefully before and during construction to ensure that the slope is stable and that no triggering action will be caused by pipeline construction.

Landslides and related movements of earth materials can be expected to occur along much of the proposed route, particularly where underlying bedrock materials are unstable or are incompetent from an engineering geology standpoint. For example, slumping and landsliding may occur where the proposed pipeline crosses incompetent shales, such as at the crossing of the Peace River at milepost (MP) 1112 in Alberta, or wherever bentonite is encountered, for instance along the North Border segment. In addition, landslides can be anticipated on steeper slopes throughout the Appalachian Plateau, along scarps in the Canadian segment, and steep hillsides along major river valleys of the San Francisco leg. The proposed route, where it crosses the John Day Canyon will border or cross an ancient landslide area which, according to the applicant's investigations, is presently stable.

Liquefaction is the alteration of clay layers to a mass that will behave very much like a liquid. This alteration may occur by shaking during an earthquake. The clay can flow rapidly causing disruption of the land surface, and the resulting movement could damage the pipe. In the Arctic and Subarctic, liquefaction can be caused by thawing of ice-rich permafrost. This thawing can generate water at a rate exceeding discharge, increasing pore pressure, and as a consequence, supersaturating the soil causing it to behave as a liquid. These conditions can precipitate massive slides. This process could be of major concern in pipeline construction and operation on slopes of more than 3° if thawing is more than 5 feet deep.

Where the proposed route crosses the Rocky Mountains, in southern British Columbia, the potential exists for snow avalanches. Local relief in this region can be as great as 1,000 feet at major ridges and mean annual precipitation at Fernie, B.C., is 41.46 inches largely in the form of snow (143.2 inches).

Subsidence

Collapse or subsidence of earth materials can be anticipated in several locations along the proposed route:

1) Where underground mining of coal has taken place (Illinois, Ohio, and southwestern Pennsylvania).

2) Where surficial materials consist primarily of organic soils and are thus susceptible to compaction under loading (agricultural lands along the North Border segment).

3) Where extensive drainage for cultivation has taken place (the Sacramento Delta area, near Antioch, California, where over one third of Sherman Island was 10-15 feet below sea level in 1952, and in the Baker Valley area of Oregon, along the Stanfield to Rye Valley segment of the West Coast route).

4) To a lesser extent some subsidence or collapse may be expected where the route crosses lava tubes and cavities, in the region of the Mayfield Ice Cave and Indian Spring Mountain in northern California.

5) Where sinkholes and caves occur (along the Iowa-Illinois border and in parts of western Ohio and western Pennsylvania.

Volcanism

The pipeline will pass through areas of recent volcanic activity, where reactivity could cause damage to the pipeline. These areas are along the High Lava Plains province in Oregon, where the line will pass near the Newberry Volcano. Some of the lava flows here are less than 2,000 years old. In the Modoc Plateau, near Mt. Lassen in northern California, the line will cross about 15 miles of recent lava. There are about 5 eruptive centers in this area. In either the Newberry Volcano area, or in the Modoc Plateau, if further activity were to occur, the pipeline could be covered by lava, ash or mud flows, which could cause damage to the surface installations of the pipeline. If the pipeline were to rupture under a lava flow, repairs would be difficult or impossible.

Corrosion

Many soils along the pipeline route are corrosive in nature, and will react with steel unless the steel is protected. These soils are found in a variety of different terrains, including areas of geothermal activity; alkaline areas along the western route; and organic areas such as bogs and muskegs. Unless the pipe is protected, it will be destroyed by these soils.

River Scour

Major rivers, especially in the Northern Border Route, and all rivers and streams in which the flow is intermittent, and which are subject to flash flooding, will scour their channels during periods of floods. Scouring depths of more than 10 feet can be expected in most of the larger water courses. In some of the larger rivers, depths of scour as much as 30 feet are not unknown. These scours fill during periods of slack water. Scouring depths are greatest where the flood waters are constricted by piling or other construction.

During periods of floods all rivers and streams will erode their banks laterally as their channels shift. A river may even occupy a new channel on its flood plain. Thus, during the lifetime of the pipeline, a river or stream could occupy any part of its flood plain.

To prevent damage to a pipe at river crossings, the pipe should be buried below the expected scour depth across the entire flood plain.

Erosion

Soils stripped of vegetation will be subject to erosion by wind and water. Erosion control techniques will be needed to keep erosion to a minimum.

Water Resources

An undetermined amount of water will be required for the construction of temporary snow and ice roads and for hydrostatic testing of the pipeline. Information appears to indicate that no more than half the amount required in Alaska is available during the winter.

The extent of lowered water-quality due to accidental discharge of chemicals is dependent on the type and quantity of material spilled, the season and location of the spill, and the success of remedial measures.

Repeated small spills of fuels and lubricants may have as serious an impact on water quality as a single large spill. Petroleum products entering the subsurface drainage system may lower the freezing point of ground water and thus delay formation of the frost bulb. Methanol will similarly inhibit frost bulb formation. Pipeline integrity will thus be threatened.

Repair work necessary during the summer would cause significant impacts or subsurface water drainage. Movement of equipment and supplies across a thawed tundra surface will cause almost instantaneous compaction and concentration of water in a "slump depression."

3.OV Environmental Impacts of the Proposed Project

Summary

The following is a system-wide summary of what might be considered the most outstanding impacts that the pipeline will have on the environment. In so far as possible without extensive duplication or discussion it attempts to broadly aggregate the effects of all geographic segments covered in other volumes and present the total general cumulative effect of the entire system, impact by impact.

Permafrost

Thawing will occur in the ice-rich, fine-grained material. The extent of the thawing will depend on the care that the Applicants take during construction. Thawing will result in one or more of the following: solifluction, skin flow, and liquefaction of the surficial material, each of which will increase the erosion potential; differential settlement, forming uneven ground and thermokarst lakes; and disruption of surface drainage, which would increase erosion and ponding. The permafrost regime could be irreversibly changed north of the 60° parallel under "worst case" conditions on an area approximately the width of the corridor and extending as much as 665 miles through ice-rich zones of both continuous and discontinuous permafrost.

Geology

Construction of the pipeline trench may trigger mud flows, soil falls, and landslides. Mudflows and soil falls could cause immediate local damage and loss of life. Landslides, which will generally move more slowly, will cause more extensive damage, altering drainage and creating an erosion hazard. Although these hazards will occur throughout the pipeline length, they will be particularly severe in the eastern part of the Northern Border Route. The effects of these events spin off into other impacts and are accounted for elsewhere in the analyses that follow.

Soils

Stripping of the vegetation along the right-of-way will expose the soil to erosion by wind and water along the entire 5,557 miles. Mixing the top soil with the barren surficial material when the trench is backfilled will result in loss of fertility along the trench. In the permafrost area and in areas where the average annual rainfall is less than 10 inches per year, revegetation will be difficult. Tile and open drains will be disrupted temporarily in areas of high watertable on the Great Plains in Canada and on the Northern Border route. This will affect the productivity of the land in these regions until drainage systems are fully reestablished.

Water Resources

In the permafrost areas, construction of snow and ice roads, establishment of construction camps and the hydrostatic testing of the pipeline will require large amounts of water that may be difficult to obtain during the winter construction periods. In addition, the frost bulbs that might develop around the pipe when it is chilled could lead to damming of surface and ground-water, altering drainage and increasing erosion.

Temporary heavy water loss from storage areas will occur; major alteration of local drainage systems might also occur.

The demand for water for construction, hydrostatic testing of the pipe and domestic consumption in the arid areas, such as the western edge of the Great Plains Province in Canada, Montana, North and South Dakota, could amount locally to more than is actually available.

At numerous stream and river crossings, sediment will be generated by pipe burial and other activities. This sediment, although causing a serious water quality hazard locally, will for the most part be temporary.

Contamination of ground and surface-water by accidental discharge of oil and toxic chemicals could result in a local long-term threat to water quality and plant and animal life. Water quality will be lowered locally in most drainages for a period of years and local water supplies will be reduced.

Vegetation

Vegetation will be destroyed along the entire 5,557 mile length of the proposed pipeline. Although the impact of this removal is serious, its effect on shrub and grass will be temporary throughout most of the route. Forest areas cleared will remain cleared for 30-60 years and potential timber production lost. In areas where rainfall is less than 10 inches, revegetation will be difficult, and in a few areas, impossible.

Clearing of trees will cause some loss in forest productivity that in the aggregate is of limited importance only in the western U.S. among coniferous timber stands on Federal lands.

Wildlife

Pipeline construction will have a detrimental effect on various mammalian species, especially those wilderness-prone animals in the Arctic requiring a large or undisturbed home range. Opening these areas to increased human encroachment will restrict the animals, by compressing their range, and increasing legal and illegal hunting, which all together will tend to reduce animal populations. A critical situation could occur with the Porcupine caribou herd, which cumulatively over the life of the project could suffer some losses unless care is taken during construction. Wolf, grizzly bear, wolverine, Dall Sheep, and polar bear will suffer similar but less extensive impacts.

The removal of vegetation in the Badlands of North Dakota will adversely affect the winter range of the antelope. This will be a long-term impact, for revegetation of this area will occur very slowly if at all.

Disturbances of migrating, nesting, feeding and staging of waterfowl, shorebirds and other birds as well as destruction of their habits will be a potentially major adverse effect. This will be especially true along the route from Alaska, through Canada, and in the pothole areas of North and South Dakota. Drainage of potholes would have a major adverse effect on the nesting of waterfowl in the prairie pothole region.

Noise of construction and maintenance of the line and operation of compressor stations along the line will disturb and displace wildlife, especially wilderness-dependent species, harassing and driving them into even smaller natural ranges.

Economic Factors

The proposed project will also cause short-term surges in demands for all public services and increased competition for housing, recreation, transportation and entertainment. These will be especially severe in rural parts of Canada, Montana and North and South Dakota.

Native Subsistence

Native populations (some 6,700 people) in the Arctic and Subarctic still rely heavily on a subsistence use of the land. Their overall relationship with the land is an integral part of their cultural pattern. Increased pressure on wildlife resources as a result of the proposed development will impact this use of the land as harvestable yields of wildlife and fish decrease and wildlife distribution patterns are changed. This impact will be accompanied by socio-psychological impacts associated with rapidly accelerated cultural evolution. The result will be a trend toward the break up of the man-land relationship among Native peoples as industrialization increases. The most severe impacts will be felt by Natives north of the Arctic circle.

Archeological and Historical Sites

Adverse effects in archeological and historical sites will depend on the effectiveness of the archeological salvage program that will precede the construction of the line. Some sites will be damaged or destroyed. This will be especially true in the Arctic and Subarctic where little is known of the extent of such archeological and historical sites. However, it is expected that major resources of national significance will be reasonably salvaged or protected. Particular care will have to be taken at river, stream and lake crossings in the Great Plains areas, where numerous archeological sites are present. The Cannonball site in the bluffs along the Cannonball River in North Dakota will be particularly vulnerable, for the proposed pipeline is to pass directly through the area.

Aesthetic and Recreational Considerations

The scars left by the proposed pipeline will have a detrimental effect on the aesthetic quality of the area through which it passes, though this will be a local condition. Extensive wilderness and other isolated remote or primitive type areas, especially in the Arctic and Subarctic, will be opened up for recreation, settlement and further oil and gas exploration and extraction.

Wilderness

The approximately 495 miles of Arctic wilderness traversed by the proposed line will experience cumulative long-term adverse impacts. Aesthetic degradation and access will increase with accompanying loss of natural wilderness characteristics. The proposed development will catalyze additional exploration and industrialization in the northern regions of Alaska and Canada. The last remaining wilderness continuum from the Beaufort Sea to the Brooks range will be destroyed for at least 133 miles east-west along the route. Construction of the proposed project will cumulatively open up the frontier wilderness regions of northeastern Alaska and northwestern Canada.

Hazards

The Applicants have not demonstrated that a buried, chilled pipeline can be operated safely in the permafrost region, especially in the discontinuous permafrost zone.

The pipeline design criteria formulated by the Applicants permit unconservatively high levels of stress and strain to develop in the pipe under certain combinations of external loadings. These levels are in excess of the allowable stress levels described by Part 192, Title 49 of the C.F.R.

The following evaluation of individual impact discuss the above impacts and others more fully and in more intensive detail.

3.OV.1 Impact on Climate

Construction, operation, and maintenance of the pipeline would have no effect on regional climate, but some microclimatic changes will result from operation of the completed system.

Compressor station turbine exhaust emissions at 600°F will cause the atmosphere downwind of the station to be warmed. Due to dispersal of these warm emissions into the air column, there should be no noticeable change in the temperature at ground level beyond the pad site. The buildings on the sites will present a windbreak, causing snow accumulation on the windward side. These snowdrifts will likely be restricted to the gravel pad on which all facilities will be located. No impacts due to drift accumulation are foreseen as a result.

Clearing through forests will create either wind tunnels or sheltered openings, depending on the orientation of the right-of-way to the prevailing winds. The ultimate impacts of this action on microclimate will be discussed later under Vegetation and Wildlife.

3.OV.2 Impact on Topography

Pipeline construction will result in minor, local alterations in topography. These will result from cut and fill, the pipeline ditch berm, with its possible subsequent subsidence, borrow pits, and spoil piles. On flat terrain such as the Arctic Coastal Plain and Great Plains, the microrelief will be increased to a minor degree. In steep canyons or on other steep slopes where the pipeline route is parallel to the slope, cuts and fills will create benches that will increase in size in direct proportion to the steepness of the slope. The probability of secondary impacts, including erosion, slumping, or landslides, are greatest on unstable, but not necessarily steep, slopes. Due to the linear nature and limited width of the pipeline right-of-way and construction area, significant impacts on topography are not anticipated in ice-rich permafrost areas. However, deep thawing along the pipeline route, which conceivably could occur if the schedule of construction were to be delayed into Spring; if repair work during thaw periods were improperly handled; or if trails designed for winter use only were to be used during the thaw periods, will result in a series of cross-country, water-filled ditches. In the Arctic and Subarctic this could amount to as much as 665 miles of the pipeline route.

Additional changes in topography are discussed under geology, soils, and esthetics.

3.OV.3 Impact on Geology

The proposed pipeline will have the most immediate effect on the surficial deposits along the route. In general, this impact, although of great magnitude, will be of little importance in the long run, for after the pipeline is buried and the surficial material is re-vegetated, little environmental change will be evident. An exception to this will be the disturbance of the surficial material in the permafrost area.

Impact on Permafrost

The disturbances in permafrost areas will most likely have long-term effects on the permafrost regime. Modification of the heat balance between the existing insulation properties of snow, soil texture and vegetation almost always causes degradation of the permafrost. If a high ice-content area is involved, subsidence, slumping, gullying and establishment of new drainage patterns occur. Once initiated, this degradation is difficult to arrest until a new heat balance is achieved. Disturbed areas are slow to regain a natural insulation because vegetation grows slowly due to the shortness and coolness of Arctic summers.

During both construction and maintenance phases, damage to the tundra by disturbance or removal of the overlying organic mat will occur, causing the underlying permafrost to thaw more deeply in summer. The behaviour of the material underlying the surface may be drastically affected, although the change may not be completed for a decade or longer.

Thawing of permafrost due to construction and/or maintenance activities could result in slope failure, especially where fine-grained, ice-rich soils are encountered. As melting of interstitial ice takes place, the volume of the soil profile is reduced and, if water is generated at a rate exceeding the discharge rate of the soil materials, the total mass may behave like a liquid. Permafrost close to the surface prohibits percolation and the collection of moisture at the base of the active layer provides a lubricated surface, both of which enhance slope instability. This could result in slope failure and mass wasting, causing accelerated erosion hazard anywhere in the continuous and discontinuous permafrost area (approximately 1370 miles of the pipeline route) where the slope is 3° or more and ice-rich soils are present. In "worst case" conditions as much as 665 miles of the proposed route might be affected along the corridor.

Thaw consolidation, generally a local occurrence, must be considered an annual event occurring most probably during early summer. Slope instability could occur throughout the life of the project. Any repair work to the proposed pipeline necessitated by such instability would thus have to be carried out when the ground surface is most susceptible to disturbance, thereby further aggravating the situation.

Secondary impacts which could occur as a result of thaw consolidation and attendant slope instability are increased siltation and lowered water quality, further upsetting of the heat balance, causing further movement of surficial materials.

The proposed buried pipeline system will cause pore water to migrate toward the advancing freezing front of the frost bulb created in the soil as gas at a temperature below freezing is moved through the pipe, thus providing conditions favorable for localized frost heave. Potential for frost heave appears most likely at or near thaw lakes, braided drainages, and wherever unfrozen lenses of soil are encountered. Frost heave is likely to take place during the summer; therefore, again, repairs to ruptures in the pipeline may be necessary during the summer.

Although the Applicants propose to maintain the frozen condition of the permafrost by cooling the gas below 32°F, they further state that the pipeline may have to be inactive for a period of a year or more after construction. Unless preventive steps are taken, settlement of the berm over the pipe will occur, and soil erosion and slope instability during thaw periods could take place.

After the life of the project, the man-made permafrost would be subject to thawing, causing potentially serious problems including soil liquefaction, mudflows, landslides, differential settlement, disruption of surface and ground water drainage and erosion.

The frost bulb will act as a dam to movement of near-surface water, which will be concentrated and ponded on the upslope side of the pipeline and will thus accelerate thawing of adjacent permafrost. Complete blockage of flow is probable. In river and stream beds along the Arctic Coast this blockage may extend to a depth of as much as 35 feet, and would force water to the surface, enhancing formation of aufeis and thus increasing the potential for formation of ice dams during spring breakup.

Similar but perhaps less extensive blockage of surface drainage patterns will occur from the presence of any surface structures, such as snow and ice roads, and work pads.

Impact on Mineral Resources

The most immediate effect on the environment from pipeline construction will be the need to extract more than 40 million cubic yards of sand and gravel for roads, building foundations, air strips and the like. If summer construction in the permafrost area has to be resorted to by the Applicant, the amount of gravel removed will increase by several orders of magnitude, because a road along the corridor will be necessary. The removal of such a large tonnage will have a temporary detrimental effect on the environment. If the gravel is dredged from rivers and streams, the silt that is stirred up will be deposited further down stream. At periods of low flow, the silt may cause moderate damage to fish and other aquatic life. The amount of sediment generated by dredging, however, will be only a fraction of that generated by a severe summer storm. In rivers and streams in the permafrost area, where spring runoff naturally carries large quantities of sediments, the effects of gravel extraction will be minimal. Removal of sand and gravel in borrow pits will create temporary erosion problems unless erosion control measures are practiced during and after removal. Present and future exploration for additional mineral resources will not be hampered significantly by construction or operation of the proposed pipeline.

No known open strip mines, pits or quarries, whether active or inactive, are known to be crossed by the pipeline so that no reduction in production of coal, clay or sand and gravel is foreseen in this area. Construction materials are, for the most part, readily available along most of the proposed route, so impacts on these resources are considered minor.

Access to the Arctic Coastal Plain and Foothills regions and to other prospective basins along the corridor provided by the proposed pipeline project can be expected to encourage exploration for and therefore exploitation of additional oil and gas supplies. Thus consumption of a non-renewable resources would be accelerated.

Future production of other mineral resources, notably coal, may be negatively affected temporarily by construction of the pipeline in sections of northeastern Montana and western North Dakota, in Illinois, and in the Appalachian Plateau area.

Coal gasification plants are contemplated or planned at various localities within eastern Montana and western North Dakota, and some reportedly would be located adjacent to or in the vicinity of the proposed pipeline. Undoubtedly the proximity of a gas-transportation pipeline to coal-gasification sites would encourage that use of the coal. The impacts probably would be both increased consumption and an increased rate of consumption. Coal deposits in northern Illinois, eastern Ohio and southwestern Pennsylvania can also be used for coal gasification and reportedly are now being studied. This gas could be transported by the pipeline. Supplies of arctic gas could delay the gasification of coal and the use of coal for industry. The largest impact on mineral resources will be an irretrievable consumption of at least 22.5 TCF of gas during the life of the project.

Impact on Geologic Hazards

Seismicity and Faulting

The proposed project is not expected to have any impact on seismicity or faulting in any region through which it passes. Disturbances which might be considered "man-made earthquakes" are possible during the construction of the project resulting from activity of heavy equipment and from blasting through bedrock for trenching, for example, through the High Lava Plains Province basalt outcrops along the West Coast route. Ground shaking might be felt from a distance of several yards to one mile, but it should be of short duration. Only minor damage, such as cracking of plaster, would be anticipated.

Landslides and Related Mass Movements

Construction of the proposed pipeline may affect slope stability to a moderate degree if: (1) the slope has previously undergone landsliding, (2) the slope is underlain by clay and silt, claystone, shale or siltstone, and especially if these rock and sediments contain swelling (bentonitic) clay, (3) the slope is steeper than about 30 percent (3 percent in ice-rich permafrost areas), and (4) the trench is parallel with the slope and is situated near the base of the slope or in the steepest part. Slope stability may be somewhat reduced if the slope is supported in part by massive, well-fractured sandstone, limestone or dolomite, and blasting is needed for trenching.

Construction of the pipeline could cause temporary loss of support of the slope because of the excavation of the trench. If the trench were open for a brief period before backfilling, landsliding might occur; the longer the trench remains open the greater the possibility. Blasting to permit excavation might cause loss of support by jarring earth materials from a position of support to overlying strata, or might cause a loose fragment to fall free.

The addition of water to an unstable slope may be hazardous because it adds weight, and because it reduces shear strength. Water may be introduced to a slope or a former landslide mass by the trench. If the gradient of the trench permits, the water can reach and enter permeable earth materials underlying the slope or an old landslide mass.

One aspect of landsliding is that it is difficult if not impossible to stop permanently. In addition, most landsliding is progressive upslope. The downslope movement of one mass removes support from material upslope, and in some cases laterally, so that material in turn is subject to landsliding. Thus, a small landslide low on a slope can eventually affect structures or crop production on the upland adjacent to the slope crest.

Along the proposed route landslides most likely will be encountered along steeper slopes, especially those that form the walls of valleys, for example in the Appalachian Plateau and in the Moyie River Valley, Idaho.

Rockfalls can be expected to occur where layers of hard to moderately hard rock, notably sandstone, limestone or dolomite, form ledges that crop out in steep faces or cuts. Conditions locally are favorable for rockfalls along the North Border segment between the Canadian border and the vicinity of the second crossing of the Missouri River, (2) at crossings of steep rock-walled river valleys, and (3) through the Appalachian Plateau province.

Mud and debris flows can occur as a result of pipeline construction, chiefly involving the trench backfill, but their likelihood appears negligible.

A potential impact of landsliding is damage to property, including structures associated with the proposed pipeline and property and structures belonging to others adjacent to the proposed route.

A further hazard can be expected through rock and soil falls within the trench leading to personal injury or death.

The scarring of the land surface by landslides can be considered an undesirable impact.

A secondary impact of landsliding can be the associated loss of vegetation cover and increased erosion leading to greater sediment loads in streams and subsequent sedimentation.

Other potential impacts of construction of the proposed pipeline on landsliding will be: (1) the introduction of water into presently stable landslide deposits and into rock and earth materials underlying presently stable slopes; (2) loading of the upper parts of presently stable landslides and slopes with excavation materials and equipment, and (3) undercutting by trenching of the toes of now stable landslide masses and the lower parts of presently stable slopes. Any or all of these can cause movement which, in turn, can affect the pipeline. If the trench has permitted the introduction of water to a landslide mass, movement of the mass increases the ease with which additional water can be introduced. The impact, thus, can be cyclical in character.

Landslides caused by the pipeline can occur at a given locality during construction and within the 100-year lifetime of the pipeline. They are more likely to occur during construction where the trench is situated in weak glacial-lake clays, at the base of a valley wall or at the toe of a presently stable landslide deposit.

Rockslides and rockfalls can occur at any time during construction or within the lifetime of the pipeline also. However, those occurring during construction are more likely to have been triggered by the work, even though their development may have begun earlier. Conversely, those that occur after construction may have developed mainly as a result of construction--but not necessarily--and probably were triggered by natural processes, perhaps enhanced by construction.

Mud-and-debris flows will occur after backfilling and subsequent to prolonged heavy rain. Those caused by the pipeline will involve trench backfill.

Construction and operation of the proposed pipeline will not damage bedrock strata or firm glacial deposits.

3.OV.4 Impact on Soils

Construction of the approximately 6,000-mile-long pipeline will cause impacts upon the natural inherent productivity and physical qualities of the soil. The construction process will result in soil disturbances on approximately 84,000 acres. The disturbance alters the soil's structural and chemical characteristics, micro-biological activity, and soil-climate relationships which have been established over a long period of time.

Increased susceptibility to soil erosion by wind and water will occur on the acreage of soil disturbed by construction activities. Eroding soil particles will provide particulates that will contaminate the air and sediments to pollute streams.

The most severe erosion impacts caused by construction activity will occur on the soils situated along the proposed route between Spokane, Washington and the Cascade Mountains in Oregon and in North and South Dakota. These segments of the route contain soils such as the aridisols that have a high susceptibility to wind and water erosion if vegetation is removed. Soil loss from the 4,800 acres of soils situated in this segment under existing conditions could amount to nearly 24,000 tons/year. Revegetation will be difficult on these sandy, low productive soils. The actual amount of soil loss which will be incurred following pipeline construction will be dependent on weather conditions and the conservation measures applied by the Applicant.

Where the Applicant utilizes single trenching the topsoil will be mixed with the subsoil. This mixing process will alter the physical and chemical properties of the soil profile. Mixing and burying the topsoil with the relatively infertile subsoil will prevent full restoration of the soil's productive potential until the physical and chemical properties of the material left on the soil surface are rehabilitated to the point where they are equal to the topsoil which was destroyed. The severity of this impact on plant reestablishment and crop growth will depend upon whether the topsoil is saved and replaced after construction and on the nature of subsoil material left on the surface. This will be particularly true in the mollisols and on the plains in Canada and the Northern Border routes.

Compaction of soils caused by heavy equipment traveling over the soil will cause a loss of soil productivity and also reduce water infiltration within the pipeline right-of-way.

In areas of permafrost, thermokarst will develop if vegetation and the soil surface is disturbed during the months of thawing.

Disruption of water supply and irrigation delivery systems will occur in Idaho, Montana and North Dakota where the pipeline will cross irrigation canals. This disruption, though of major importance, will be temporary. Subsurface drainage tile systems will be temporarily disrupted, especially from North Dakota to Pennsylvania.

Some soils, especially in Washington and Oregon and in organic soils in Canada and Alaska, contain acidic concentrations that are corrosive to untreated steel.

In addition to impacts on the construction site there will be offsite disturbances from the excavation of bedding material and disposition of surplus spoil from the pipeline trench.

3.OV.5 Impact on Water Resources

The impacts of the project on water resources, for the most part, are not expected to be severe over the long term because of the short duration of some impacts, the decrease in effect with the passage of time of others, and the self-correcting nature of some impacts. Although most impacts are readily identifiable, they are difficult to quantify at this time because no final alignment has been determined and also because of lack of basic data and experience with a project of this type in some regions, particularly the far north. The impacts of the project on water resources will involve temporary lowering of: (1) the physical quality of the resource in all construction localities, (2) potential change in its chemical quality from pollutants, (3) alteration of the physical environment of which it is a part, and (4) to a lesser extent, its availability for all use. This could result in a temporary local depletion of major impact.

Impact on Surface Water Quality

Increased sediment load and turbidity of streams due to erosion in the project area can be anticipated, mainly during the few weeks of actual construction and to a lesser extent the time it takes the area to be revegetated. One estimate (unpublished communication, U.S. Geological Survey) suggests that in Montana, for example, the increase in sedimentation could be 10 to 20 times the normal load, due partly to eroded soil and partly to eroded underlying earth materials. In parts of Canada this temporary increase in concentration could be as much as 1,000 times greater than normal, unless care is taken during construction. Increased erosion of soil and other earth materials could occur along the entire pipeline right-of-way, along access roads, in borrow pits and disposal piles unless mitigating methods are applied during construction. Other causes of increased turbidity and sedimentation include: disturbance of stream-bottom materials during construction and/or maintenance activities at and in the vicinity of stream crossings, especially in areas subject to flooding; increased erosion of channel banks as well as floors due to removal of vegetative cover and thus greater exposure of earth materials to current action; and, as a secondary cause, increased access to off-road vehicular traffic provided by the clearing of the proposed right-of-way.

Discharges of hydrostatic test water could cause substantial amounts of channel erosion if released to dry channels or to those with small surface flows. These discharges could amount to as much as 950,000 cu.ft. for a 20-mile length of pipe, a volume which could modify channel configuration, induce local streambed erosion or gullying, and create or augment surface flow for at least several miles.

Impacts of increased turbidity and sediment load include increased deposition on channel floors and banks, one result of which could be restricted channel dimensions and concomitant increased potential for flooding and/or greater likelihood of higher flood levels. Prolonged increases in suspended-sediment concentrations could cause an increase in biochemical oxygen demand and a lowering of dissolved-oxygen concentration, which could be critical to stream biota if it occurs when oxygen levels are naturally below saturation. Burying of stream organisms can also occur and effects could be severe, especially if burial occurs during periods of low flow. Impacts of increased turbidity and sediment load on aquatic biota are discussed in greater detail below.

Increased turbidity and sediment loads can also cause fouling of private and public water-supply filters, requiring modification of normal maintenance schedules. There may also be an increase in lateral and longitudinal migration (shift) of stream channel meanders.

The aesthetic quality of the surface waters will be degraded to some extent by change in color due to increased turbidity and sediment load.

Generally, increased sediment load and turbidity levels are expected to be of short duration, occurring only during construction and maintenance activities; these levels, barring further disturbance, would gradually return to normal, over periods of time varying due to flow and gradient characteristics, etc., of individual streams. Nevertheless a general lowering in water quality around all pipeline interfaces with water bodies will take place locally and downstream. Generally this will continue only during the construction phase, but in isolated cases may continue for a year or more. This could have an impact on fisheries especially in the Arctic.

Quality of surface waters can also be affected by accidental leaks and spills of fuel oils, methane, methanol, and other toxic materials, such as pesticides. A certain amount of fuel spillage at concentrated storage and distribution points is inevitable. Generally, the impacts of small petroleum spills on the environment are expected to be minor. Catastrophic spills in a body of water, however, may severely affect aquatic life. A critical area is the Mackenzie River, where heavy barge traffic is proposed.

Methanol, to be used in hydrostatic testing of the system in the far north, will also affect water quality. Aquatic biota appear relatively tolerant to 1-percent solutions of methanol in water. The effect of stronger concentrations, such as the 26-percent solution to be used to test the pipe, is unknown, but it is presumed harmful.

It is assumed that accidental leaks of methane during operation of the pipeline system can occur. Methane should dissipate rapidly in an open-stream system; however, a small, undetected leak of long duration may add small quantities of methane to the water. If a leak occurs in a buried pipe which intercepts a shallow aquifer, hazards to public water supply may exist. For example, as little as 1 mg/l of methane in water at 74°F may create an explosive atmosphere in a confined area, such as a shower stall (Harder, A. H., and others, 1965, Methane in the fresh-water aquifers of southwestern Louisiana and theoretical explosion hazards: Dept. of Conservation, La. Geol. Survey, Water Resources Pamphlet 14, 22 p.).

The possibility exists for the introduction of fertilizers, pesticides and herbicides to surface waters as a result of the proposed pipeline construction. Application of fertilizers will take place during revegetation. Of the major fertilizer components, nitrogen and potassium are capable of migrating to and in bodies of water. Natural ion exchange processes will trap most of the potassium, but significant nitrogen, as nitrate, may reach waterways and contribute to eutrophication processes.

It is possible as well that pesticides and herbicides, to be used along the route for insect and weed control, may reach bodies of water, mainly by soil erosion and/or spills due to careless discard of empty containers. Most of the insecticides and herbicides break down within a day or two.

However, the chlorinated ones, which are long-lived, can enter the food chain and become stored in fatty tissues of consuming wildlife, thus causing poisoning.

Most of the farming regions along the proposed route already show "background" levels of pesticides in the soil. The impact of pesticide use, therefore, is expected to be incremental, barring a catastrophic spill.

Potential impact to water resources along the route also exists from the disposal of waste materials generated during construction and operation and maintenance. For example, it is estimated that each compressor station will generate annually about 150 gallons of waste oil. Water pollution problems could develop in the event of spills or leaks of this waste into lakes or flowing water. These petrochemicals and petroleum products are toxic, stable compounds which can remain in the aquatic ecosystem for long periods of time.

Impact on Water Supplies

Large and indiscriminate use of surface waters for test-water supply could cause temporary drawdown and possible interruption of flow in small streams.

Primary and secondary impacts on both surface and ground water resulting from the presence of construction workers can also be anticipated. It is estimated that, along the West Coast leg alone, about 40.5 million gallons of water may be required for a 6-month period for worker consumption. Most of this water would be returned to the environment via body wastes to surface and ground water. Even where less water would be required, impacts can be expected on local water supplies.

In general, construction, operation and maintenance of the proposed pipeline should have little effect on ground-water quality. Any leaks of methanol to ground water, accidental spills of fuel or other chemicals, seepage of sewage effluents from lagoons or ponds, or leaching of buried solid wastes all have the potential to degrade the ground water, but impacts are expected to be negligible to nil. The major effect on ground water are most likely to be on its supply.

It is possible that trenching can "behead" the upper part of ground water present in a shallow aquifer, if the floor of the trench is lower than the water table surface, and if the trench provides a gradient. A resulting impact is the lowering of the water level of wells; however, only dug wells are dependent on such shallow supplies, and very few would be affected along the proposed route. Another impact is the possible draining of ponds or wetlands, such as those present in the pothole country of North and South Dakota, Minnesota, and northern Iowa. A third potential impact may be reduction of flow from a spring downslope of the trench. No such impacts are anticipated along the West Coast route, however, because the proposed pipeline would be buried substantially above the water table for almost the entire distance.

It is anticipated that pipeline construction will have no impact on the quantity of water recharging deep aquifers used as municipal water supplies.

Overall, the most significant effects for water supply conditions along the corridor appear to be likely in the Arctic region where supplies could be short in winter and construction demands could be great.

3.OV.6 Impact on Vegetation

Vegetation will be totally removed from the part of the right-of-way required for the pipeline ditch, permanent roads, and other permanent facilities. On the remainder of the right-of-way, usually 100 feet in width, the vegetation will be removed or damaged due to construction of snow or ice roads; forest, grass or tundra fires; spillage or fuel or methanol; exhaust emissions; and off-road vehicle use, this last of which would more commonly occur during emergency repairs. Methanol is used in hydrostatic testing of the welded pipe. Spill rates of 36 liters/m^2 of a 20 percent methanol solution was found to cause a reduction in plant cover by as much as 65 percent (Northern Engineering Services Company Ltd, 1975). For construction purposes, the vegetation will be entirely removed from a total of 84,138 acres or more of permanent and temporary right-of-way, the majority of which will be revegetated.

Soil compaction or alteration of drainage patterns could cause a long-term change in the species composition of the various plant communities. In all cases, including the revegated pipeline ditch berm, the previously existing community will be replaced by one of an earlier successional stage, due to the physical, chemical, or biological changes in the soil. Loss of the microflora and microfauna and mixing of the various soil horizons will change the previously established water and nutrient exchange pathways, thus creating a new plant habitat to be invaded by adapted species. Through plant succession, the original community should reestablish itself in time, provided that the habitat is not irrecoverably changed or that artificial means are not used to prevent plant succession from proceeding. For example, removal of mature forest and maintenance of the right-of-way will result in development of an open shrub community where coniferous forest formerly dominated. Arctic revegetation studies predict long-term impacts on species diversity, cover, and flower production due to scraping of winter roads; compression resulted in predicted long-term impacts on species diversity only (Battelle, 1974). Long-term adverse impacts are also likely in areas of eastern Oregon, where revegetation on the existing pipeline was unsuccessful due to excessive wind erosion.

Communities low on the successional scale tend to have little storage, but rapid turnover and considerable loss, of nutrients. They also tend to be highly productive. Where succession takes place readily, there is likely to be an overall increase in primary production. This will be most probable in certain of the boreal and temperate coniferious forests and in the deciduous forests. On the other hand, succession tends to be naturally restricted in severe environments, so that an overall loss of primary production could be anticipated. This could be anticipated in the chaparral, desert, tundra, and certain of the temperate grasslands. These latter will also be difficult to reestablish. Therefore, an overall decrease in primary production is a certainty in these biomes. The extent of these various vegetation types is shown in Table 3.OV.6-1. Considering the areal extent of these vegetative types, there is not likely to be a significant change in primary production on the whole. However, local decreases or increases could be extremely significant. For further elaboration, chapters 3, Sections 6 of the various geographical volumes should be consulted.

Normal operation of the pipeline will result in compressor station exhaust emissions, composed of mostly normal atmospheric components, i.e., nitrogen, water, carbon dioxide, along with nitrous oxides, carbon monoxides, sulfur oxides, and unburned hydrocarbons. Depending on whether or not atmospheric conditions are conducive to dispersal of emissions, vegetation in the immediate area of the compressor stations could suffer a loss of vigor or possibly death. Sulfur, which would be emitted at less

Table 3.0V.6-1 Vegetation types traversed by pipeline rights-of-way (miles)

	APPLICANT					
Vegetation Types	AAGPC	CAGPL	N.B.	PGT/PGE	ITA(A)	Total
Tundra	173	648				821
Coniferous Forest		1212		315	98	1625
Temperate Grassland		399 1/	265	505 1/	27	1187
Deciduous Forest		176	76			252
Chaparral				25		25
Desert				72		72
Riparian & Marsh	22	*	25	*	4	51 2/
Crops		*	1243	*	262	1505 2/
Total	195	2435	1600 3/	917	391 4/	5538

* Denotes that this category was not used in the applicant's environmental assessment, although the vegetation type does occur.

1/ Includes lands planted in crops.
2/ Incomplete total; some of the total is included in other categories.
3/ Approximate total.
4/ New construction only.

than 1 part per million (ppm), has the greatest potential for harming vegetation. However, the area immediately surrounding the compressor stations will usually be covered with asphalt or other impervious material or with gravel, and no vegetation will remain. Computer simulations have shown that under worst case conditions the SO_2 concentration at ground level from compressor stations will be less than 0.2 part per billion (ppb). Lichens of the tundra, which are among the most sensitive of plants, suffer reduced photosynthesis at SO_2 concentrations at 50 ppb of air. Therefore, no adverse impact on vegetation is anticipated from compressor station operation. Further discussion of impacts on air quality appear in Section 3.OV.14.

In most cases, the pipeline right-of-way will be kept clear of trees. PGT has indicated that trees will be permitted on the right-of-way as long as there is little potential of their root systems damaging the pipe. Methods for controlling woody vegetation include chemical and mechanical procedures. Chemicals (herbicides) tend to be non-selective and kill many non-target species, as well as causing loss of vigor to vegetation adjacent to the target area. Some herbicide is invariably carried away by surface runoff and enters streams, where aquatic vegetation could be adversely affected. Cutting on the other hand affects only the target species with the probability of increased productivity due to the lowering of the stage of succession of the community within the right-of-way. This increased productivity would not be obvious until at least the year following cutting. In either case, the previously created ecotone between the original mature community and a successional community will be maintained.

Immediate repairs will have to be made if the pipe should rupture or be severed after it is in operation. These repairs will have to be made with complete disregard for weather conditions or other environmental factors that could be mitigated during the initial construction of the pipeline. The impact on vegetation would be most severe in the tundra, if repairs must be made when the active layer is thawed. Access during this period would be by air cushion vehicle, which would have a minimal impact on vegetation, or low ground pressure vehicles, which would cause some compaction of soil and compression of vegetation. In addition, ditching through the thawed soil and permafrost would cause drainage problems. Ice-rich permafrost is likely to form in the backfilled ditch, once the pipe is returned to operation and the soil freezes. Revegetation in some cases would have to wait until the following spring, with probable erosion in the meantime. Ultimately, drainage patterns would be altered and community succession initiated. Impacts would most likely be long-term and significant. In other areas, the impacts of rupture would be that of fire or, in its absence, similar to the original construction impact. These impacts would be relatively less significant.

Fire itself will result in impacts on vegetation. Fire is not necessarily restricted to the operation phase of the transmission line. During construction, the concentrated presence of men, machinery, and fuels will increase fire hazards as well. Certain communities, such as chaparral and prairie are somewhat fire resistant on long-term or successional basis. However, they tend to burn readily and extensively once ignited. Extensive fires can also occur in forests, under favorable moisture conditions. In closed forests during the dry season runaway crown fires can burn extensive acreages of forests with significant, long-term adverse impacts. Recovery in some cases requires in excess of a century, e.g., climax deciduous forest in the eastern U.S. Tundra does not burn extensively, and recovery is somewhere between the grassland and climax forest. The forest tundra complex may require 50-70 years to stabilize, while revegetation appears to be quite rapid in tundra vegetation (Wein, 1974).

Of its approximately 5,557 mile length, the pipeline will traverse 821 miles of tundra vegetation. This vegetation will be changed in the indefinite future. For the most part, tundra vegetation characteristic of dryer sites will be replaced by wet sedge meadow where subsidence occurs. Where well-drained sites are reestablished, tundra will eventually reinvade, with a probable long-term reduction in cover and a decrease in the abundance of lichens. Approximately 1870 miles of the right-of-way will be cleared of forest, and maintained in grasses and shrubs. Of this, major commercial forest types involved are confined to less than 10% of the woodlands crossed. These are primarily located on the West Coast route and are largely on Federal lands. Approximately 315 miles may become reestablished in forests of shallow-rooted trees on the West Coast. Between 95 and 100 miles of the pipeline will traverse the desert and chaparral. These vegetative types will recover extremely slowly and a long-term reduction in cover will be obvious on the cleared right-of-way. Of the 1187 miles of right-of-way in grasslands, most will recover completely within a few years, although long-term reductions in cover will occur in dryer areas, such as eastern Montana and eastern Oregon. Marsh vegetation will recover rapidly, provided that drainage patterns are not altered. However, some landowners are likely to request that marshes be drained for agriculture.

3.OV.7&8 Impact on Wildlife and Ecology

Impact on Terrestrial Wildlife

There will be a temporary loss and often permanent change of habitat from the clearing of a 100 to 120 foot wide swath of vegetation approximately 5,557 miles in length. This will result in displacement of resident populations of the earlier described large ungulates, small mammals, birds, and other wildlife. The magnitude of the impact will vary from community to community, depending upon the timing of construction, the availability of similar habitat, and the ecology of the various component species.

Along the entire 5,557 mile approximate length of the proposed pipeline, the potential for serious impacts on wildlife from a national standpoint is greatest in the Arctic. This area is essentially undeveloped and extensive wildlife populations have been little affected by human activity to date. Human activity is most incompatible with species that are characteristic of wilderness areas. Included in this category are caribou, musk ox, polar and grizzly bear, wolf, and wolverine.

The potential effects of the proposed gas pipeline project on the Porcupine caribou herd which migrates twice annually between Canada and Alaska have been assessed by Calef (1974) using published and unpublished literature, and 3 years of field data collected by consultants to the Environmental Protection Board and Canadian Arctic Gas Study Ltd. These impacts will be compounded by and inseparable from those of the Dempster Highway, a petroleum carrying railway, and subsequent heavy traffic on each. Calef (1974) indicates that the potential impacts of traversing 280 miles of calving grounds and intersecting migration routes for 380 miles are:

1) Direct mortality of caribou from hunting, from collisions with vehicles, and from injuries sustained in stampedes caused by disturbance;

2) Disturbance by human presence, aircraft, construction equipment, and blasting;

3) Physical barriers to migration including berms, thawed right-of-way, access roads, open trench, and pipe strung on ground; and

4) Habitat destruction by fire, direct destruction, and terrain degradation.

If adequate mitigation is not developed and enforced for the ANGTS, highway, and railway projects, it has been estimated that the Porcupine herd could decline by as much as 90 percent in 5 to 10 years (Calef, 1974).

Pipeline construction and operation has the potential for impacts on several other Arctic mammals. These impacts which fall into 3 categories, as described in Kucera (1974), include direct mortality, disturbance, and change of habitat. In addition to the Porcupine caribou herd, key species that will be affected to one degree or another would be the polar bear, grizzly bear, wolf, wolverine, and musk ox. These impacts are described by Kucera (1974) as follows:

1. Direct Mortality

Blasting under the water or on the ice may kill aquatic mammals. Oil spills are also a major threat in the sea (polar bear, seals and whales). The most important mortality factor is the killing of animals by humans. Legal or illegal, hunting remains a major threat to bears, wolves, wolverines, and musk ox. Increase in accessibility of the area provided by the right-of-way and permanent and winter roads will result in increased hunting pressure. Easier travel on cleared routes will encourage the trappers to use additional areas.

Grizzly bear, polar bear, and wolverine populations will probably decline in the vicinity of the pipeline route. Wolf production in the open tundra will also decline, unless present management practices are modified. Effect on other mammals will be insignificant, provided that adequate recommendations are followed and enforced.

2. Disturbance

The most harmful type of disturbance is deliberate harassment with vehicles or aircraft. It would affect all large mammals in treeless areas. Harassed animals may die from fright and accidents, or become more vulnerable to predators. Availability of garbage can attract bears, wolverines, and foxes, and increase the probability of the animals eventually being killed.

3. Loss or Change of Habitat

Dens of wolves and grizzly bears may be destroyed during grading and borrowing; but the probability of such destruction is low. Any activity that would cause decline of the caribou population would also eventually cause decline of populations of wolves and wolverines, by decreasing their food supply.

Since the population of smaller mammals such as lemmings is large and well distributed, a miniscule fraction of foraging areas will be lost. It is impossible to avoid loss of some small animal burrows and dens. This localized loss is not expected to severely affect the total populations (Quimby and Snarski, 1974). Individuals and/or local populations of arctic ground squirrels or microtines could conceivably be forced into other habitats, but as long as well-drained soils are available within the range of the species, this impact will be minor. A localized absence of lemmings within the Prudhoe Bay test area was observed in one study (Battelle, 1974). This absence was assumed to be due to construction activities, as there was no difference in the vegetation and surface conditions of the test area and an area outside the test area. A density of 35 animals per acre was observed in the peripheral "control" area, while the "disturbed" area had a density of only 4 per acre. Since microtines are indicators of productivity, reduced populations show that the habitat underwent a change in carrying capacity.

The response of wildlife to direct disturbances is generally in the form of behavior alteration. Direct disturbances associated with construction activities include blasting, noise associated with machinery and vehicle use, visual presence of equipment, aircraft overflights, and human activities.

Indirect disturbances to mammals include alterations in less obvious environmental factors such as changes in soil-surface moisture regimes or composition of vegetation. While these indirect disturbances are not expected to result in any identifiable short-term effects, possible long-term changes in vegetation type, chemical content of vegetation, and/or relative abundance could conceivably alter the associated mammal populations. For example, as long-term stabilization of the pipeline crown proceeds, small mammals are expected to occupy the drained portions of the crown for burrows and/or dens. Predator populations will dig into these disturbed soils in search of ground squirrels, lemmings, and voles. This can lead to local reversal of revegetation success and further displacement of small mammal populations until restabilization can occur.

Summer construction south of the permafrost zones and other activities conducted during the summer (including stockpiling and shipping in the far North) will directly impact wildlife populations. Those species inhabiting the grasslands, temperate forests, chapparal, and agricultural areas (see Section 2.OV.7 for common species) will be present while the construction occurs. Clearing will result directly in the death of various small mammals and birds with the greatest loss occurring during the rearing of young. Ditching will also kill species that inhabit or den in the soil. These species are usually very prolific, and such losses are quickly replaced. Larger mammals will escape, although loss of fawns is possible.

Ungulates and their predators will be affected to a greater degree. The open ditch spoil pile, and activity in their environs will constitute a barrier to the free movement of these animals. This will only be a major impact should seasonal migration routes be intersected. This would be most likely to occur on the West Coast legs, where a pipeline is already in place. Timing is a determining factor, since migration routes are known. No significant impact is expected.

In areas of summer construction, there could be a loss of winter range, since revegetation could not be accomplished before the following spring. Assuming successful revegetation, the range should recover within 1 year. However, where such habitat is vital to a herd, a significant decline could occur. In Canada and on the west Coast, many of the river valleys provide winter range for deer, elk, and moose; there is also winter range for antelope in the sandhills and badlands of southern Alberta, Montana, and the Dakotas. In many of these areas, herd size is determined by the availability of the winter range, and any decrease in range brings about a subsequent decrease in herd size. Decreased carrying capacity for antelope and deer is anticipated.

Successful revegetation and forest regeneration can increase the carrying capacity for grazers and browsers in forested areas. This could ultimately provide summer or winter range, depending on its location. It would be good winter range where protected from snow accumulation. However, any increase in summer range without the provision for winter range could create problems, with a need for greater culling of herds in the fall. This is especially true of white-tailed and mule deer, but may also apply to elk. Hence, the "edge-effect" (ecotone) may be beneficial or adverse depending on the pre-existing balance between summer and winter range and the amount of hunter use.

The whole of the Alaskan, most of the Canadian (excluding the Kingsgate lateral), and the western part of the Northern Border proposed pipelines in Montana, the Dakotas, Minnesota, and Iowa traverse habitat important for the breeding, staging, and migration of waterfowl and other water-oriented birds. The pipeline has the potential for causing some major unavoidable and many avoidable impacts on bird populations, depending on the location of the route and associated facilities and the construction practices and scheduling utilized (Jacobson, 1974).

The major potential for avoidable impact associated with pipeline construction and operation is disturbance by aircraft, construction activities, and human presence. Such activity could disrupt normal staging activities of swans, geese, and ducks along the Mackenzie River during spring migration; it could disrupt normal nesting activities of swans, geese, and sandhill cranes in the outer Mackenzie Delta, and of geese, ducks and loons in all regions (including the prairie pothole region of the Great Plains). It could displace colonial nesting birds on the Arctic Coast, where it could also disrupt normal molting activities of ducks and fall staging of geese. Uncontrolled barging activity on the Arctic Coast could disturb thousands of molting ducks (Jacobson, 1974). Disturbance during nesting can cause adults of some species to abandon eggs or broods or leave the nest for a long enough period for eggs and young to fall prey to predators. Disturbance during molting can increase a bird's vulnerability to predators, while disruption of staging would interfere with subsequent migration and a greater than usual number of birds would be lost. Further impacts, as described in Jacobson (1974) include the following:

The noise of operating compressor stations on the Arctic Coastal Plain could alter traditional use of the area as a feeding and staging area by snow geese.

Large fuel spills into the Mackenzie River, the Mackenzie Delta, or the Beaufort Sea have the potential for widespread and large-scale destruction of waterbirds and their habitat.

Except for large fuel spills, uncontrolled use of firearms is the major potential source of direct mortality.

In addition to the disturbance by the construction and operation of the pipeline proper, a vast supply and service infrastructure will develop during the construction phase. The activities and human presence associated with these developments will provide a major source of impact on many species.

The cumulative effect of all disturbances, including; effects of future seismic activity, exploratory drilling, extractive drilling and transport of oil and gas along the proposed route and adjacent areas would have a detrimental impact on the Arctic wildlife resource. The entire north coast and part of the outer continental shelf could be affected. The Arctic National Wildlife Range may have substantial oil and gas reserves, and refuge status may not preclude development under the present policy of energy independence.

The State of Alaska has sold and may sell more coastal oil leases between the Arctic National Wildlife Range and Naval Petroleum Reserve No. 4 (Pet 4). The Navy is proceeding with exploration and development on Pet 4.

Coastal areas west of Pet 4 may have oil and gas reserves and are eligible for Native selection under terms of the Alaska Native claims settlement Act. These lands probably will be developed. The Department of Interior has identified the Beaufort Basin as one of nine Alaska outer continental shelf areas scheduled for early leasing. The State of Alaska has prepared an environmental assessment in preparation for leasing State owned submerged lands in the Beaufort Sea. No firm plans for State leasing have been made.

Approval of the pipeline could serve as a catalyst to stimulate development, particularly petroleum development, in the Canadian Arctic (Jacobson 1974). If the gas pipeline were the only factor to affect the north coast environment it might be argued that effects on North Slope wildlife would not be too serious. However, combined impacts of the gas pipeline and other proposed activities will have most serious environmental effects including disturbance to wolves, musk ox, caribou migration and calving, polar and grizzly bear denning, reduced productivity of Arctic terrestrial and marine species, and disturbance to the food web with resulting reductions in the populations of resident and migratory mammals and birds.

In the prairie pothole region, particularly in the Dakotas and Minnesota, important waterfowl breeding habitat could be lost through dewatering or silting in of potholes resulting from or in conjunction with construction. The impact would be locally significant. This area is also an integral part of the Central and Mississippi Flyways. Construction during spring and fall would effectively reduce available resting and/or feeding habitat for migratory waterfowl and shorebirds.

On the relatively undisturbed northeastern portion of the Arctic Coastal Plain and in the Mackenzie Delta area relatively severe impacts are possible. Aircraft movements and human presence would be the principal sources of impact. The potential for serious impact is greatest with snow geese staging for fall migration on the Arctic Coastal Plain. Snow geese are particularly sensitive to disturbance by aircraft. They will flush as far as nine miles from a low-flying aircraft; even at 10,000 feet, aircraft disturb resting snow geese (Salter and Gallop, 1974). Repeated exposure to this disturbance is critical because it limits the storage of energy necessary for migration. Such impacts are probable near active airfields and stockpile areas, where activity will take place all year.

The severity of construction impacts on wildlife, especially on migratory species, is often dependent on the construction schedule. For example, winter construction in the Arctic would have a minor impact on caribou and waterfowl. However, if construction continues through May, activity would be ongoing during the arrival of pregnant caribou or mating waterfowl. Depending on the location of construction, migration routes for caribou could be cut off and migrating maternal groups would not be able to reach their traditional calving grounds, which are bisected by the route. Similarly, elk migration could be adversely affected by poor timing. Such events would result in severe, probably long-term reduction in population size.

The possibility of future expansion exists on any reach of the pipeline. This would involve looping on the Alaska, Canada, and North Border pipelines. The impacts of such looping would displace wildlife species that inhabit the rights-of-way following the initial construction. The ITAA pipeline expansion would involve new construction of 670 miles of pipeline through Oregon, Nevada, and Southern California, along with the associated compressor stations, block valves, and other facilities. This would result in impacts similar to those of other new construction in arid areas. In some cases, repeated disturbance in an area will cause wildlife to abandon such areas, resulting in an effective loss of habitat and subsequent population decrease.

Should a pipeline rupture or malfunction occur, immediate repairs will be necessary. Such repairs will possibly necessitate travel over thawed permafrost, with consequent impacts on the tundra vegetation and the wildlife on which it is dependent. Such impacts would most likely be localized, but long-term.

Active airfields and maintenance camps could effectively deprive snow and white-fronted geese and whistling swan of nesting habitat up to a radius of 1-1/2 or 2 miles around the perimeter (or air traffic pattern) of each site. While the impact at each site would be minor in relation to the total available habitat, there would be a cumulative long-term loss in reproductive capacity. Such overflights and maintenance activities in the summer would also adversely affect mammals that will not tolerate such disturbance. Caribou, grizzly bear, musk ox, wolves and wolverines do not tolerate human activities. Disturbance will cause these animals to flee. This can result in a negative energy balance if it occurs with sufficient frequency. In addition, traditional areas of habitat may be abandoned, placing a greater burden on adjacent areas. Ultimately there would be a long-term reduction in carrying capacity with eventual decrease in size of the populations of wilderness-type species.

In summary, wildlife will suffer most severely in the Arctic, although local aberrations will occur elsewhere. In the Arctic it is the wilderness-dependent species that will take the heaviest impact from the pipeline and its cumulative long-term effects, namely; the caribou, grizzly and polar bear, wolf and wolverine. These are closely matched by most waterfowl, but particularly snow geese.

Although it is difficult to differentiate among these species, the Porcupine Caribou herd of 100,000-140,000 head stands out as the prime loser. Its migration routes and calving grounds in both Alaska and Canada are repeatedly transected by prolonged development, maintenance and operational activity plus clear potential future development and opening of the region. The cumulative prolonged exposure to all influences including the Dempster Highway construction, could reduce the herd in a decade, to 10 percent of its present size. Control of construction schedules during migration and calving periods could prevent this.

Snow geese, numbering 300,000 in the region of the pipeline, use the Mackenzie River for spring migration and fall staging and the coastal plain for feeding and staging. As these geese are susceptible to fright, particularly from aircraft, a single airstrip would make large areas of critical habitat unavailable. A zone of influence on snow geese could exceed 250 square miles about the strip. Also, there is no practical flight altitude that does not frighten snow geese. Forced to leave staging areas, they may interrupt migration and increase their exposure to natural and hunter mortality. Cumulative long-term exposure could destroy the population.

Impact on Aquatic Life

Major impacts on fish will occur at river crossings due to construction machinery, ditching, and filling. Activities within river channels will resuspend bottom sediments, resulting in an increase in suspended and dissolved solids. Suspended sediments decrease the depth of light penetration and consequently gross primary production; in setting, they can clog the gills of aquatic organisms and cover gravel bed required by many fish species for successful spawning. All of the above would be more severe in cold-water habitats where the organisms are adapted to clear water and rocky bottoms. Warmwater species are usually well adapted to conditions described above, and will be relatively little affected. Since construction of any river crossing will last no longer than one year, and since most cold-water streams are degrading (channel depth decreasing), gravel beds will be scoured and resident populations should recover within 1-3 years. However, erosion and mass wasting could possibly extend increased sediment loading for several years, with a subsequent extension of the time required for recovery. Looping the line will create impacts similar to those of the original line.

A number of potentially toxic materials will be used during construction. If spilled, these could reach streams, causing mortality among resident organisms. Among these materials methanol used as antifreeze in hydrostatic testing has the greatest potential of entering streams. However, any spill is a chance occurrence, and no precise assessment of the impact is possible due to the number of variables involved, but potentially serious adverse impacts could result. For example, char and grayling fry cannot tolerate exposure to one percent methanol for greater than 24 hours, and concentrations greater than 2.5 percent are lethal in a much shorter time. Eggs of these species, while not killed by a 24 hour exposure to one percent methanol, will be damaged and their development will be delayed. Therefore, methanol and fuel spills of sufficient size will kill most or all life in the immediate area, while smaller spills will result in subtle but deleterious effects that could seriously affect the long-term productivity of an aquatic community.

Dewatering of streams or lakes for hydrostatic testing, for domestic use at construction camps or for snow and ice roads could adversely affect resident organisms directly. In the permafrost area there is a possibility that a shortage of water necessary to support winter construction will cause use of water in sensitive overwintering areas for fish. This could cause a decline in the fish population. Secondary impacts could also result due to the interaction of decreased flows and increased BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand). The primary source of BOD is untreated sewage, while COD will be increased due to the increased dissolved solids that arise from the anaerobic lower layers of sediment. The latter will be of significance only in heavily polluted streams. Competition for oxygen then arises between resident fish and their food organisms and the decomposers that break down organic wastes. The potential for oxygen depletion is greatest in small streams or under ice. Oxygen depletion would eliminate all oxygen breathing organisms for the distance downstream that is required for reaeration to occur. The magnitude of these impacts cannot be determined until water sources and discharge points for effluents have been defined.

The frost bulb around the chilled pipeline would act as an ice dam blocking the groundwater flow in the alluvium under Arctic streams. Very serious aufeis (icing) problems could be anticipated when this occurred. Extensive aufeis areas can persist throughout a summer season. Water temperatures in a stream would be significantly depressed below a large aufeis area, 5.5°C in one case (Craig and McCart, 1975). This could result in thermal barriers to migration or cause a spawning area downstream to become unacceptable or unproductive because of the depressed water temperature, although spawning areas downstream from the river crossings in the Arctic are rather limited. However, a barrier to upstream migration has the potential for eliminating all or a significant part of a fish population.

Arctic fish are long-lived and slow growing. Ice-free streams of sufficient depth to maintain sufficient oxygen to enable fish to survive the winter are relatively scarce. As a result, all age classes become confined to limited overwintering areas, including deep river pools, a few relatively deep lakes, and river reaches fed by springs. Dewatering of such streams or lakes, decreasing the dissolved oxygen due to addition of silt and organic wastes, or the interaction between dewatering and decreased dissolved oxygen would result in an extensive fish kill. Some construction activities may modify or destroy aquatic habitats and thus result in a long-term loss of fish which would be even more damaging to most species than the more severe short-term environmental degradations. Sprague (1972) has noted, for example, that in the Arctic:

> ...It might be difficult to wipe out a species of fish through serious but temporary damage to the environment, if it lasted for only 2 or 3 years. This is because the fish population would be made up of many year classes, only slightly different in size because of slow annual growth and long life. Therefore, a few missing year classes would be filled in by older and younger fish, with little effect in the long run.

However, long-term effects certainly could result from short-term environmental degradation in certain overwintering areas where all age classes are confined within a small area.

Overall, the cumulative impact on anadromous fish and grayling stocks in the Arctic seems the outstanding aquatic impact. Combined effects of 3-7 years of sedimentation and other direct constructicn or human activity effects, particularly water depletion in overwintering areas, could seriously reduce fish populations.

Marine Systems

Construction and use of wharves and stockpile areas would subject the inner contential shelf and the Beaufort Sea coast to marine surface shipping. Accidental spills of fuels or toxic chemicals or discharges of wastes could interfere with the delicate balance of this ecosystem. The extent is unknown. The size and frequency of fuel spills from a variety of sources cannot be predicted nor can they be entirely prevented as has been demonstrated from experience gained on the trans-Alaska oil pipeline. Oil spills can have a devastating impact on living organisms the severity of which will depend on a number of factors including size of the spill, type of fuel spilled, and effectiveness of clean-up measures. Following construction, shipping will decline. The presence of permanent facilities would preclude the use of these areas by polar bear and Arctic fox. The coastal zone and barrier islands are also used by ducks, gulls, and terns for nesting and or molting. Barge routes are well off shore except at the point of docking, therefore, significant adverse impacts are not anticipated as long as oil spills are prevented, and the barges give a wide berth to the barrier islands. No long-term adverse impacts are foreseen on whales, fish or other aquatic organisms.

Impact on Endangered and Threatened Species

Mammals

There are five endangered and one threatened species of mammals that may be encountered along the proposed route. Of these two of the endangered species and the threatened species are most likely to be encountered.

The endangered wood bison exists in widely scattered herds in northern Alberta. They are mainly concentrated in Wood Buffalo National Park, which is to the east of the corridor; however, they may be encountered in small numbers in western Alberta. Impacts on this species would be limited to possible harrassment or poaching, the latter of which is of course illegal. No significant adverse impacts are anticipated if harassment and poaching are controlled.

The black-footed ferret may also be encountered along the route. This species, once thought to be exclusively associated with prairie dog towns, ranges through the Dakotas to Alberta and Saskatchewan, to the north of the range of prairie dog towns in Canada. This ferret is secretive and nocturnal. It is possible, but unlikely, that a den with its inhabitants could be destroyed during trenching, if construction occurs through a prairie dog town. Considering the preparatory activity conducted prior to trenching, this species is likely to have fled prior to the actual excavation. Any loss of a den, however, would have to be considered a significant adverse impact. The effect of displacement is unknown, but would be presumed adverse if adequate habitat did not exist nearby. The risk of probable impact seems low.

Of the remaining endangered mammalian species, two, the northern Rocky Mountain wolf and the northern kit fox, are highly unlikely to be encountered. The northern Rocky Mountain Wolf, as its name implies, is a resident of the Rocky Mountains in the western parts of Wyoming and Montana and therefore to the west of the corridor. The range of the fox is somewhat to the north and east of the pipeline corridor. Impact on the species is not anticipated.

The Indiana bat is known to winter in caves in two counties of southwestern Pennsylvania and in a mine in southeastern Illinois. As construction would be in the summer, no direct impact is expected on either the Pennsylvania or Illinois population.

The grizzly bear is listed as a threatened species in the lower United States, but also ranges through Canada to the Arctic Coastal Plain of Alaska. In the lower U.S. on the pipeline route, its range is restricted to Idaho. Chance encounters with this species in Idaho are quite possible. The grizzly bear is basically a wilderness species that is unable to adapt to living closely with human activities. Since its range in the U.S. is traversed by an existing pipeline, no additional long-term impact is anticipated. However, there could be harassment and displacement during construction.

Birds

The Eskimo curlew is known to have nested on the tundra of northern Canada and northeastern Alaska. The last confirmed sighting was in 1963 (specimen was collected). Since its present status is unknown, there is a remote possibility of encountering the curlew during summer activity. The curlew could be adversely affected during the nesting season but because of low population numbers, if indeed the curlew still exists, the probability of the curlew being encountered is very remote. There will be no adverse impacts on the curlew from winter construction activities.

There is a chance of encountering whooping cranes during their migration, at which time they disperse in small family groups throughout the central flyway. The whooping crane has a major flyway across Montana between miles 75 and 180 of the proposed route where six or seven towers are strung across their path. The collision of even one of these birds with a tower would be a serious loss to this critically low population. The probability is unknown.

Both the Arctic and American subspecies of peregrine falcon are listed as endangered species. The Arctic peregrine falcon nests on the tundra of Alaska and Canada and migrates to the southern U.S. and Canada for the winter. The American subspecies breeds from the southern edge of the tundra to areas of Mexico, but in the lower U.S. is restricted to areas west of the Continental divide. The primary cause of the decline of these falcons is thought to be concentration of insecticides through the food chain. This results in a lowered reproductive success. Secondary causes for the decline, especially for the American subspecies, are believed to be habitat destruction and the taking of young for falconry. Of these, the loss of habitat could be aggravated. The falcons nest on cliffs or bluffs. Due to the engineering difficulties involved in construction in these areas, there is no direct loss of habitat expected. However, there could be indirect habitat loss if traditional nesting sites are abandoned due to the high level of human activity. There is a high probability that there are several such sites along the route in Canada. An increase in traffic or the presence of compressor stations in the immediate area of nest sites could adversely affect nesting success, with a resulting adverse impact on the falcon population.

Fish

The Scioto madtom, a catfish, inhabits Big Darby Creek, a tributary of the Scioto River in Ohio. The pipeline does not cross Big Darby Creek and there will be no impact whatsoever.

The Tecopa and Owens River pupfish both occur in Inyo County, California. These are both listed as endangered species. As the pipeline will not go through Inyo County under the current proposal, the pupfish will not be affected. However, if ITAA should extend the route beyond Rye Valley and expand their pipeline to the 1.1 MM cfd or fully powered system, there is a high potential for adverse impact. Considering their extremely limited range and the vulnerability of their habitat, potentially irreversible adverse impacts would be possible.

3.OV.9 Impact on Economic Conditions

Construction of the proposed pipeline would have national as well as local, indirect as well as direct economic impacts. The most direct impacts will be in the immediate area of the pipeline route. These impacts will be proportionately larger in more remote areas with smaller resident populations, less important along those portions of the route near larger metropolitan areas. Economic impacts on communities along the pipeline route will be both beneficial and adverse.

Impacts will take a variety of forms: Additional employment, additional personal income, increased tax bases, temporary loss of agricultural production, increased strain and cost on local facilities and services, widely diffused increase in demand for construction equipment and materials and the availability of a substantial supply of energy in the market areas served by the applicant companies. Impacts on the subsistence economy of Natives in Alaska and northern Canada are discussed in 3.OV.10.

The purchase of right-of-way will provide new income to property owners along the right-of-way. Whether this will be a net benefit to those property owners depends upon how adequately it compensates for damage to and loss of production on individual properties. This additional income can be expected to flow in varying degrees into local economies.

Local suppliers will benefit from the local purchase of construction supplies by pipeline contractors. Supplies purchased locally are likely to include fuel, hand tools and smaller construction materials. These purchases will represent new money in local economies and flow via the multiplier throughout each community. Some negative impact may be felt in local communities in the form of shortages of those items bought up by pipeline contractors and employees. The major materials such as the pipe itself and large construction equipment will be purchased from large manufacturers throughout the country. Specific locations of this part of the economic impacts can not be identified since it will depend upon contractors hired and their purchasing patterns, but these expenditures will be large and may be considered an economic benefit to the Nation.

Workers hired to build the pipeline will be those possessing the required skills. It is not likely that these will be available locally. The applicants estimate that 25-40 percent of construction labor forces can be hired from local labor pools. Where local people are hired, this will constitute an economic benefit in income flowing into the economy. In areas where there is a shortage of labor, these benefits will be tempered by delays in other projects and increases in cost resulting from additional competition for scarce labor. A benefit to local communities will accrue from expenditures by all pipeline workers for food, lodging, entertainment and other goods and services. A large portion of the income will flow to their home communities wherever they may be. Adverse impacts associated with this increased employment will be mainly upon small communities in the form of overcrowding of facilities and increased social stress. The obviously temporary nature of this demand should not induce communities to expand their capital facilities. Some additional expenditure on road repair will likely be required as most county roads are not built to heavy equipment standards and will suffer more rapid deterioration from construction use. Also, increased use from trucks and workers cars will accelerate deterioration.

Counties in which the pipeline is located will benefit from the increase in taxable value that the pipeline and related facilities represent. The State of Alaska will also receive royalties and tax revenues based on production. Governmental jurisdictions at all levels throughout the country would benefit from sales taxes, income taxes and excise taxes related to the production, transportation and use of materials and equipment required in the construction of this pipeline.

The availability, for consumption of 4.5 MMcf/d of natural gas in U.S. and Canadian markets will have a beneficial effect in sustaining income and employment that might otherwise decline as current sources of natural gas are depleted.

3.OV.10 Impact on Social Conditions

The types of sociological impacts will be similar along most areas of the proposed route, but the intensity will vary. Impacts of development are often unexpected, making projections debateable though general statements usually hold true. Smaller isolated communities and counties with low populations will feel the impacts most intensely. Generally, impacts are greatest in the northern areas of the route. This corresponds with areas of low population and little economic development.

Many of the impacts would be temporary as crews work each 100 mile spread for a fairly brief time, with the longest time period being 3 to 6 months. Operational and maintenance crews will settle in an area for the life of the project. However, the number involved in this second phase is much smaller than the 250-800 temporary construction workers and support crews that would work a given spread. The biggest spreads in terms of workers are in the Arctic where population is low. The smallest are in the Plains. Also, a large support crew is not needed where facilities are already available, as in the more industrialized areas. This puts the heaviest impact in terms of additional people on the Arctic. Government facilities, housing, education, health services, fire protection and other public services would all be affected by the population increases. Also, cultural upheavals, which are not as temporary in nature, are likely to occur, especially in the small Native communities of the north. (Discussed under Subsistence.)

The State of Alaska as a whole will be influenced by the pipeline, but the corridor location will focus impacts on the Arctic Slope. The North Slope Borough, Fairbanks and Anchorage have already witnessed a substantial population increase and subsequent social and community disintegration due to the influx of construction crews for the oil pipeline. Damage to roads, a soaring divorce rate, increased rent, decreased housing conditions, increased crime rate and heavy traffic in Anchorage were unpredicted impacts of this influx. There have been additional breakdowns of family units as parents go to work for construction teams and do not return to their children. Also, alcohol abuse has increased along with a demand for increased recreation. All of these would be expected to continue during construction of the gas pipeline. (Urban and Rural Systems Assoc., 1974)

Natives of northern Alaska and Canada whose values, sustenance and arts are entwined with the natural environment will find it hardest to adjust.

According to Gourdeau (1974):

> "Life standards and models imported to the North by pipeline construction will hit communities both directly, in Inuvik, Norman Wells and Fort Simpson, where the company will maintain district headquarters, and indirectly, in all the small villages, as pipeline workers return to their homes with new aspirations and money. This impact is bound to last after the pipeline is built. Changes in group aspirations and demands will be precipitated, some pertaining to better housing and improved community services, others corresponding to habits of spending for gadgets and increased alcoholic consumption. The less possibility natives will have to acquire better homes and improved community services, the more they will spend on gadgets and alcohol. As a group the native people will receive a negative impact from the pipeline, in social and cultural terms, unless they have opportunities to enjoy some of the positive models displayed to them."

Many Natives are unprepared to take advantage of opportunities brought by development. They lack the skills or competitive spirit, and fear the change. This leads to a feeling of insecurity, inferiority, and loss of identity; and thus to increased alcohol abuse, which has become a major social problem among the Natives in the far north (Gemini, 1974). If Natives are hired for much of the work, social and economic disparities could be reduced. If not, they will be increased.

Small local governments along all routes may find it difficult to supply the services required by construction workers and support crews that pass through their area. Crews would be working long days and weeks while receiving high pay, and will be looking for a good time when they come into town. This will create a temporary increased demand for recreational services and, likely, increased law enforcement. Large communities will find it easier to assimilate the increased level of demand with existing systems.

Housing the temporary construction crews and support teams could be a problem throughout the corridor areas. The Applicants will supply temporary living quarters in Alaska, Canada, Montana and the Dakotas. Workers in the rest of the contiguous United States would be expected to find living quarters in communities near the work site or supply their own mobile homes. In some areas where there is a housing shortage, as in Oregon, trailer spaces are also not generally available. PGT may provide construction camps in isolated areas. When hotels and motels are used, a minimum number of units will remain available for tourists in the construction area. This may especially be felt along the West Coast line in areas which depend upon a tourist-oriented economy. Transportation in the more isolated areas is likely to be strained as well, by both congestion and deterioration of roads by heavy equipment use. Local inhabitants are likely to experience inconveniences and delays in travel as well as possible increased taxes for road maintenance.

Health hazards would be involved in the gas processing operations at Prudhoe Bay and during construction of the pipeline. Natural gas is a fire hazard as well as an asphyxiant if a leak of purified gas is undetected. Throughout the route toxic substances include methanol and mercaptan. The latter is used to give the natural gas an odor and is only harmful in large doses. Electrocution from contact with overhead power lines is also a potential hazard. Health services will be supplied in the construction camps of the north. A contractor will generally supply health facilities for other temporary crews. Therefore, services in the smaller communities should not be adversely affected. However, local hospitals will be used. In Alaska, the Fairbanks hospital will have the greatest increase in use.

As construction workers will be in each area for a fairly short time, they are not likely to bring dependents. In fact, in Alaska, families are specifically forbidden, because of the harsh conditions. Educational systems, therefore, would not be affected at this time.

The permanent maintenance and operational crews will create a long term impact where they settle. Families will accompany these workers. However, they will be fewer than the temporary construction crews and more spread out. As an example of size, 60 new residents per 100 mile stretch would be located along the Northern Border route. This is if all were hired outside the local area. In Canada it is projected that 3,500 new housing units in the corridor area will be needed between 1973 and 1983 without pipeline construction. With construction an additional 1,100 units would be required. Northern housing needs are only slowly being accommodated. These "second shift" residents will put a more permanent demand on limited local health services, education facilities and recreation.

Areas, as the Arctic, Montana, the Dakotas, and parts of Oregon, where population and development are low and where the incoming construction crews would be large, will necessarily experience the greatest degree of social impacts. Where crew numbers are small and industrialization more advanced, i.e., the Great Lakes Industrial Belt, the influx will not be greatly felt. As explained in 2.OV.10, throughout the route population density is lowest in the north, increasing as the corridor continues south. Figure 3.OV.10-1 graphically illustrates the relationship between latitude and the probable degree of impacts.

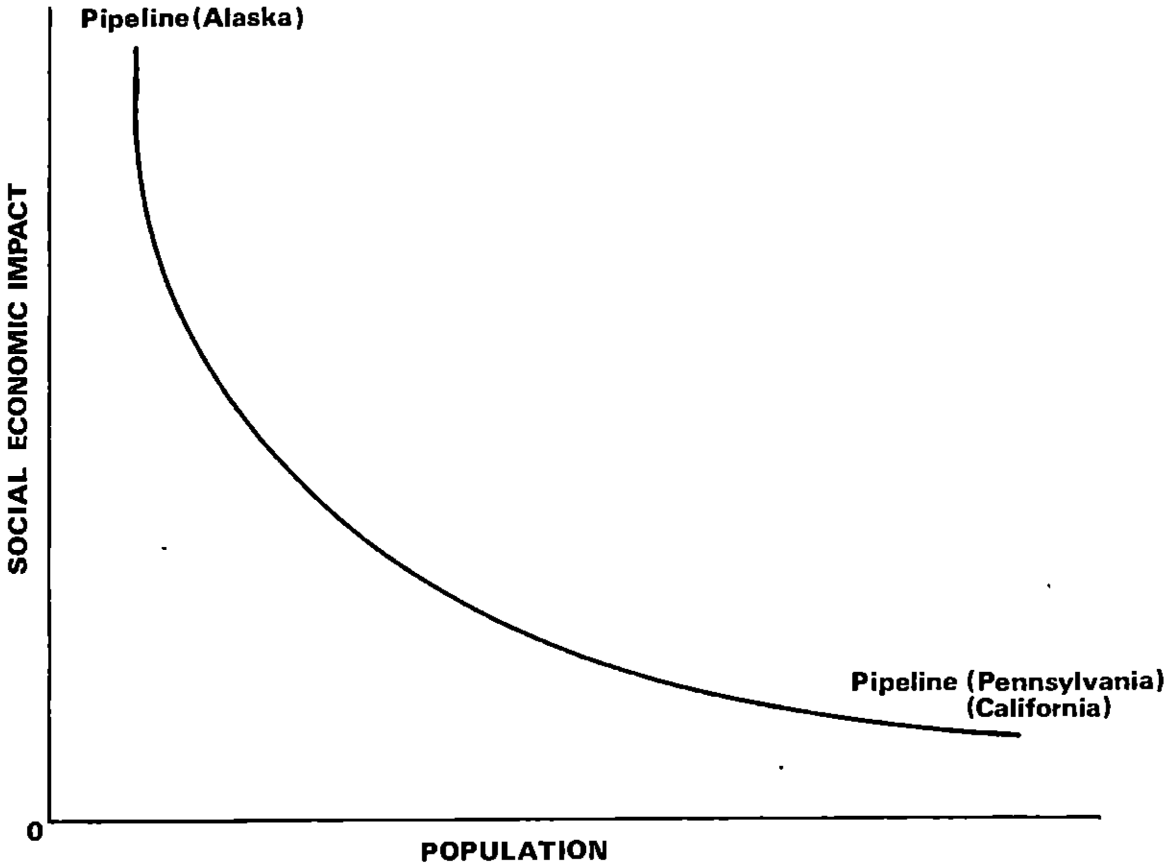

Figure 3.0V.10-1 Social impact as it relates to pre-construction population level

Impact on Native Subsistence

The mere construction and eventually the operation of the pipeline and its indirect and induced developments will bring into the Arctic on a regular basis increasing numbers of outsiders in quest of fish and game. Operational pipeline life is possible for up to 60 years. Two extensive regions of the far North, the North Slope and the Mackenzie Valley will be opened up to accelerated use of resources, travel and habitation. Twenty seven (27) airstrips and 134 heliports will change the entire travel pattern of the far North. For Natives the significance of this will rest heavily upon what happens to the wildlife resources and to their former isolated way of living.

Subsistence food is still drawn from the land by most native people in the far North. Fish, caribou and moose meat are a significant part of their diet as well as small game and waterfowl. Natives also draw cash revenue from fish, fur and game harvesting activity. For example, in the Mackenzie country direct value of $1.5 million accrues to about 1,500 families annually. In the same region about 74% of the male population 15-64 years old are (1971-1973 data) trappers and hunters. In the Arctic, natural habitats are crucial to biological productivity. Any significant change in the productivity levels of wildlife stocks will begin to decrease the sustainable yields of those populations for Native use. It is out of these annually produced stocks that Natives now live without depressing the base wildlife population levels. The crossover point to depletion is not presently known but North American history has shown that sustained pressure on resources is certain once a frontier region is opened up. Some wildlife stocks will be depressed locally and sometimes quickly. For others this will not occur for a longer period of time. The pattern and extent of impact is uncertain but that there will be a cumulative effect is certain.

Since there is no other large industrial activity immediately in sight except oil and gas development, it seems reasonable to assume that present Native populations can probably continue to derive sustained support from present resources on a sustained yield basis for approximately 2-3 decades (Goundeau, 1974).

Of 29 communities (approximately 6,700 Natives) north of Parallel 60° affected by the corridor, about 21 have a predominantly native population. Of those, 13 are within 50 miles of the proposed line. The insistence by Native people to maintain their important inbred relationship with the land is well known. It is not and will not be easy to change social attitudes toward this traditional life and culture. Most researchers of the North and many individual Natives indicate profound dissatisfaction at the idea of being cut off from the land in which their culture and way of life is rooted. Reliance upon the land and its wildlife productivity is not likely to fade quickly or easily.

The result of this trend in conditions would indicate that conflict for resources and land use will become intensified during the next two decades.

Impact on subsistence will follow two avenues, impacts on available wildlife resources and impact on cultural patterns. First it would seem certain that cumulatively over the long term, subsistence resources of the Arctic and subarctic will experience decline and redistribution similar to that historically noted in the lower 48 states and southern Canadian lands.

Second with increased development will come an increase in cultural imports; i.e., those aspects characterizing the so-called 20th century industrialized technological society. These imports will include not only technological factors but different life styles and mores. There will be strong conflicts between the more traditional land ethic and technological use of the land. Cultural evolution will be rapidly accelerated. However, a trend away from the land related pursuits toward a wage economy has already been established in several parts of the proposed route. This acceleration will be the result of pressures primarily arising outside of the Native society added to others from within, thereby not carrying with it adequate time for complete acceptance or absorption. The evolutionary trend will likely be away from the traditional Native culture patterns toward the breakup of the Man-Land relationship, the classical corollary to industrialization.

3.OV.11 Impact on Land Use

The route of the proposed project traverses substantial portions of agricultural lands from southern Canada through the midwestern and western parts of the United States. The pipeline rights-of-way will preclude agricultural use of traversed land during the construction period. The land required for compressor and pumping stations, permanent access roads, and other permanent facilities will be lost to agricultural use for the life of the project or the pipeline. For example, this will amount to about 570 acres of the total of acres on the North Border right-of-way.

Soil disturbance could have long-range impacts upon the productivity of some types of farmlands, but use for pipeline purposes will not preclude use for agriculture. In irrigated areas, with tile drains, the pipeline will be buried beneath the tiles, which will be replaced. Temporary tiles will be installed while the ditch is open, but the integrity of the drainage system may still be affected. Impacts on drainage systems are expected to be short-term.

Rangelands and pastures through which the pipeline is installed will be impacted to a lesser degree than croplands. However, native range is difficult to reestablish in arid areas, and some reduction in forage production may result, at least for several years following construction. Significant or long-term impacts are not anticipated.

The pipeline is currently expected to traverse 1877 miles of forests. Commercial forests occur in four areas of Canada and for about 23 miles in Idaho and Oregon on the pipeline alinement. Also, woodlands cut along all routes, though not of usual commercial quality, will generally be marketed. For example, approximately 1,200 acres of timber can be harvested on the Rye Valley (L.A.) line, though quality timber production on about 156 acres would be curtailed. These timber resources will be precluded on the permanent right-of-way to protect the pipe. Between 20 and 25 miles of orchards will be traversed in California. This use will be precluded during construction and production curtailed until mature trees begin producing again. Orchards may be reestablished on the right-of-way following construction; this is obvious since the orchards are on the existing right-of-way.

Residential, commercial and industrial land uses would be precluded from the pipeline right-of-way and from sites of related facilities. Many of these rights-of-way and sites are located in the vicinity of communities and railroad sidings throughout the route system. While the total area involved is less than 1 percent of the total, the linear nature of the project makes it difficult to avoid key areas; impacts tend to be localized. Furthermore, since the exact alinement has not been surveyed and staked, deviations can be made to avoid key areas.

The pipeline will traverse existing and potential oil, gas, coal, and other mineral deposits. The impacts associated with this have been discussed in Section 3.OV.3-Geology.

The corridor also traverses numerous existing and potential Federal, State, County, and municipal management areas such as parks, wildlife refuges, and nature preserves. These are discussed fully in Section 3.OV.13-Recreation and Aesthetics.

There is a wide variety of rights-of-way within the proposed corridor. These include major highways, secondary roads, railroads, navigable rivers, canals, transmission lines for gas and electricity. These would be traversed or paralleled. In Canada, much of the alinement in the North parallels the existing or proposed rights-of-way for the Dempster and Mackenzie Highways. In the contiguous United States, these range from about 2 percent of the route on the North Border corridor to nearly 100 percent on the West Coast legs, these latter of which are existing gas transmission pipeline rights-of-way. Major highways and railroads will be crossed by boring, with no stoppage of traffic. Secondary roads will usually be crossed in a similar manner, although open ditching has been proposed in some cases with detours provided. Traffic delays can be expected in some areas due to the slow-moving vehicles traveling along, entering or leaving the highway. Increase in traffic can be expected from construction crews commuting to and from work, and by trucks hauling pipe, test water, fuel and other materials.

The proposed route crosses many buried and overhead transmission facilities. These facilities can suffer damage if good, safe construction practices are not followed. All known underground facilities such as gas, petroleum products, telephone, water and sewer lines will be located prior to trench excavation. No adverse impact is expected on underground installations. Overhead power and telephone lines, while in plain view, are infrequently severed by high lifts or cranes, with a subsequent interruption in service. Such occurrences are an inevitable result of carelessness but result only in minor, extremely short-term impacts, including damage to equipment, injury to employees and disruption of service to customers.

Planning for comprehensive land use is under way in most of the counties crossed by the proposed pipeline. Many governmental units are represented: Federal, State, regional, county, and city. Planning and zoning steps have been taken in varying degrees. Formal land use planning in the States along the pipeline is in the early stages of development. State legislation that creates authority and staffing for statewide land use planning and controls has not occurred in any of the States. Section 2.OV.11 in this overview summarizes the status of land use planning efforts.

The impacts on land use planning resulting from the construction and maintenance of the pipeline will be variable. Compatible uses of lands on the right-of-way and adjacent lands, especially near compressor stations, will result in some restrictions on land use. Because most of the land in the corridor consists of grazing and cultivated land, little change of use is anticipated. Most areas place no restriction on utility corridors on agricultural land. Problems result where land is zoned as residential or is unclassified has potential for residential development. Usually, residential areas may be crossed only if a variance can be obtained on the basis that no other feasible route exists. The potential for residential classification of unclassified land may decrease in the presence of the pipeline. Once the pipeline is in place there are restrictions on the proximity of structures to the pipe, and consequently the density, as well as the desirability, of residential development. Considering that there is little urban land within the corridor and that unclassified lands with such potential are usually near urban centers, no significant conflicts with land use planning are anticipated. There may be localized conflicts that will result in variances, reclassifications, or changes in the pipeline alinement.

3.OV.12 Impact on Paleontological, Archaeological, and Historical Resources and Unique Areas

Impact on Paleontological Resources

No significant known paleontological sites are to be crossed by the proposed pipeline. Most of the surficial deposits in which the pipeline would be laid were deposited during the last glacial period, limiting potential for finding significant paleontological sites on the route. The pipeline would skirt the mountainous area in Alaska where there is exposed bedrock, resulting in slight or no impact. Blasting through fossiliferous bedrock, as would occur along the Kingsgate Delivery Line and sections of the eastern part of the Northern Border Route, could easily destroy any potential finds before their existence is realized. Generally though, fossils are more or less dispersed throughout the particular rock stratum in which they are deposited. Consequently, destruction of all the fossils in a rock stratum is not likely. There is, however, a possibility that blasting of bedrock where unknown finds exist could locate or destroy fossils of previously undescribed species. Once the rock stratum is exposed fossils will also be open to vandalism. Of the two paleontological sites along the West Coast Line near the Snake River in Washington, the closest is considered an important site. Neither known site is likely to be directly destroyed by construction, but they may be subjected to increased access and vandalism. Also, similar sites could exist in this area. Farther south outcroppings of fossiliferous bedrock are not likely to be encountered due to the inherent geology of the region.

Impact on Archeological Resources

Very little is known about the prehistoric occupation of the Arctic coastal plain by man. A number of cultural-historical problems pertaining to the peopling of the New World and native adaptations may be clarified by currently undiscovered archeological evidence. The proposed pipeline follows the first migration route from the Bering Sea land bridge along the north coast of Alaska and south along the McKenzie River. This is a potential area for finding sites from varying time periods, as this route was used for subsequent migrations as well. Since so little is currently known about this area, the discovery of any site could greatly increase our knowledge of Arctic prehistory and the peopling of North America. New sites may be found which contain information pertaining to cultural transitions and cultural contacts between groups from different geographical areas, particularly throughout the route in Canada. The evolution of the Eskimo Culture from the Arctic Small Tool Culture appears to have occurred independently in Alaska and Canada. However, each has traits suggesting trade contacts existed between them at certain times. The unknown middle ground lies along the northeast coast of Alaska where the proposed route lies. Also, below 60° N in Canada a variety of sites may be found depicting man's adaptations to a changing environment. Camp sites and semi-permanent villages are most likely to be found in protected bays or along rivers and streams. The Arctic coast and several of the rivers appear to have been trade routes for Indians, Eskimos, and later settlers, making this a high potential area for finding archeological sites. A report on archeological resources in the Yukon and Northwest states, "Borrow pits, wharves, and river crossings are locations where the probability of impact will be greatest. Stations, airstrips, stockpile sites and communication sites are locations where construction of roads and the right-of-way will disrupt surficial sites and perhaps render some of them uninterpretable. foundation pads. The construction of roads and the right-of-way will disrupt surficial sites and perhaps render some of them uninterpretable. Trenching will destroy some sites but it will also lead to the discovery of others that otherwise might never be found." (Doyle, 1974).

As in Alaska, any site discovered in the northern part of Canada will have great significance in adding to our knowledge of North America's prehistory. If the pipeline is constructed as proposed during the dark Arctic winter, discovery, protection and recovery of sites will be very difficult. They may be passed by or destroyed without anyone being aware of their presence.

Throughout the route in Canada, river crossings are likely spots for discovering new archeological sites. Along the pipeline route from Kingsgate to San Francisco, 21 known archeological sites would suffer direct damage from the construction. Numerous sites have been found in the interior Pacific Northwest, suggesting this area was heavily occupied by aboriginal groups. There may be a number of yet undiscovered sites along the route, especially near streams and lakes. Throughout Washington and Idaho many sites have been lost with the development of civilization, hence the remaining sites have more value. However, since the area surrounding the San Francisco line has been excavated for an existing pipeline, much new information is unlikely to be gained with the current archeologic techniques. Few studies have been made in eastern Oregon where the proposed route to Rye Valley is located. Almost every spring and water course is likely to have been used by aboriginal populations. Unknown sites along this route could supply needed knowledge of the area. If sites are as prevalent as expected, similar general information could probably be found outside the corridor right-of-way as well, though specific or unique information may be lost. Besides direct destruction by construction procedures the digging may accelerate erosion, exposing artifacts to vandalism and weathering.

Fifteen known archeological sites are threatened by the proposed Northern Border pipeline route. Five of these (in North Dakota, Illinois and Pennsylvania) could suffer major damage. The Cannonball Site in North Dakota is one of the most sensitive sites crossed by the proposed Northern Border route. In the Plains area potential sites are not likely to be encountered except near rivers and lakes. Little is known about the early nomadic hunters and gatherers who lived there. Since remains of these early hunting groups are rare and widely distributed, any site or artifact uncovered in the Plains could have considerable significance. Increased access and vandalism could be detrimental here since finds are scattered and often isolated. As the pipeline route moves eastward potential archeological areas increase, but their relative significance decreases slightly as the type of site becomes more common. This refers more to general knowledge of the area than specifics, which are often needed to understand cultural contacts and changes. Loss of the integrity of the setting, and in some cases, the significance of the site could be caused by construction. Relationships of artifacts to their surrounding area may be obscured.

In most cases damage would be a direct consequence of site disruption and excavation by man and machine without knowledge of the paleontological or archaeological values. In other cases the impact will come as a consequence of increased access and vandalism to unprotected sites.

Cultural sites are finite, non-renewable resources. Once lost they cannot be regained. Those sites discovered and excavated prior to construction would add to the knowledge of our heritage, though the site and possible the relationships of artifacts would be destroyed for future study. If, on the other hand, the site could be preserved it would remain intact until more advanced techniques for excavation are developed. More complete knowledge could then be gained. Preservation of a site is always preferable when possible.

Impact on Historical Resources

No known historic sites are crossed by the proposed pipeline corridor in Alaska. As the line follows and crosses trade routes, some historic locations may be discovered. The pipeline is expected to have only a slight impact on historic sites in Alaska.

Additional trading centers as well as structures associated with the history of mining and railroad construction could be encountered on the route through Canada. In Saskatchewan the Monchy Delivery Line passes near two of the province's 143 sites of historic interest. They would not be directly damaged by construction, but noise disruption, increased vandalism and aesthetic damage to the nearby landscape could occur. A change in the scene where historical events occurred could make the interpretation of developments at currently unknown sites more difficult to both the layman and researcher.

Seven known historic sites would suffer direct damage from construction along the two West Coast lines. Also, sections of visible historic trails would be obliterated by construction procedures where crossed by the pipeline. Though 10 known historic trails would be crossed by the West Coast routes, there is no visible evidence of the Lewis and Clark Trail, Kentucky Trail, Texas Road, Fremont's Route and Whitman's Route. Potential for unidentified historic sites and properties is great in the interior Pacific Northwest. Sites may be found on the Umatilla Indian Reservation as well as along the Oregon Trail, which follows the route to Rye Valley, Oregon for some 65 miles. Besides destroying sections of the trail itself, the pipeline route could disrupt the view and make the area more accessible to vandals.

Along the Northern Border route historic sites are generally expected to be in urban areas. Consequently, not many sites are likely to be discovered or destroyed. The Dakotas and Pennsylvania are exceptions. Since the rivers provided a convenient mode of transportation, historic sites in the Missouri Basin tend to be located near major rivers. Many historic sites in North and South Dakota are not associated with standing structures. Stone foundations still exist where forts once stood, but many other buildings, such as sod dwellings, left no currently visible foundation. Little research has been done in this region, therefore, unrecorded historic sites may be found along the route. With no obvious structure to mark the area some sites could be unknowingly destroyed in construction, making later interpretation impossible. Only one known historic site, the Fort Bouis Fur Post on the east bank of the Missouri River, would be crossed in North Dakota, but five other sites occur near the corridor. The closest ones could be subjected to increases in vandalism and ambient noise levels. Farther east, in Illinois and Ohio, two historic canals are crossed. They are the Illinois-Michigan Canal and the Miami-Erie Canal respectively. If the pipeline is not bored or tunneled under them, construction will inevitably destroy sections of the canals. The proposed pipeline is located within 1/2 mile of two sites in West Virginia and one in Pennsylvania. Indirect "effects" could again result here. The route in Pennsylvania traverses an area so rich in history that unknown sites are likely to be uncovered. If sites are recognized before damage is done necessary procedures for protection could be put into effect.

Since historic sites are generally documented, not many unknown sites are likely to be uncovered. Areas where sites are known to exist can be avoided during the survey stage.

Impact on Unique Areas

Unique areas are areas of rare or unusual flora, fauna, ecology and geology, where disturbance could be detrimental. Of the 15 areas near the route in Alaska and Canada (listed in 2.OV.12) which have been nominated for special management, 6 are likely to be affected. They are discussed briefly below (see 3.1.1.12 for more details).

Jago River: In the Jago River Basin the proposed pipeline would disrupt the continuum of plant and animal communities north of the Brooks Range or disturb their present untrammeled condition. The opportunity to preserve an entire major Arctic Coast drainage system intact will be lost.

Beaufort Lagoon: The proposed AAGPC pipeline system will intersect all streams flowing into the Beaufort Lagoon. Therefore, construction, operation, and repair of the proposed pipeline system will cause water quality impacts in the Lagoon through siltation and from potential spillage of fuels, lubricants, and toxic fluids.

Neruokpuk Lakes: There may be impacts on fish life in the two lakes if the downstream AAGPC project restricts fish movements in the Sadlerochit River drainage. The extent of such impacts on fish life in the Neruokpuk Lakes is not known at this time.

Sadlerochit Springs: Any winter withdrawal of water from Sadlerochit Springs would seriously lower, if not destroy, its natural values. As the Spring is 6 miles from the route there is potential for its use.

Demarcation Bay: Ships moving to the Demarcation Bay area for the 2 years during initial construction, and possibly when compressor stations are constructed during the 2 to 5 years after initial operation of the pipeline, are expected to procude little, if any, impact on the natural formation or destroy offshore bars and islands. However, there will be major impacts on the birds, particularly waterfowl, fish, and animals using the offshore bars and islands in the Demarcation Bay area as a result of the port activities (noise and movement).

Firth River: The permanent facilities and right-of-way through the proposed Firth River ecological area would destroy or alter about 800 acres of wilderness quality vegetation in the Herbaceous Coastal Tundra although the approximately 655 acres of right-of-way would recover through a combination of reseeding and natural succession of native plant communities. The most critical impact would be on the total wilderness ecosystem represented.

Along the Northern Border route several areas of unique or rare vegetation would be affected. The pipeline will diagonally cut through the 7,600 acre tract of native prairie in the Ordway Memorial Prairie (South Dakota). Also, in the Pecumsaugan Creek Nature Area (Illinois) plants considered rare in Illinois are likely to be destroyed by construction activities. The pipe will not be allowed to cross any designated Nature Preserves in Illinois, thus preserving the natural quality of Starved Rock State Park Nature Preserve.

Impacts on the wilderness value within the Arctic National Wildlife Range and the adjacent proposed refuge area in the Yukon are discussed in 3.OV.13.

3.OV.13 Impact on Aesthetics and Recreation

Both construction and operation and maintenance of the pipeline will affect recreation and aesthetics along the proposed route. While recreation would generally be disrupted only during construction, impacts on areas with special aesthetic values would continue in many cases beyond the life of the project.

Impact on Aesthetics

Cuts and fill, gravel extraction sites, compressor stations and communication towers affect aesthetics along the proposed pipeline corridor differently. During the construction phase introduction of noise, smoke, dust and additional human activity will occur. The noise and visual impact of compressor stations, airfields, communication towers and other facilities as well as the removal of some vegetational types will continue at least for the duration of the project. Structures of all types would mar the visual quality of areas not previously marked by the works of man, as, for example, the Arctic National Wildlife Range and North Dakota Badlands. True wilderness quality would be destroyed and quasiwilderness further degraded. Compressor stations and communication towers would be especially discordant on treeless areas of low relief as in the Arctic tundra and parts of the desert. Aesthetic qualities would be restored eventually, but many decades would be required before natural processes would obliterate the scars where recovery of vegetation is slow and where stands of trees have been cut. The relative significance of an impact on aesthetics depends on the inherent quality of the landscape, the number of viewers, and their sensitivity for the landscape being observed. Visual impacts will be most apparent in forested areas and in open range or desert country. Those in agricultural and industrial areas will be much less obvious.

In the Alaskan and Canadian Arctic, aesthetics are primarily tied to the "wilderness mystique" exemplified by the Arctic National Wildlife Range. The proposed pipeline system will have a cumulative, long-range adverse impact on 495 miles of wilderness in northeastern Alaska and northwestern Canada. Wilderness values are discussed in more detail below under Impact on Wilderness.

Aesthetics may be more degraded by construction camps and pipeline facilities in the Arctic tundra than by the pipeline itself due to the introduction of structures and workers as well as the slow vegetational recovery. Vapor plumes at compressor stations would be visible for many miles. Noise from the compressor stations and airplane patrol flights will be seen and heard by people who may not otherwise notice the pipeline operations. Though vegetation will be removed during construction of the pipeline, the Applicant proposes to replace the original sod cover in tundra areas that are not highly erodable.

Five miles of the route in northern Canada crosses the Ebbutt Hills natural area in the Great Slave Lowland. This area is to be set up as a long-term study area to monitor the effect of pipeline construction, use and maintenance. This will enhance our knowledge of potential pipeline impacts.

Types of impacts in corresponding geographical areas along the routes in southern Canada, the Northern Border and West Coast would be similar. Clearing the right-of-way of trees, cuts across steep bluffs and cliffs, and the crossing of some rivers and streams will create upheavals of long duration. Cleared strips through wooded areas especially in Canada and the Pacific Northwest, e.g., in the Moyie River Valley, will change the scenic quality of the immediate area. Swaths through forests will be revegetated, but trees and large shrubs will be removed for the life of the project. PGT (San Francisco route in Idaho, Washington and Oregon) will allow shallow rooted orchards on the right-of-way. The relatively straight path of the pipeline would be a discordant note on all landscapes not otherwise affected by road and seismic line patterns. Revegetation would lessen the impact, but color and texture differences would make it apparent in many areas for the duration of the project.

In some areas trees surrounding the cleared right-of-way will provide a "screen" or "buffer" unless viewers are able to look directly down the cleared path or are observing the landscape from a higher or lower elevation. Along the Mackenzie Highway, the route is screened from motorists but may impair the scene for hikers and photographers. Since forested areas usually occur in mountainous regions where diversity of topography, vegetation, waterforms, and color often have inherent scenic or aesthetic qualities, adverse visual impacts are frequently more pronounced because of the total landscape involved.

Scenic impacts in the agricultural lands of much of Alberta and the midwestern United States would be slight. Agricultural activities will erase most visible evidence of the right-of-way, probably within one growing season. In British Columbia, Saskatchewan, and the eastern part of the Northern Border route the rolling topography creates vantage points again where the pipeline corridor could be readily seen by motorists and recreationists. The routes to San Francisco and Rye Valley would not tend to create new problems as they will share the right-of-way with existing systems in most cases. However, old scars would be reopened and enlarged, making the corridor even more noticeable. As the need arises to widen the corridor and add new pipes, the aesthetic values in the vicinity of the corridor will continue to decline.

Topographical and vegetational changes in areas of unique or special significance may be permanent. Soil instability in areas such as the North Dakota Badlands and along Frenchman Creek in Montana may prohibit restoration of the natural landscape after construction. If the Northern Border route continues as proposed, crossing Ordway Memorial Prairie (South Dakota) a section of native grasslands will be lost. The impact would be significant, as this is a fairly unique vegetational area. Also, aesthetic damage in Starved Rock State Park, Illinois could be severe. Damage to the bluff at the Illinois River crossing would not be rectifiable. In California unused lava caves in Lava Cave State Park extend under the right-of-way. The earth is thick enough to support the pipe and construction equipment, but if blasting is required some damage could occur in the caves. Some of the significant scenic areas which may be affected by the pipeline are:

Arctic National Wildlife Range, Alaska
Moyie River Canyon, Idaho
John Day River Canyon, Oregon
Sacramento River near Red Bluff, California
Umatilla River crossing, Oregon

Umatilla National Forest, Oregon
Wallowa-Whitman National Forest, Oregon
North Dakota Badlands
Little Missouri River crossing, North Dakota
Ordway Memorial Prairie, South Dakota
Wapsipinicon River crossing, Iowa
West Fork River, Iowa
Big Bend State Conservation Area, Illinois
Starved Rock State Park, Illinois
Matthiessen State Park, Illinois
Pecumsaugan Creek nature area, Illinois
Wabash River crossing, Indiana
Salamonie State Recreation Area, Indiana
Mingo Creek Park, Pennsylvania
Round Hill Regional Park, Pennsylvania

The cutting of trees at river and trail crossings would necessarily lessen their attractiveness. This may occur only in a limited area or for a distance if the route parallels the watercourse or trail. The designation of a waterway as a National Wild and Scenic River may be influenced by pipeline construction, although attractiveness should be lessened only at the given crossing area. As long as the corridor cannot be seen paralleling the river and towers or compressor stations are not visible from the river, potential for designation should not decrease. This is most important for the designation as "wild," second for "scenic" and probably not too important for "recreational" rivers. Erosion resulting from construction at river crossings could also reduce the attractiveness. Structures which inundate the river bank may bar its consideration as wild or scenic. Also, the availability of access changes its designation potentials.

Impact on Wilderness

Cumulative, long-term adverse impacts will arise along the 495 miles of wilderness the proposed pipeline route traverses in northeastern Alaska and the Yukon, Canada. Besides aesthetic degradation from structures as mentioned previously, the presence of more people will have a long-term detrimental effect on resources which are scarcer each year--solitude and quiet. People will become more aware of the area through publicity and personal association. Arctic wilderness values will decrease as many additional recreationists enter the area. As long as access roads are temporarily constructed of snow and ice, they will not be available for use by the general public. However, once opened by construction, access is bound to increase over a period of time. As the Arctic environment is fairly easily destroyed and recovery is slow, it would not be able to serve large numbers of people and still keep its natural wilderness characteristics.

The proposed pipeline system will also provide the catalyst for intensive prospecting of the Beaufort Sea offshore oil and gas province and the Marsh Creek anticline. These will separately and cumulatively alter the existing wilderness character of the pipeline area to such an extent that in Alaska portions would no longer qualify for inclusion in the National Wilderness Preservation System. It is expected that the zone of lowered wilderness character would extend southward to the northern flanks of the Brooks Range, thereby removing entirely the wilderness continuum from the Beaufort Sea through the Brooks Range for al least a 133 mile length of the Alaskan segment.

Impacts on the wilderness of the Arctic may have effects outside the study area as well. Construction destroys the image of vast openness and mystery, eliminating the last vestige of the great American wilderness. It will open up cumulatively the now frontier wilderness regions of NE Alaska and NW Canada.

Impact on Recreation

Recreational resources are based on the natural features and character of the land. As they are often in the most aesthetically pleasing environment of a given area, a reduction in the aesthetic quality may cause a similar reduction in the recreational value in the immediate area of the corridor. Recreationists such as fishermen, hunters, and backpackers are usually interested in the aesthetics as well as their particular activity. Therefore, degraded aesthetics would decrease the value of the experience.

The Arctic National Wildlife Range provides most of the recreation in the North Slope, and use is currently light. Along the route in Canada, those areas where the recreation potential could be most seriously affected are the Yukon Coastal Plain wilderness and the wilderness north of the Porcupine River, both parts of the proposed Arctic Wildlife Range. Other recreation areas in Canada to be impacted include several sites to be occupied by compressor stations and related facilities, sections of canoe routes on the Rat and Thunder Rivers, and several sites near the pipeline river crossings. Activities which have the potential for being most seriously affected are lowlevel aerial viewing in many areas, big game hunting, and general wilderness experience. (Isaak, 1974) In the Canadian north impacts are more likely to occur on potential recreation areas than on existing ones. The aesthetic quality of the area would decrease, possibly making the establishment of recreation sites less likely.

As long as construction occurs during the winter months in the Arctic, migratory animals and recreational hunters should not be affected. However, noise from such installations as compressor stations and the introduction of additional people may tend to scatter wildlife. Arctic fish are very slow to regenerate, and over-fishing of deep water lakes and streams may become evident. Though the company forbids fishing and hunting along the route by workers, all the crew members may not refrain from the activity.

Wildlife would be temporarily reduced in construction areas along all routes. However, as long as construction does not take place during hunting season, hunter activity should be unaffected. Construction will create an adverse impact for those people wishing to view waterfowl or other wildlife in such areas as the Tule Lake-Upper Klamath Lake region along the route to San Francisco.

Fishing and boating would be temporarily hampered near river, stream and lake crossings by construction, increased turbidity, waste disposal and noise. For the duration of the project, increased noise would have an impact upon developed recreation areas located up to two miles from compressor stations and gas blowdown sites. Parks which are crossed by the pipeline, as Starved Rock State Park and Matthiessen State Park (Illinois) along the Northern Border route, will be temporarily disrupted by construction. Visitor enjoyment of wildlife, continuous forest and relative silence would be reduced. The swath through the trees, of course, would remain beyond the lifetime of the project. Also, use of the right-of-way within parks and recreation areas will be limited by its nature. In some cases, the corridor may eliminate potential campsites for motorists, e.g., where it runs between the Mackenzie River and Highway.

During construction the quantity of recreation will be reduced throughout the route. However, additional areas will be opened up to the general public for future use when permanent access roads are constructed through previously inaccessible or lightly used areas. This increase in use may change recreational activities of a once fairly isolated area from, say, backpacking and camping to picnicking and hiking. Where there is a delicate balance with nature, as in the Arctic, increased use could spoil the attractiveness of the area. Also, if access is increased on private lands the landowner may lose some desired privacy. For certain, new or better access to areas desirable for recreation will create new impacts resulting from the increased recreational activity.

3.OV.14 Impact on Air Quality

There are several emissions from this project which will cause degradation of air quality. A few, such as dust and construction equipment emissions, will be significant but temporary, while others, such as compressor station combustion products and their effects on lichen and in the creation of ice fog, are lower level but long term. Each are discussed separately below.

Construction Equipment Emissions

Many millions of gallons of diesel fuel and gasoline will be consumed directly in the construction of the pipeline and associated facilities. It is estimated that a similar amount will be expended on secondary activities related to the support of the construction personnel. The primary emission from the combustion process will be NO_x at an estimated rate of 11 grams per bhp-hr (Hare and Springer, 1973). The expenditure will occur over large distances and during several years of construction. This will result in average annual concentrations that are negligibly small. However, there are circumstances when construction equipment may be concentrated for extended periods of time at locations that are conducive to concentration of the emitted pollutants. River crossings under stable atmospheric conditions are of particular concern. Examples are the crossings of the Mississippi, Ohio, and Monongahela Rivers on the Northern Border Route, the Moyie and Kootenai Rivers on the West Coast Routes, and the Kootenay River on the Kingsgate leg of the Canadian Route. If all adverse conditions combined, it would be possible to have concentrations up to 10,000 $\mu g/m^3$ (See Section 3.1.3.14).

Fugitive Dust

Dust from construction activities would also create short-term adverse impacts on air quality and upon visibility. This problem would be most severe for the arid soils of the far western states. The two primary sources of dust are the construction activities on the pipeline right-of-way and the truck traffic associated with pipe-hauling and other support activities. Considering that pipeline construction is similar to highway construction, it was estimated that about 5 tons of dust will be generated for each pipeline mile. On unpaved roads it was estimated that trucks would generate about 0.1 tons of dust per pipeline mile. These figures are most applicable in the western parts of the North Border Route, along 300 miles in the Columbia River basin and in Nevada and in parts of Canada. The range of influence of the dust deposition is expected to be on the order of 1 mile. Because the dusty regions are almost or completely uninhabited, the primary impact will be dust cover on the local vegetation.

A secondary source of dust will be the extraction and transportation of materials from borrow pits. The impact is considered to be small.

Compressor Station Emissions

The only continuous long-term impact on air quality would be from the operation of compressor stations along the gas pipeline system. Turbine exhaust emissions would contribute both nitrogen oxides and carbon monoxide as products of combustion, and negligible amounts of other gases as air pollutants. Side effects will be the emission, in the arctic, of sulfur dioxide and water vapor. Each are addressed separately below.

Emission of Air Pollutants

Because the compressor stations will be burning natural gas, which is considered to be "clean-burning," the amount of pollutants emitted will be less than for other combustion processes. The stations are widely spaced sc that ground concentrations will be below natural ambient air standards on an annual basis. The standards are based upon concentrations which directly relate to health effects. However, because the proposed system is sufficiently large to require many compressor stations, the absolute emissions will be quite large, contributing to the general environmental degradation. For the initial system it is estimated that 10,000 tons of NOx and 4,000 tons of CO will be emitted each year, while for the possible fully powered system 15,000 tons of NO_x and 6,000 tons of CO will be emitted each year. These emissions will occur primarily in areas that are relatively clean in the conterminous states and totally unpolluted in the arctic and sub-arctic regions, so that significant additions of pollutants will occur even though the concentrations will be too low to affect health.

Sulfur Dioxide Emissions

A number of studies have been performed that show the effect of sulfur dioxide on lichens, a significant food for arctic caribou. One study (LeBlanc and Rao, 1973) has suggested that long-term average concentrations of SO_2 above .03 ppm cause acute injury to epiphytes, concentrations between .006 and .03 ppm cause chronic injury, and below .002 ppm no injury is caused. These values may be subject to small variations for various types of lichen.

To estimate ground concentrations, the total sulphur content in the pipeline gas had to be estimated. Several sample tariffs, provided by the applicants, indicated 20 grains of total sulphur per 100 cubic feet as a maximum allowable amount.

Computing the effect of combustion and estimating dispersion (Turner, 1970), it is estimated that for the most stable atmospheric conditions, maximum ground concentrations can go as high as .007 ppm under high wind conditions but only as high as .002 ppm for 5 mph winds. Since these are maxima, it is highly likely that long term average concentrations on the order of .0002 to .0005 ppm will exist. Any reductions in the allowable total sulphur in the tariffs will cause further reduction in emissions. These values are sufficiently below the injury thresholds for lichen stated above, so no impact is expected.

Ice Fog Effects

Ice fog forms in arctic regions under certain circumstances that include very low temperatures. Although the formation of these fogs cannot be predicted completely, it is known that water vapor emissions form small ice crystals around particulate nuclei (Ohtake, 1971). The applicant has estimated that 7,200 lbs/hr of water vapor will be emitted from the 30,000 h.p. stations, and the combustion process will generate enough particulate nuclei to predict that ice fog can form. Under favorable conditions, over 10 million cubic feet of ice fog can be generated per hour from each station. Such fogs will reduce visibility in lowland areas where it will settle and will add to the number of days of fog now present in the arctic. This would be especially true during periods of air stagnation, which might persist for as much as two weeks. The ice-fog plume could cover an area of a half mile radius of the site with decreasing intensity outward. Since ice fog is not directly harmful, the impact will be visual and indirectly may pose a safety hazard. Helicopter and low flying aircraft flights might be affected by these fogs.

Market Area Effects

The use of natural gas in the market areas will result in an indirect but favorable impact on air quality. The market areas include some of the more industrialized and consequently more heavily polluted areas of the country. The availability of natural gas should prevent conversion to other more highly polluting fuels, such as coal by delaying the use of dirtier fuels equivalent to the amount of energy derived from the gas during the life of pipeline service. The end result would be primarily in lower levels of particulates and sulfur oxides in the market areas of the Eastern seaboard states and California than would be expected without the additional gas supply.

3.OV.15 Impact on Environmental Noise

Ambient noise levels along much of the proposed 6,000-mile pipeline system are now very low and any pipe hauling, pipeline construction, or operating noises will be noticeable to human and animal life in proximity to the pipeline.

Effects of Pipeline-Related Noise Emissions on Humans

Construction Phase--Short-term Impact

Road Traffic

Pipe-hauling trucks will produce sound levels of 86 to 90 dBA at 50 ft., if they meet the U.S. EPA standards for interstate motor carriers. It is estimated that a total of 445,000 people will be impacted by pipe hauling over the entire period of construction.

Geographical Area	Population Potentially Impacted by Pipe-Hauling Truck Noise
Alaska	Unestimated
Canada	162,000
North Border	160,000
West Coast:	
San Francisco Line	75,000
Los Angeles Line:	
Kingsgate to Rye Valley	29,000
Rye Valley to Cajon	19,000

Pipeline Construction

The day-night sound level (L_{dn}) of pipeline construction activities is estimated to be 84 dBA at 50 ft. The total number of people residing within an area impacted by an L_{dn} in excess of the U.S. EPA goal for human welfare, along with other measures of impact, are presented below.

Geographical Area	Estimated no. of people residing within a L_{dn} ≥55 dBA	Estimated no. of people highly annoyed	Estimated no. of complaints
Alaska	0	0	0
Canada	978	464	18
North Border	13,048	4,263	182
West Coast:			
San Francisco	4,558	1,636	131
Los Angeles:			
Eastport to Rye Valley	1,881	895	63
Rye Valley to Cajon	494	198	15
TOTAL	20,959	7,456	409

Blasting

Blasting will be required along several stretches of the proposed route where trenching cannot be accomplished with a backhoe. Safe limits of ground motion from blasting have been established at an acceleration level of 38.6 inches per second per second from 5 to 15 Hertz (Hz) and a velocity level of 0.4 inches per second above 15 Hz. Structures were located close enough to blasting locations to cause damage in West Virginia and Pennsylvania (North Border).

Operational Phase -- Long Term Impact

Gas Compressor Stations

Compressor stations are long-term, continuous, fixed noise sources. All the proposed stations in Alaska, Canada, North Border, and the future expansion of the Los Angeles Line (Rye Valley to Cajon) will be newly constructed. The proposed locations are in essentially rural or undeveloped areas which are presently very quiet. Additions to the horsepower of existing stations is proposed for the San Francisco Line and the Los Angeles Line (Eastport to Rye Valley). The predicted impact of these stations, totaled across geographical areas, is:

Geographical Area	Estimated increase in no. of people residing within a Ldn of 55dBA	Estimated increase in no. of people highly annoyed	Estimated increase in no. of complaints
Alaska	0	0	0
Canada	79	17	0
North Border	3,474	479	11
West Coast:			
San Francisco Line	9	1	0
Los Angeles Line:			
Eastport to Rye Valley	Unknown	Unknown	Unknown
Rye Valley to Cajon	Unknown	Unknown	Unknown
TOTAL	3,562	497	11

Blowdown Noise

Venting of high pressure gas will produce sound levels between 108 and 115 dBA measured at 100 ft. from the station. Blowdowns are infrequent, long-term noise sources. They are expected to occur approximately once per year in the North Border and West Coast lines. In Alaska and Canada, they are predicted to occur 9-15 times per station per year. Sound levels from a station blowdown will be near 70 dBA at 3 miles.

Effects of Pipeline Related Noise Emissions on Wildlife

There are no definitive studies which would enable quantification of the long-term impact of pipeline related noise on wildlife. Studies do indicate that the most probable immediate effect will be to reduce utilization of habitat areas impacted by noise. Whether this effect will be long or short term is unknown but likely to be variable among species.

Construction Phase

Very little research has been completed on the reaction of wildlife to construction noise. Since construction noise is temporary, it is likely that the impact, if any, will be short term.

Operational Phase

Gas Compressor Stations

It is predicted that the maximum horizontal distances at which wildlife have been observed to react to station noise is indicative of the maximum distances at which decreased utilization of habitat areas will occur. These distances are presented below:

Wildlife	Estimated Maximum Horizontal Distance (ft.) of Reaction
Caribou	2,640
Dall Sheep	5,280
Ground Squirrels	0
Red Foxes	5,280
Snow Geese	15,840
Lapland Longspurs	2,980

Pipeline Surveillance Aircraft Flights

Inspection flights will be made approximately once per week at an altitude between 150 and 500 ft. Ground sound levels at these altitudes will be 85 to 103 dBA for a Cessna 185 traveling at 145 mph. The estimated maximum distances at which habitat utilization will be reduced (assuming inspection flight altitude of 500 ft.) is:

Wildlife	Estimated Maximum Horizontal Distance (ft.) of Reaction to Surveillance Altitude
Caribou	890
Dall Sheep	5,250
Moose	350
Grizzly Bears	870
Black Bears	870
Wolves:	
Aerial hunting prohibited	No reaction
Aerial hunting permitted	870
Snow Geese	47,520
Canadian Geese	5,650
Waterfowl	5,250
Black Brants	10,550
Common Eiders	3,000
Glaucous Gulls	3,000
Arctic Terns	870

Air Cushion Vehicles (ACV)

ACV produce a sound level of 98dBA at 150 ft. from the vehicle when cruising at 40 to 45 mph. Birds have been observed to flush at distances of 275 to 3,960 ft. away. The reactions of mammals have not been observed. These vehicles will be used in Alaska and Canada to transport heavy equipment to sites requiring repairs.

3.OV.16 Impacts of Hazards and Pipeline Integrity

The environmental impacts that can occur when a pipeline system fails are in two broad categories: (1) failures associated with the break, such as gas release or fire, and (2) failures associated with repair of the system such as those caused by repair crews. In general, the environmental impact of system failure will be greatest in the more forested or populous areas of the lower states, while the impact of the repair process will be greatest in the Arctic and Subarctic regions. The potential for hazardous breaks is placed in perspective by discussing pipeline failure rates of record, causes of failure, and projected applications to the ANGTS. Impact of the repair process and its probable result are also discussed.

Transmission Pipeline Ruptures

The historical record for transmission pipelines suggests that the catastrophic failure rate has been quite low. The Department of Transportation, Materials Transportation Board Operations (OPSO), regulates transmission pipelines under 49 CFR 192 to minimize the potential for failure. OPSO, under the authority of 49 CFR 191, keeps records on pipeline leaks. Most leaks are minor, which cause no environmental impact, and most are associated with distribution lines which are of basically different construction than transmission lines.

Some historical data that were available from a number of sources on ruptures of transmission lines are given below:

Year	Period (Yrs.)	Miles	Pipe Size	Owner	Ruptures/ Mile/Year
1970-1972	3	12,842	>36"	All	.000078
-	17	7,000	>30"	Canadian Co.	.000084
-	6	3,115	-	Northwest	.00054
1974	1	43,000	>30"	All	.000046
-	14	618	36"	PGT	0
				AVERAGE:	.00011

The results suggest that an average of one rupture has occurred in 10,000 miles of transmission line each year. The result compares very closely with an independent assessment by the Nuclear Regulatory Commission. Based on this estimate one might expect a rupture in the proposed pipeline once every 1-1/2 years. For the various segments, a rupture would be expected once in the number of years noted: North Border, 6 years; San Francisco, 10 years; Los Angeles, 8 years; Canada, 4 years; and Alaska, 48 years.

The proposed pipeline, however, will need to meet more stringent standards than those that have ruptured in the past for fewer breaks to result. Counteracting this trend are the new engineering problems that need to be solved in the Arctic and seismic regions. For example, the API XL 70 pipe will be subject to a tremendous stress and strain under certain combinations of external loading in the permafrost area; these will be in excess of the allowable stress levels described in part 192, title 49 of the CFR.

Causes of Pipeline Rupture

There are a number of mechanisms by which a pipeline can fail and they can be categorized as those that are: (1) self-induced, such as overpressure, corrosion, material defects, or construction stresses; (2) naturally induced, such as earthquakes, slope failure, or erosion; and (3) man-induced such as excess loadings, and accidental or deliberate contact. The primary causes, other than accidental contacts, are discussed below.

Permafrost

Permafrost conditions can exert pressures and tensions on the proposed pipeline and associated structures.

Modification of the heat balance, for instance during construction of the pipeline system, between the existing insulation properties of snow, soil texture and vegetation will probably degrade the permafrost; this degradation is difficult to arrest until a new heat balance is achieved, a process which may take decades. Imbalance of heat may impact the operation of the pipeline. Through thermal erosion and thermal melting the pipe-filled ditch could become filled with water, reducing the strength of the underlying supporting materials, creating subsidence and compaction, and potentially adding pressures on the pipeline which may finally result in rupture.

Frost heave may also occur and it is probable then that the buried pipeline would be jacked out of the ground as ice accumulates along the periphery of the frost bulb. As the pipeline is lifted upward by ice, increasing stress on the pipe could cause the system to fail.

Construction of the proposed pipeline ditch may create local conditions favorable to deep-seated creep. The impacts of this would be significant, major and adverse since creep could cause movement of the pipeline and subsequent rupture.

Wherever the freezing temperature of water in permafrost is lowered--for example, if methanol is accidentally released--pipeline integrity may be threatened. Formation of the frost bulb will be inhibited and slope instability abetted.

Creation of a new stream profile as a result of gravel extraction downstream from a proposed pipeline crossing could result in increased scour depth and possible pipeline failure through undercutting of the streambed. This would be most critical at crossings of rivers in Alaska for example, where the gradient can range from 31 to 41 feet per mile, as it does at the Sadlerochit and Jago Rivers.

Seismicity and Faulting

The pipeline route will cross active faults throughout its route, and it will pass through zones of some seismic activity. The classification of damage risk is given below:

Seismic Risk Measures

Zone	Expected Damage	Modified Mercalli Intensity	Approximate Richter Magnitude
0	None	IV or less	4.5 or less
1	Minor	V, VI	4.5 to 5.5
2	Moderate	VII	5.5 to 6.5
3	Major	VIII or greater	6.5 or greater

Segments of the proposed route, in northeastern Oregon, Washington, and Idaho, nearly all of Nevada, central California for the San Francisco line, and southern California for the future expansion of the Ios Angeles line, pass through zones of significant potential future seismicity and possible ground failure. About 50 percent of the Los Angeles route and its expansion is in seismic risk Zone 3, while 120 miles of the San Francisco route is also in this high risk zone. Most of the remainder of the west coast routes are in Zone 2, with a few hundred miles in Zone 1. On the Northern Border route, the seismic risk zone is 1, except for a part in western Ohio that is in Zone 2. A dozen earthquakes ranging in intensity from about (Modified Mercalli intensity) III to VIII are recorded as having occurred within about 20 miles of the proposed route in that part of Ohio.

The maximum expectable earthquakes along the Canadian segment of the line are given below:

Segment	Richter Magnitude	Approximate Risk Zone
Main Line and Supply Lines		
Alaska border to 138° W	5.5	1
138° to Arctic Red River	7.0	3
Arctic Red River to 65° N	5.0	1
65° N to 62° N	6.0	2
62° N to 55° N	4.5	1
55° N to Caroline Junction	5.5	1
Kingsgate Delivery Line		
Caroline Junction to British Columbia-Idaho border	5.5	1
Monchy Delivery Line		
Caroline Junction to Saskatchewan-Montana border	4.5	1

The entire Alaskan segment is in seismic risk Zone 1 where no damage is expected.

Seismic events can cause ground shaking that can damage the pipeline and associated structures. In addition, ground shaking can trigger landslides, rockslides, and rockfalls, or can trigger ground failure by lurching and settlement. Liquefaction (flowage) of some fine-grained sediments can also occur. These areas include, for example, lake sediments found in the region of the Walla Walla River crossing in Washington, and at the crossing of the Fall River just south of the Oregon-California border. If this should occur, foundation materials would behave as if they were a liquid and support for the proposed pipeline would be removed, causing rupture. Portions of the pipeline itself could move, also causing rupture.

Landslides and Related Mass Movements

Differential displacement of rock and other earth materials supporting the pipe can cause a loss of support which, in turn will cause a variety of stresses including tension, compression, torsion and shear. If one or more of these stresses becomes great enough, pipe rupture can result.

Areas crossed by the proposed route that are most susceptible to landslides and related problems are, among others, near Antelope Creek in Oregon, in the Appalachian Plateau, and at any steep-walled river valley crossing, such as the John Day.

Snow avalanches, possible where the proposed route crosses the Rocky Mountains in southern British Columbia, may also exert undue pressures on the pipeline, causing it to rupture.

Subsidence

Subsidence of the ground surface along the proposed route would cause uneven settlement of earth materials supporting and surrounding the pipe and associated structures. Collapse could occur wherever the proposed route crosses underground mine workings or caverns or sinkholes. Because State mine records are commonly incomplete and inaccurate, and because no records are known to exist of some mines, unknown or unreported mines can inadvertently be traversed by the pipeline route. This is most likely to happen along the 160 miles of the route in the Appalachian Plateau province. The likelihood of serious settling in this region is considered moderate to great.

The impact of compaction of loose sediments, such as windblown silt or sand, for example across roughly 200 miles of the route in Illinois and Indiana on the proposed project is considered small. Since pipe placement in a trench excavated in and floored by organic-rich sediments is unlikely, the impact of compaction of these deposits on the pipeline is likewise considered negligible.

Collapse of lava tubes in the Modoc Plateau province, along the western leg of the proposed route, and collapse of cave roofs in eastern Iowa on the Northern Border route, could occur after construction of the pipeline, especially during earthquakes, thereby causing rupture.

Water Resources

Burial depth of the pipeline at stream crossings in relation to maximum scour depth is significant in terms of pipeline integrity. Without the precautions of weighting the pipeline and burying it below scour depth, the pipeline could be floated during a major flood and consequently jeopardized.

Flash flooding, characteristic of the drier portions of the route, for example in the Basin and Range province, has the potential for rupturing the pipe by either excessive streambed scour or transport of very coarse sedimentary detritus. However, such extreme flood events are generally too rare for normal hydrologic analysis.

Impacts of Pipeline Ruptures

The impact of natural gas pipeline ruptures can result directly from the rupture process or by resultant explosion or fire. Widely reported impacts of natural gas line failures relate to distribution systems in populated areas where gas seepage into a building results in gas accumulation and subsequent explosion. Gas transmission lines are generally remote from buildings so danger from explosion is slight. The primary factors for environmental impact are the pipeline pressure and the proximity of people, wildlife, or vegetation. Thus, to estimate the impact, the consequences of the rupture of both distribution and transmission lines will be discussed without regard to age or use.

A 780 psi, 14-inch diameter pipeline failed on September 8, 1969 near Houston, Texas (NTSB Report dated July 1, 1971). About 8 to 10 minutes later, the gas exploded violently, destroying 13 houses up to 250 feet from the rupture point and damaging 106 nearby houses. No one was killed, but nine were injured. A weak weld was considered to be the cause. Based on this incident, a total damage radius of 250 feet and a partial damage radius of 600 feet is estimated. The gas flow from the leak had burned until the gas supply was exhausted.

On March 2, 1974, an 800 psi, 30-inch diameter line near Monroe, Louisiana ruptured beneath a highway (NTSB, Par. 75-1). A trench 100 feet long, 30 feet wide, and 25 feet deep was formed. The gas ignited immediately and burned 10 acres of forest. One of the automatic-closing block valves functioned improperly. Approximately 53 million cubic feet of gas burned.

More recently, a 718 psi, 30-inch diameter pipeline ruptured in a rural area near Bealeton, Virginia (NTSB Par. 75-2). A trench 118 feet long, 37 feet wide, and 7 feet deep was formed. Shrapnel was found as far as 300 feet. The gas self-ignited and burned an area about 700 feet by 400 feet, part of which was forested. There was a loss of trees, but there were no deaths or injuries. Two automatically closing valves failed to function. The cause was estimated to be a crack propagating from a hardspot in the pipe wall.

The dynamics of the escaping gas is also of importance. With regard to the size of a pipe rupture, a very large failure would exhaust the gas rapidly so that both upstream and downstream block valves would experience a rapid pressure drop and would close, if functioning properly. For "small" holes, on the order of 17 square inches on the smaller lines, and 40 square inches on the larger lines, critical flow would be established in the break. There are substantial questions as to whether the upstream block valve would experience a sufficient pressure decrease rate to close under these conditions. Applicants have said that the valve would close, but there does not appear to be a body of data to establish whether a "small" hole ever occurs, and if it were to occur, whether the block valve would close.

The gas exhausting from a break has its pressure energy converted to momentum which must ultimately be directed vertically. The initial supersonic expansion process is nearly isentropic causing the gas to cool to the saturation point. Some droplet formation is bound to occur. The evidence suggests that these droplets do not separate from the gas stream, so dissipation processes in the stream cause them to revaporize and the system enthalpy increases slightly. Consequently, the gas, after discharge, although cold, is not denser than air and will continue to rise, disperse and therefore not pose a distant ground level adverse environmental impact. Experience has shown that in most cases ignition occurs at the break, consuming the gas and causing a fire hazard in the immediate vicinity of the break.

For the largest lines, a loss of about 160 million cubic feet is estimated in Class I locations. It is possible to have a break encompass a block valve so twice as much gas is lost, but it is estimated to occur once in 1,500 years.

Based on this discussion it appears that a severe damage radius of 250 feet is a reasonable estimate, with lesser damage at increasing distances except for possible downwind fire damage. Most of the proposed pipeline has been carefully chosen to avoid populous areas. About 20 percent of the entire route is through forested areas. Assuming that all major ruptures will result in a fire, a burn of forested areas might be expected once every 7-1/2 years. The amount of burn is not assessable. There are some populated areas near the pipeline route where potential hazard could occur. Between Penn and Jeanette, Pennsylvania, there are several homes with 250 feet. The length of pipe, compared to the total length, is so short that a break at that position is an extremely unlikely event. East of Bend, Oregon, there are a number of homes quite close to the existing pipeline, one particular trailer home appears to be within 100 feet. The proposal calls for another pipeline to be placed in this corridor. Although 49 CFR 192 does not require a class change when two pipelines are in near proximity to residential units (which doubles the exposure), the probability of a major rupture at this point is once in 9,500 years.

Potential hazard to wildlife is considered slight, and depends upon the density of wildlife and the size of any subsequent born.

Pipeline Repairs

In the northern parts of the route, access to the pipeline to repair a rupture is difficult. Spring would pose the worst problems. Using the previous data, it is estimated that a rupture requiring access would occur in the permafrost region once every 7-1/2 years and once every 15 years during the spring and summer seasons. These estimates are based on the history of existing pipelines and may be in substantial error, either way, because of the unique conditions of the arctic.

The applicant has described the kinds of equipment he might use to repair a pipeline break. Basically, he would use a low ground pressure (LGP) or an air cushion vehicle (ACV) to transport equipment over the tundra. Such vehicles are projected to cause very little impact on tundra vegetation. For a discussion of the impact of tundra vegetation, see the Alaskan Vol., section 3.1.1.6 and the Canadian Vol., section 3.1.2.6.

4.OV Mitigating Measures in the Proposed Action

The Applicants indicated they will execute numerous mitigating and environmental control actions. Some are firmly committed and specifically stated while others are not. Based upon its own experience, the Department of Interior in the absence of stipulations yet to be developed, has selected the following mitigatory measures as firm commitments by the Applicants. Also, these are commitments having reasonable assurance of control.

In the following assumed controls the four marked (*) pose a particular problem. The degree of control assumed in the impact analysis accepts at face value the commitment of the Applicants. However, construction delays, economic difficulties and faulty enforcement are common occurrences on large projects. The tight control action called for may, under stress, become compromised. For instance, if firearms and hunting are not rigidly controlled or if winter construction activity is not stopped before spring thaws occur, before spring and fall caribou migration and spring calving begins, or before wildlife nesting begins, the related impacts described in the preceding section (3.OV) will become major and unavoidable and should then be listed in section 5.OV.

Each mitigating measure section of the geographic volumes has a thorough discussion and analysis of the specifics for that geographic area. In these more detailed discussions additional measures have been added which indicate other mitigation that could take place to further reduce impacts. These will be essential for the development of stipulations for any grant of right-of-way.

The following control measures are only those measures which are assumed active within the analysis of environmental impacts developed in this overview and the geographic volumes.

4.OV.1 Climate

No mitigating methods proposed.

4.OV.2 Topography

No mitigating methods proposed.

4.OV.3 Geology

<u>Permafrost</u>

*All construction of the pipeline will be done from snow and ice roads during the winter when the ground is frozen.

Gas in the pipeline will be chilled below 32°F to maintain the frozen condition of the ground.

All slopes over 3° will be checked for possible instability and special construction methods will be used.

All repairs to the pipe during thaw periods will be done from air cushioned vehicles to preserve the tundra.

Landslides

Most areas of instability will be avoided. In those areas where the pipeline must cross unstable ground the line will be carefully constructed and the slope monitored during and after construction to detect any movement that might damage the pipe.

Mineral Deposits

All borrow pits will be protected from becoming erosion hazards during the construction period, and when the pits are abandoned, the land will be reclaimed.

Seismic Conditions

All effort will be made to design the pipeline to withstand expected movement in earthquake areas.

4.OV.4 Soils

A program of prompt revegetation will be undertaken as soon as possible after the pipe has been laid to lessen the impact of wind and water erosion.

Drain tiles crossed by the pipe will be restored to working condition.

4.OV.5 Water Resources

All water used to test the pipe will be clean when it is discharged.

No water low in oxygen will be discharged into any body of water.

All water discharged will be above freezing.

Where ground temperatures are below freezing, water for testing will be mixed with methanol. When this water is discharged, it will be first distilled to remove the methanol.

All tile drain fields crossed by the pipe will be replaced.

4.OV.6 Vegetation

All disturbed soils will be revegetated to prevent soil erosion, to provide wildlife habitat where it has been destroyed and to reduce permafrost degradation in Alaska and northern Canada. Mechanical stabilization methods will be used where needed.

All revegetation will be done with grass, trees or shrubs that are adapted to the region (see Table 4.OV.6-1).

All marketable timber will be salvaged.

All areas will be fertilized. The type and quantity to be used will be determined by local conditions.

If revegetation fails, it will be reapplied.

Table 4.OV.6-1 Pipeline revegetation specifications for areas north of 60° based upon regional climate and potential erodibility

[1]Climatic Region	Erodibility Rating	Seed Specifications: Initial Seeding species	Initial Seeding rate (Kg/ha)	Follow-up Seeding species	Follow-up Seeding rate (Kg/ha)	Revegetation Measures: Sod Replacement	Seed Mats	Stem Cuttings
Low Arctic Tundra	High	[2]NKB	18	NKB	9	No	Yes	[3]Yes at river crossings
		ACRF	38	ACRF	19			
	Medium	ACRF	40	ACRF	19	Yes	No	No
		ET	6	NKB	0			
		MT	6					
		Rt	6					
	Low	ACRF	22		None Planned	Yes	No	No
		NKB	6					
Forest Tundra	High	NKB	22	NKB	9	No	Yes	Yes
		ACRF	22	ACRF	19			
		MF	11					
	Medium	ET	11	NKB	9	No	No	No
		MF	11	ACRF	19			
		BCRF	34					
	Low	BCRF	11		None Planned	No	No	No
		MF	17					
Boreal Forest	High	BCRF	22	BCRF	17	No	Yes	Yes
		CCB	17	CCB	11			
		SF	17					
	Medium	BCRF	22	BCRF	17	No	No	No
		CCB	11	CCB	11			
		MF	11					
		CB	11					
	Low	BCRF	6		None Planned	No	No	No
		MF	11					
		CB	11					

[1]based upon major vegetation zones
[3]will be used if available

[2]NKB - Nugget Kentucky Bluegrass
ACRF - Arctared Creeping Red Fescue
ET - Engmo Timothy
MF - Meadow Foxtail
Rt - Redtop
CCB - Cannon Canada Bluegrass
SF - Sheep Fescue
BCRF - Boreal Creeping Red Fescue
CB - Creeping Bentgrass

Vegetation destruction caused by fuel spills will be replaced.

4.OV.7&8 Wildlife and Ecology

*Construction will be scheduled to avoid the most sensitive periods of the animals' life cycle.

Barriers and protective fencing will be placed around construction areas and open trenches where possible hazards to the public or animals exists.

*Firearms will be prohibited in camps and hunting will be prohibited by project personnel.

Barge traffic will be kept away from bird nesting and moulting areas.

Work crews will not be permitted to use company vehicles to visit critical habitat areas.

Fish spawning areas will be located and avoided.

Buffer zones between the right-of-way and rivers and streams will be provided.

Blockage of streams during construction will be prevented.

Competent aquatic biologists will be employed to monitor construction, operation and maintenance procedures from the standpoint of protecting fisheries.

During spring of the construction period in Alaska and northern Canada, the movements of caribou will be monitored, and construction halted when they come close.

Construction has been scheduled from May through November in Saskatchewan and Montana to avoid possible conflicts with sage grouse on their strutting grounds.

No barrier in the form of stored pipe and equipment will be placed to restrict migration of caribou.

4.OV.9 Economic Conditions

Right-of-way easements will be acquired by private contracts between individual property owners and the pipeline companies.

Road overload permits and charges for the use of other public facilities will be arranged between local governments and the pipeline contractors.

Marketable timber will be salvaged from the right-of-way and sold.

Training programs for skills related to pipeline construction will be offered to Natives in Alaska and Canada.

4.OV.10 Sociological Conditions

The Canadian Applicant will offer a two-fold social training program: Natives will be counciled on living in a wage-oriented economy; "Southern" industry supervisors will be instructed in the culture, history and lifestyle of the Native northerner.

Dependents are forbidden to accompany workers in Alaska.

4.OV.11 Land Use

Following initial pipeline construction, temporary rights-of-way will revert to original ownership and the land will be allowed to return to its original use where compatible with operation of a buried pipeline.

Fences and gates with locks will be replaced on private roads leading to the right-of-way.

Preferences of landowners along the alignment will be given full consideration during all phases of pipeline activities.

4.OV.12 Archeological, Historical, and Unique Areas

Archeological Values

Archeological sites included on and eligible for inclusion on the National Register of Historic Places will be protected.

Newly discovered sites on Federal lands that appear to qualify for inclusion on the National Register of Historic Places will be nominated.

The Applicants will conduct an archeological survey of the corridor and related sites on Federal lands and State lands where required.

Arrangements will be made to have an archeologist available to make surveys of any artifacts or previously unknown archeological sites discovered during grading or trenching.

Archeologic sites will be avoided by minor rerouting where possible. When this is not possible an archeologist will be contacted for salvage excavation.

In Canada, surveys will be conducted prior to and during construction to identify prehistoric sites.

In Alaska, archeologic crews will accompany ditching and other construction or excavation activities to provide surveillance of any archeologic site exposed.

Sites discovered, but not otherwise affected by construction, will be clearly marked and identified for future investigations in Alaska.

The Applicant in Alaska will arrange for artifacts to be deposited in appropriate public repositories and expects that most will be placed in suitable northern museums.

Historical Values

Historical sites included on and eligible for inclusion on the National Register of Historic Places will be protected.

A survey of the corridor will be made before construction.

Identified sites will be avoided or construction is planned to preserve the historical integrity of these sites.

Any historic site on Federal land which appears to qualify for the National Register of Historic Places will be nominated.

Unknown buried historical sites will be treated the same as archeological sites.

Unique Areas

The Applicants propose to by-pass unique areas by minor route changes cr to limit development to the margins of the site.

4.OV.13 Aesthetic and Recreational Resources

Aesthetic Resources

Through areas of steepe and shrub steepe vegetation, all cleared areas other than compressor station compounds will be revegetated with grasses.

Through forested areas where viewer sensitivity may be high, techniques to screen fore and middle-ground views of the right-of-way at road crossings will be used as determined by on-site conditions and requests of regulatory agencies. Techniques to be used are:

- Preservation of existing vegetation screens by extending the length of road borings
- Reducing the right-of-way width at road crossings
- Reestablishing disturbed screens by planting

Where applicable as addressed in FPC guidelines in 18 CFR 2.69 the Alaskan, Canadian and Northern Border segment Applicants will:

- Screen the right-of-way at stream and highway crossings
- Feather the right-of-way
- Make minor bends in alignment to avoid tunnel views at wooded stream and highway crossings

The West Coast route will share an existing pipeline corridor.

Recreation

Temporary access to parks will be provided and other measures will be adopted to assure continued operation of parks.

The Applicants will consult with park management in planning construction through park units.

*Construction will be timed to avoid peak wildlife nesting periods in areas designated as major wildlife habitats when possible.

Where rerouting of the pipeline through a recreation area acquired or developed with the assistance of Land and Water Conservation Fund money is not practical, the Applicant will comply with Section 6F of P.L. 88-578 (Land and Water Conservation Fund Act of 1965) regarding the Secretary of Interior's approval of conversion of use of Federally assisted recreation areas.

4.OV.14 Air Quality

The Applicants will comply with established local regulations and Federal Air Quality Standards.

4.OV.15 Noise

The Applicants will conform to all established Federal, State and local regulations and standards (see Table 4.OV.15-1).

4.OV.16 Hazards and Pipeline Integrity

General

Design, construction, testing, and operation of the pipeline will be in accordance with Title 49 CFR, Part 192, "Transportation of Natural and Other Gas by Pipeline, Minimum Federal Safety Standards."

Pipe specifications will meet or exceed the industry standards described in American Petroleum Institute (API) Specification for High-Test Line Pipe (API 5LS) or API Specification for Spiral-Weld Line Pipe (API 5LS). A Drop Weight Tear Test requirement will be used in the specification to ensure against brittle fracture and a Charpy V Notch requirement to assure adequate toughness at the pipe operating temperature.

Padding material will be used where necessary to provide a uniform trench bottom on which to lay the pipe.

Hydrostatic testing will be used prior to operation of the pipe to detect leaks and verify pipeline integrity. Test pressures will be in accordance with requirements specified in Title 49 CFR, Part 142.

Internal corrosion will be prevented by: (1) internal coating of the pipe (except Los Angeles Pipeline) and (2) carrying only non-corrosive gas which satisfies the gas specifications of the Tariff. (Note: the primary purpose of the internal coating is to reduce friction and thereby reduce compressor power requirements.)

External corrosion will be limited by: (1) application of external pipe coating and (2) installation and operation of a cathodic protection system.

Mainline block valves will be automatic self-activation valves with pressure differential sensing and powered closing to isolate pipeline segments in the event of a pipeline rupture (except San Francisco Pipeline).

Table 4.OV.15-1 Noise regulations along the proposed route in the lower 48 states 1/

State	Laws or Regulations
Montana	Muffler law and law controlling noise from snowmobiles and motorcycles; proposed legislation (1973) would allow stationary noise standards on construction equipment and motor powered vehicles.
North Dakota	State Code permits adoption of standards on construction equipment noise and motor powered vehicle noise.
South Dakota	None.
Minnesota	Pollution Control Agency Law permits development of noise standards; standards have been proposed. 2/
Iowa	None.
Illinois	Noise Pollution Control Regulations adopted in 1973 limit noise emissions by dividing all land into 3 major land use classifications and setting maximum allowable noise emissions for each of the three classifications. 2/
Indiana	State Code provides maximum allowable noise emission standards for motor vehicles 2/; regulations also proposed for residential areas.
Ohio	Proposed legislation would give a tax exemption to that part of a facility used exclusively for air or noise pollution control.
West Virginia	None.
Pennsylvania	State law controls noise emissions of motor vehicles 2/; State Department of Environmental Resources guideline establishes definitive sound level emission standards for community noise; State Code allows Occupational Safety and Health Act noise levels to be enforced at State level; proposed legislation (1971) would permit development of regulations to abate nuisances, including noise.
Idaho	State has general code covering horns, warning devices, and use of mufflers.
Washington	State noise control act permits development of performance standards which would cover compressor stations; none issued thus far.

Table 4.0V.15-1 Continued

Oregon	In accordance with State noise control laws, State has issued comprehensive set of noise control regulations which limit noise levels of trucks and stationary sources including compressor stations. 3/
California	State regulates noise levels of motor vehicles.
Nevada	State law provides for motor vehicle noise regulations but none have been established.

1/ Excluding State general public nuisance laws and nonspecific muffler laws.

2/ See specific standards in Part V (Northern Border).

3/ See specific standards in Part IV (West Coast).

Compressor stations will be equipped with safety devices to: (1) prevent overpressuring the line; (2) detect fire or presence of explosive mixture of gases in the station atmosphere, shut down equipment and activate fire extinguishers; and (3) shut down compressors in case of mechanical failure such as overspeeding or excessive bearing temperature. Similar safety devices will be installed in metering stations.

Measures to reduce likelihood of damage to the pipeline by third parties include: (1) pipeline markers to indicate location of the pipe, (2) fencing around all above ground facilities, and (3) periodic aerial inspections of the route.

During pipeline final design a specific design will be prepared for each major river crossing to account for the hazards of that particular crossing including such things as potential scour depth, bank erosion, and negative buoyancy requirements.

The pipeline will generally be constructed approximately perpendicular to the slope contours to reduce the hazard of potentially unstable slopes.

To reduce hazard to workmen in pipeline trench, all sections of trench that are likely to cave in will be properly shored.

An operations and maintenance manual will be prepared prior to start of system operation.

Alaska Pipeline

Design criteria were developed to show the allowable stress levels for combinations of loads.

The gas will be chilled (10° to 30°F) to maintain integrity of the permafrost.

Depth of pipe burial will be used to mitigate the potential problems of frost heave and differential settlement. The pipe will be below the active layer of permafrost, with the top of the pipe four feet under the surface. In areas where frost heave potential exists the pipe will be buried at a depth which provides the overburden weight required to arrest growth of the frost bulb around the pipe.

A detailed analysis of mass wasting hazards to the pipeline will be performed as part of final design.

Measures to minimize erosion by water during thaws will tend to mitigate potential hazards to the pipeline integrity through loss of overburden. Measures proposed include: mound breaks, plugs on downside slopes, riprap to control gullying, ditch plugs and grading of slopes with breakers, crossberms, terraces, and diversion ditches. Detailed reclamation and erosion control plans will be prepared prior to start of construction.

All slopes to be cut for the pipeline will be analyzed in detail before start of construction and appropriate slope stabilization techniques applied (five methods cited) to mitigate the potential hazard of slope unstability which might adversely affect pipe integrity.

Borrow pits will be located at least 2,000 feet from the pipeline in order to eliminate any potential hazard to the pipeline.

Mechanical reinforcement bands will be attached to approximately every third 80-foot section of pipe as a mitigating measure to arrest running cracks.

Northern Border Pipeline

The Northern Border Pipeline final route will be adjusted to avoid areas of potential subsidence due to abandoned underground mines.

Secondary stresses imposed upon the pipeline other than internal gas pressure will be considered in the detail design phase and appropriate wall thickness will be specified.

San Francisco Pipeline

As a part of the final design phase, detailed studies will be performed to predict pipeline stress levels resulting from sources other than internal pressure.

Special construction methods are available for construction on the John Day River area to mitigate effects of trenching and reduce the probability of causing landslides.

Various methods are available to reduce effects of erosion in the deep canyons of Oregon and on the Columbia Plateau.

Mining and Quarrying operations would be prohibited on pipeline right-of-way and any expansion of existing mining operations would be detected by the aerial patrol and appropriate action taken to prevent damage to the pipeline.

Los Angeles (Rye Valley) Pipeline

Design and construction criteria will be incorporated into the system to enhance its ability to withstand possible natural and third-party accidents or catastrophes.

General pipeline designs are available to withstand displacement by fault movements.

All areas identified as being susceptible to liquifaction, particularly in the Owens Valley, will be bypassed by the pipeline.

5.OV Adverse Effects Which Cannot Be Avoided Should the Proposal Be Implemented

The following discussion is of the adverse effects which cannot be avoided should the proposal be implemented. Mitigating measures proposed by the Applicants in Section 4.OV have been taken into account for this evaluation. Thus these conditions will occur in spite of the Applicants' proposed mitigating measures.

5.OV.1 Climate

Microclimatic changes downwind of compressor stations, principally ice fog, resulting from the emission of combustion products at a temperature around 600°F will occur. These effects are expected to be dispersed through the air column rapidly under most winter conditions. Further discussion of this aspect appears in the impacts on air quality.

5.OV.2 Topography

Changes in microrelief will occur due to requirements for cuts and fill, borrow pits, spoil piles, and providing a berm over the backfilled ditch. Some scarring resulting from terraces constructed on steep slopes to divert sheetwash and gullying will be evident and unavoidable. Channel scour and lateral migration by streams will be unavoidable in some localities following construction of river crossings. In some of the permafrost areas, subsidence will also be unavoidable to a certain extent. Due to the linear nature and limited width of the pipeline right-of-way, impacts associated with these effects will be of possible local significance only, and greatest in continuous, ice-rich permafrost. The ultimate impacts will be changes in drainage and esthetics.

5.OV.3 Geology

In the permafrost region the most important unavoidable impacts that will develop will be the differential settling over the pipe and the thermokarst that will develop. The differential settling will result in minor relief changes. Although these will probably be no more than 3 feet, the result will cause minor changes in drainage and shallow ponding. The thermokarst that will develop, even with extreme care in construction, will cause water-filled ditches in the vicinity of the pipeline. The extent of melting of the permafrost will depend on how carefully the Applicants adhere to the construction schedule, and the care that they take of the tundra cover. The Applicants state that the pipeline may have to be inactive for a year or more after construction. This will result in deeper thawing over the pipe, with resultant settling of the berm and soil erosion.

5.OV.4 Soil and Surficial Material

Probably the most important impact that pipeline construction will have on the soils will occur in those areas where rainfall is less than 10 inches a year, such as in North and South Dakota and northern Oregon. In areas such as between Stanfield and Juniper Canyon in Northeast Oregon, wind erosion becomes a major factor when the scant vegetation is removed. Since revegetation will be difficult, if not impossible, disturbance of vegetation will cause the soil to be blown into dunes, or gullied by erosion. The effect could be serious locally in this region.

5.OV.5 Water Resources

Water Quality

During construction at river crossings, an abnormal amount of sediment will be discharged into the water. Although this amount will do some environmental damage in the far north, for the most part it will be less than that developed during a normal spring flood in Alaska and Northern Canada.

Oil spills, though unplanned, will occur.

Water Supply

The pipeline construction will require a tremendous amount of water to test the pipe. It has been estimated that in the Alaska section almost 150 million gallons will be needed; in the West Coast section, perhaps as much as 13 million gallons; and in the Canadian and Northern Border sections about 140 million gallons. The supply effects will be serious in the Alaskan stretch. Over drawdown of over-winter fish pools may occur with resulting loss of some fish breeding stock.

5.OV.6 Vegetation

Clearing of the pipeline will result in complete removal of vegetation on approximately 84,000 acres along a narrow belt. The various plant formations, including crops, that will be affected have been shown in Table 3.OV.6-1. Revegetation will take place over the entire right-of-way, with losses occurring in the deciduous and coniferous forests, croplands and throughout most of the prairie. Except for the deciduous and coniferous forests, these losses will be short-term. Long-term losses are anticipated in the desert, chaparral, and certain areas of tundra, as well as the prairie in Montana, western North Dakota, and eastern Oregon, where rainfall is low and secondary succession is slow. In these areas, the decrease in the density of plants will result in a localized decrease in primary production. On a regional scale these losses would not be significant.

Secondary impacts on plant communities are likely to result from changes in drainage and soil compaction. Changes in plant habitat result from such factors. These changes will be limited to the substitution of one community for another within a major biome. For example, on a formerly well-drained site, subsidence in the ditch backfill in the Arctic would favor invasion by sedges at the expense of tussock-dwarf heath tundra, which invades dryer sites. This would be adverse only where a highly productive community is replaced by one of lower productivity.

Erection of permanent facilities will cause a total loss of vegetation on these sites for the life of the pipeline.

Fire will also cause loss of vegetation. Long-term impacts would occur in forested areas if a crown fire occurred. Ground fires restricted to the litter layer, ground cover or understory would have short-term impacts only.

5.OV.7&8 Wildlife and Ecology

The potential for serious adverse impacts on wildlife is greatest in the Arctic, where wildlife populations have been little affected by human activities other than subsistence hunting. Dens of foxes, wolves, grizzly bears, and polar bears may be lost during trenching. Also, any decline in the caribou population will be reflected in wolf and wolverine populations. Harassment by aircraft would affect all large mammals in treeless areas. The most important mortality factor, however, is likely to be due to increased hunting pressure. Legal or illegal, hunting remains a major threat to bears, wolves, wolverines, moose, caribou and musk ox (Kucera, 1974).

The construction of the pipeline will contribute to the opening up of the Arctic and Subarctic parts of Alaska and Canada. Inasmuch as the proposed pipeline crosses about 250 miles of the calving grounds of the Porcupine caribou herd and intersects the traditional migration routes between the winter range and the calving grounds, the presence of the pipeline will have some effect on the herd. Interference with fall migration would cause an effective loss of winter range and subsequent winter kill. Interference with spring migration or increased human activity on the calving grounds would cause a decrease in fertility and, if repeated, possible abandonment of parts of the calving ground. Unless adequate mitigating measures are developed and strictly enforced, the cumulative effect of the opening up of the North, not only as the result of pipeline construction but also through other projects such as construction of the Dempster Highway and additional airfields, bringing with them an increased pressure for recreation in the area, could result in the reduction of the Porcupine caribou herd by as much as 90 percent within 10 years (Calif, 1974). Populations of other widely-ranging or wilderness-dependent mammals, such as the wolf, wolverine, musk ox, grizzly bear and polar bear, would alsc decline.

Disturbances of some sensitive periods in birds' life cycles cannot be avoided due to increased low flying aircraft and human presence. Snow geese, white-fronted geese, whistling swans, and sandhill cranes appear to be most susceptible to this disturbance. In the heretofore little disturbed Arctic, the stimulation of future development, with its resulting disturbance, is the major environmental impact of the proposed pipeline project (Jacobson, 1974). Although thresholds are generally unknown, the capacity of many species to absorb and adjust to increased disturbance becomes diminished with each additional disturbance; and a general reduction in bird numbers and diversity can be expected (ibid). Various mammalian species, especially those requiring a large or undisturbed home range, would be similarly affected.

In the more southerly latitudes through which the proposed route passes, the wildlife have been subjected to human disturbance in the past. Therefore, impacts in these more populous areas will generally be short-term. Exceptions to this include waterfowl habitat in the midwestern U.S. and southern Canada. Construction of the pipeline through the pothole region, which is one of the most productive waterfowl areas on the continent, could interfere with nesting.

The proposed route also traverses valuable habitat for large grazing mammals in the lower United States and southern Canada. A critical area is winter range for antelope in the Badlands. Revegetation will be difficult due to the adverse soil conditions. A long-term reduction in carrying capacity is probable.

Increased sedimentation from construction at river crossings will adversely affect fish populations, especially in the Arctic and Subarctic. This impact, though unavoidable, will be temporary. In the permafrost area there is a possibility that a shortage of water necessary to support winter construction will cause the use of water in sensitive areas for overwintering fish breeding stock. This could cause a decline in the fish population, which could be serious since fish regeneration is slow in the Arctic.

In addition, spills of toxic material, though not planned, are likely to occur. The extent and location of such a spill will determine the effects on fish and other aquatic organisms.

Frost bulbs will probably develop around the chilled pipe at stream crossings. These frost bulbs could create ice dams or aggravate problems with aufeis, forming barriers which could hinder upstream migration of anadromous fish. Should such barriers occur, spawning runs of the arctic char and grayling populations in particular would be affected.

The stimulation of future development in the Arctic will bring about an increase in fishing pressure. Arctic stocks are susceptible to overfishing, resulting in a decline in both the quantity and quality of the sport fishes, arctic char, arctic grayling, and lake trout. In northern Canada, northern pike may be similarly affected.

5.OV.9 Economic Conditions

Construction of the pipeline through agricultural areas in Canada and the U.S. will necessarily take land out of production. The amount of land involved is not large overall (less than 30,000 acres) but will be important to individual farmers. The length of time that production will be interrupted will depend upon construction schedules, but is likely to be no more than one growing season. A much smaller area may be out of production for a longer period depending upon the amount of disturbance to the soil profile that results from the trenching. Some reduction in productivity may result from soil compaction by heavy equipment. The degree of success with which the drainage systems disturbed by the trenching operation are replaced by pipeline contractors will influence future productivity of the lands involved. Cutting of mature trees where the pipeline passes through woodland and maintaining a cleared area along the pipeline right-of-way will reduce timber production on lands affected.

The influx of construction workers into communities along the pipeline route will increase the demand for public services such as public safety, sanitation, public recreation and welfare services. Although these demands will be temporary and should require no new capital investment by communities, they may require the temporary hiring of additional personnel and will represent an additional cost to these communities.

The use of State and county roads by heavy construction equipment, trucks and workers cars will accelerate deterioration of these roads requiring more immediate replacement at the expense of local jurisdictions. Whether all these prove to be a net economic loss to local governments involved will depend upon the volume increase in revenues from pipeline construction personnel and activities. Small communities along the route will feel the impact more than large communities.

Increased competition for labor and construction materials may cause local shortages, inflation in price and delay in construction of other projects. Likewise, the increased competition for housing, food, recreation and other goods and services may lead to local increases in costs of living. The relatively high pay of pipeline workers would put local residents at an economic disadvantage in this competition for limited goods and services.

Most Native peoples along the pipeline route presently rely heavily on hunting and trapping--a subsistence economy. If pipeline construction and operation reduces opportunities to continue this type of life by reducing game populations without providing long-range wage employment as a substitute, an economic loss to these people could occur.

5.OV.10 Social Conditions

Overall, impacts that cannot be avoided will be mostly related to short-term surges in demand for housing, government services, recreation and entertainment. All will be more noticeable in smaller communities, especially in those of the far north.

The Arctic will undergo continued social and community disintegration from family breakdown, alcohol abuse and racial conflict. With the influx of outsiders, Natives cannot avoid the cumulative effects of cultural upheaval. The cultural change process will be accentuated, in some cases to a pace not easily adapted to psychologically by important segments of the Native population (Gourdeau, 1974).

The permanent maintenance and operational crews will add a demand for educational facilities to the above list. The degree of impact will depend on the number of relocated families with children. These permanent employees should only slightly affect a community's facilities as they are comparatively few in number and are spread out. They will, however, have a more noticeable affect on the northern Natives as the ratio of Native to non-Native continues to decrease.

Native Subsistence

Subsistence food sources relied upon by residents of the 13 Native communities along the proposed corridor north of 60° will be cumulatively diminished by construction, operation, maintenance and the following opening up of the region to recreational and other uses. It is not expected that impacts will be severe in the short-term. Resources now drawn upon by these peoples are expected to remain productive (maintainable on sustained yield basis) for 10-20 years. Beyond that, decline is expected.

5.OV.11 Land Use

There will be a change in land use on at least 20,000 acres of agricultural land. This will last for one year except on land required for permanent facilities. The Northern Border segment of the pipeline traverses primarily agricultural land and approximately 570 acres of the 20,736 acre right-of-way will be required for permanent facilities and lost to alternative uses for the life of the project.

The pipeline traverses about 1,877 miles of forest. Commercial forest is limited to four areas of Canada and 23 miles through Idaho and Oregon. Although trees may reinvade the right-of-way following construction, they will not attain commercial quality until many years after pipeline abandonment. In most cases, timber of commercial size will not be permitted over the pipe to protect its integrity.

Residential, commercial, and industrial land uses exist on or adjacent to the pipeline. The total of these areas is less than one percent of the total right-of-way. This existing land use on adjacent areas will not change, but will be precluded on the right-of-way itself. In addition, land along the pipeline that is presently unclassified will be precluded from industrial or high density residential zoning for the life of the project.

Many areas with highly desirable classifications, such as parks, recreation areas, and the like may be bypassed in the selection of the final route, but some will still be traversed; the number is unknown. The most notable is the Arctic National Wildlife Range. The installation of permanent aboveground facilities and structures would be incompatible with current land use plans. The future expansion of oil exploration and development that is likely to be spurred by pipeline construction would change land use in many areas of the Arctic and Subarctic.

5.OV.12 Archaeological, Historical and Unique Area Values

Archaeological Resources

The lack of knowledge as to detailed archeological sites along much of the pipeline corridor promises to cause the destruction of some sites, especially on privately owned lands. If construction occurs as proposed during the dark winter months in the Arctic, some artifacts will inevitably be destroyed.

Damage or destruction of sites from construction or related activities, including vandalism or excavation, will result in the permanent loss of the site. Salvage is not a satisfactory substitute for site protection, as the site would be lost for future study. However, overall, major nationally significant resources on Federal and some State lands should be detectable following completion of surveys, confining losses.

Historical Resources

Ambient noise levels could disrupt viewers of historic sites during construction. Vandalism or damage to the landscape surrounding a site may make interpretation of events that occurred there more difficult. Also, some unmarked historic sites, as sod dwellings, could be destroyed by construction activities.

Unique Areas

Those areas not by passed will have significant losses in values, integrity or aesthetics. Many have been set aside for special use or study. The introduction of a pipeline corridor will diminish uniqueness, as within the Arctic National Wildlife Range.

5.OV.13 Aesthetic and Recreation Values

Aesthetic Values

Aesthetic values will suffer an incremental loss in those areas where man's presence has had little influence on the natural setting. A loss of wilderness values along 495 miles of the pipeline in Alaska and northwestern Canada will create a cumulative long-term impact. Although much of the route along the Mackenzie River in the Northwest Territories is currently quasiwilderness, the proposed Mackenzie Highway will further reduce its wilderness status. Within the contiguous United States the North Dakota Badlands are relatively free of man's presence. Its fragile ecosystem could be easily destroyed. Related pipeline structures would be visible particularly in areas of low relief and areas having no previous development, as in the Arctic. Once developed, the countryside cannot be restored to its former pristine or untrampled condition.

The presence of cleared strips through wooded areas would also affect scenic quality. This will be most obvious in the wooded areas of Canada and the Pacific Northwest as well as at river crossings in general. The loss of aesthetic values may also adversely affect streams that are under consideration for State or National Wild and Scenic River status. Five rivers to be crossed are being considered for the latter category. The pipeline may in some instances mean the elimination of streams from further consideration.

Recreation

Such activities as boating and fishing would be temporarily stopped near construction sites. Also, noise from construction, or later from compressor stations and blow down sites, will adversely affect the relative silence to as much as two miles from such sites. Several recreation areas lie directly in the path of the pipeline. Most of these are in the Midwest and the Ohio River Basin along the Northern Border corridor. Since many recreation sites are located in attractive natural areas the loss or damage of the area's aesthetic values may result in a long-term reduction in visitation.

5.OV.14 Air Quality

There are emissions from this project with unavoidable adverse effects that will contribute to some air quality degradation. These are the result of the proposed action to construct and operate the pipeline system.

Environmental impact on air quality will include fugitive dust and emissions from power equipment that will occur during the construction phase of the pipeline. These emissions will be significant, but will be short-lived, lasting only until the completing of construction.

The longer term effects are associated with system operations. These will consist of emissions from compressor stations and the venting of gas, which will be present for at least the duration of the pipeline lifetime. The following discussion addresses these individually.

Compressor Stations Emissions

The only continuous long-term impact on air quality will be from the operation of compressor stations along the pipeline. Turbine exhaust emissions will contribute both nitrogen oxides and carbon monoxide as products of combustion, and negligible amounts of other gases as air pollutants. These emissions will represent a significant addition of pollutants in the relatively clean areas of the conterminous states and in the Arctic and Subarctic regions. However, the pollutant concentration levels will be too low to affect health.

Studies on sulfur dioxide (SO_2) emissions show that long-term average concentrations are not sufficient to cause injury to lichens in Arctic regions if total sulphur levels are 20 grams or less per 100 cubic feet of gas. Therefore, no serious adverse effect is expected from this emission source although it will be present near the pipeline route.

Gas Venting

Venting of gas into the atmosphere will occur at blow-down points near compressor stations and pipeline block valves. This venting will generally be associated with both scheduled and unscheduled maintenance of these facilities, leading to venting various quantities of gas. While such venting is considered normal pipeline operations practice and can be safety performed, short duration local adverse effects will be present for the lifetime of the pipeline.

Ice Fog

Water vapor emission from compressor stations in Arctic regions, in combination with particulates and low ambient temperatures, aids in the formation of ice fog. Such fogs are not considered directly harmful, but will impair visibility which indirectly poses a safety hazard in the areas adjacent to compressor stations sites. This would be especially true during periods of air stagnation which might persist for as long as two weeks. The ice fog plume could cover an area stretching a half mile from the site with decreasing intensity outward.

5.OV.15 Environmental Noise

Since ambient noise levels along much of the proposed pipeline route are now quite low, it is anticipated that noise associated with pipeline construction and operation will be noticeable to wildlife and/or people in proximity to the pipeline. It will be one factor in diminishing the effective range of waterfowl and wilderness prone species.

Pipeline Construction Phase

Pipeline construction related noise such as truck, tractor, and trenching equipment operation, and blasting where rock removal in trenching is required are considered short term effects. These will be sources of local annoyance to people but their effect will end at the completion of the construction phase.

It is expected that construction will have a temporary effect on local wildlife habitat utilization. The magnitude of this effect has not been individually evaluated.

Pipeline Operation Phase

Operation of compressor stations, venting of gas, and aircraft surveillance are sources of system operational noise. Compressor stations are long-term, continuous, fixed noise sources, while venting of gas, aircraft surveillance and probable use of Air Cushion Vehicles (ACV) in Alaska and Canada for pipeline repairs are long-term but intermittent noise sources that can affect people and/or wildlife along the pipeline route.

The largest number of people that will be affected by the station and gas venting noise are located along the Northern Border route, fewer numbers along Canada and West Coast routes, and none along the Alaska route. Effects of station, gas venting and aircraft surveillance noise on wildlife in connection with pipeline operation have not been evaluated, with the exception of estimates on distance from pipeline that decreased use of habitat will occur.

5.OV.16 Hazards and Pipeline Integrity

Transmission Pipeline Ruptures

The probability of pipeline rupture was discussed above in Section 3.OV.16. When a rupture occurs, adverse effects on the environment are virtually assured. In most cases when a large pipeline ruptures there will be a fire. This fire, even though it will probably be at least 50 feet above the surface, will burn vegetation within a radius of several hundred feet. The Arctic section of the pipe offers the greatest potential for rupture due to unresolved engineering questions about the complete integrity of the pipe, for the Applicants have not demonstrated that a buried, chilled pipeline can be operated safely in the permafrost region, especially in the discontinuous permafrost zone. Also, the pipeline design criteria formulated by the Applicants permit unconservatively high levels of stress and strain to develop in the pipe under certain combinations of external loadings. These levels are in excess of the allowable stress levels described by Part 192, Title 49 of the C.F.R.

Transmission Pipeline Leaks

Leaking gas has two unavoidable impacts. If the leaking gas accumulates inside an enclosure there is a danger of explosion and fire and accompanying damage to the environment. In open areas, leaking gas is detrimental to vegetation. The effect is characterized by discoloration and is sometimes used to detect leaks.

Pipeline Repairs

Repairing a buried section of pipeline will result in a temporary environmental impact which is unavoidable. The temporary effect will include loss of vegetation in the excavated area and the noise and pollution associated with the repair crew and equipment. In addition in permafrost areas there is a potential threat to the tundra if it must be crossed while the surface is thawed.

6.OV Relationship Between Local Short-term Uses of Man's Environment and the Maintenance and Enhancement of Long-term Productivity

6.OV.1 Definitions

The effects of the proposed Project would vary in kind, intensity, and in duration, beginning with the first preparatory activity on the route and ending at an indeterminate time beyond its abandonment when natural ecological balances might be restored. Based upon proven natural gas reserves, the present indicated lifetime of the proposed pipeline system is 30 years. The Applicant, in expectation of additional gas discoveries, believes the probable minimum life of the pipeline to be on the order of 50 years and possibly extending to a maximum of a full century.

As used here, short-term means the total duration of the Project and long-term is an indefinite period beyond its termination, but at least several decades. Short-term effects would be greater during the construction phase than during the longer period of operations.

6.OV.2 Short-term Gains

The primary short-term gain involves the availability of 4.27 Bcf/d of additional natural gas in markets throughout northeastern, north central and far western regions of the United States and in Canada and its consumption as a clean fuel. Additional short-term gains include:

1) Income increase, particularly in small communities, due to pipeline personnel's use of stores, bars, restaurants, hotels and related facilities; introduction of temporary unskilled jobs; and land easement payment to private individuals.

2) Economic benefits to large industrial centers that supply steel pipe, skilled labor and additional related supplies.

3) Increase in primary production along the right-of-way due to revegetation with plants in early stages of ecological succession in amendable environments.

4) A greater availability of forage will increase carrying capacity for adapted animal species.

6.OV.3 Short-term Losses

Short-term, generally localized losses associated with the project include:

1) Additional economic and social stress in small communities with limited housing facilities, health services, transportation and similar public services due to pipeline personnel's increased demand for services.

2) Slight inflation nationwide due to increased demand for steel supplies and other construction materials.

3) Destruction of plant life on the right-of-way and related construction sites leading to a loss in primary production from soil changes and erosion in areas not amenable to revegetation.

4) Delays in construction starts of other more localized projects due to the high priority of ANGTS among material suppliers and contractors.

5) Continued increase in racial conflict, alcohol abuse and crime in Native communities in the North.

6) Population losses and changes in distribution of wildlife due to loss of habitat, hibernation dens, and breeding, feeding, and nesting areas; from noise of workers and related pipeline facilities; and the cumulative human pressures of opening a frontier region to development.

7) Destruction of small underground animals. This could affect a large number of animals in the Arctic but a small number elsewhere.

8) Degradation of water quality from sedimentation, chemical spills, sewage disposal and dewatering of streams leading to relocation or death of fish populations.

9) Degradation of aesthetic qualities of the natural environment due to the presence of workers, their machines, noise, dust, structures, and the cleared right-of-way.

10) Restrictions on recreation near the right-of-way.

11) In respect to land use planning on unclassified lands near the pipeline, potential residential classification may be lost or restricted for the life of the project.

12) An adverse impact on air quality caused by emissions from compressor stations even though emissions may be less than established emission standards.

6.CV.4 Long-term Gains

Long-term gains associated with the project include:

1) Job training programs in the far north which will prepare Natives for employment throughout Canada and Alaska.

2) Some reduction of social disparities between Natives and non-Natives if Natives are hired on a regular basis in the Arctic.

3) Increased accessibility in previously remote areas would make new recreation areas available for more people.

4) Increased knowledge through archeologic, paleontologic or historic finds; the experimental sites at Ebbutt Hills, Prudhoe Bay, and Sans Sault; and Arctic research prior to construction.

5) Notation of the location of archeologic sites not touched during construction.

6.CV.5 Long-term Losses

Long-term losses associated with the project include:

1) Consumption of at least 26 Tcf of natural gas as well as the consumption of 30.5 million gallons of gasoline, 70.6 million gallons of diesel fuel, 1.3 million gallons of lubrication oil and 800,000 pounds of grease by construction vehicles and machinery.

2) Loss of traditional life patterns of Arctic Natives regionally along the pipeline route in Alaska and Canada.

3) Decrease in resources upon which Native village populatons along the route depend for subsistence.

4) Localized loss of primary vegetative production in severe environments (Arctic tundra and deserts) from clearing the right-of-way and related construction sites.

5) Loss of mature stands of climax forest from right-of-way clearing operations.

6) Cumulative decrease in the numbers of wildlife and some endangered, threatened or sensitive species due to increased air traffic and loss of vegetation cover in areas used for calving, nesting, breeding, feeding or resting. This will be particularly relevant in the Arctic where waterfowl, Porcupine caribou, wolf, grizzly and polar bear and some Peregrine falcon populations would be affected. The latter mostly in Canada.

7) Loss in numbers of Arctic fish due to slow regeneration, increased harvesting consumption of water resources and increased sedimentation.

8) Irreversible loss of wilderness or quasiwilderness values along 495 miles of pipeline.

9) Scars on landscape where topography is changed, e.g., where river bluffs and the Badlands are crossed, and where old stands of trees are cut.

10) Subsidence, gullying and slumping from permafrost thaws over and adjacent to the pipeline ditch in the Arctic.

11) Commitment of sand and gravel used for roads, building foundations and airstrips.

12) Loss of primary production on land under compressor stations, pumping stations and permanent access roads.

13) Destruction of archeological artifacts through excavation or unintentional damage during construction.

6.OV.6 Foreclosure of Future Options

The major options foreclosed by construction and operation of the project include:

1) The option of using the natural gas at a future time as well as the fuel, oil and grease used in construction.

2) The option of gaining increased future knowledge from archeologic sites destroyed in construction or excavation prior to construction.

3) Gravel and other natural building materials used will generally be too scattered for future use.

4) Land used by compressor stations and other pipeline related structures cannot be put to other use during the life of the project.

5) Wilderness values along 495 miles of the route in the Arctic will, for all practical purposes, be irreversibly lost.

6) Several proposed research natural areas in the Arctic would lose their value as productive contributors to our knowledge of tundra ecosystems.

7) Loss of buried pipe material after the project is abandoned unless another use is found for the pipeline or it is salvaged.

8) Geologic resources located under the pipeline could not be utilized during the use of the pipeline, unless at a depth beneath the right-of-way.

9) Residents of the 13 Native communities within 50 miles of the route in northern Canada and Alaska who are currently engaged in subsistence hunting, fishing and trapping will become cumulatively less able to continue or return to a subsistence culture.

10) The option of using human resources, e.g. labor, for other projects during the construction period.

7.OV Irreversible and Irretrievable Commitments of Resources

Introduction

This chapter summarizes resources that will be irretrievably lost or irreversibly set into decline through the implementation of the proposed project. Such resources include the materials and labor required to construct the pipeline and related facilities, as well as natural resources and those of cultural value to man that may be permanently lost.

7.OV.1 Resources Committed in Construction

Many of the irreversible or irretrievable commitments of resources will be made during the construction phase of the project. These include:

1) Mineral resources used in construction of the pipeline and related facilities and those consumed by construction vehicles and machinery are estimated as follows:

Diesel Fuel	70.6 million gallons
Gasoline	30.5 million gallons
Lubricants	1.3 million gallons
Grease	8,000,000 pounds
Welding Rod	21.7 million pounds
Bituminous Material	10.8 million gallons
Concrete	376,440 tons
Gravel	12.5 million cubic yards
Steel	5.9 million tons

The steel pipe will be committed for at least the life of the project but could be reused when the pipeline is abandoned if salvaged. However, lumber, cinder block, concrete and asphalt used in project structures will be lost to future use.

2) Labor needed to construct the pipeline and related structures would be irretrievably lost to alternative uses during construction.

3) The construction of the project would require many auxiliary services such as governmental, regulatory, utilities, and transportation. These services would be irretrievable in the sense that they cannot be used for other purposes at the same time.

4) Any fossils or archeological artifacts existing in the right-of-way or on structure sites which are destroyed would be irretrievably lost to mankind. Even the salvage effort is an irreversible commitment of the integrity of the site itself. Should any historic structures be relocated, their historic setting would be lost.

5) Aesthetic damage to landscape in the form of cuts, fill and erosion would be irreversible.

6) Natives may not continue or return to subsistence living patterns after construction. Over a period of time, old patterns would be forgotten and the opportunity may be irretrievably lost.

7) Construction will bring development, people and equipment into wilderness and quasiwilderness areas. Once these areas have been altered, old values cannot be retrieved.

8) Permanent facilities will remove wildlife habitat from use, bringing about a reduction in carrying capacity and subsequent decline in population levels. Where these reductions affect an endangered or threatened species or removes a population, the wildlife resource would be irretrievably lost.

9) Water used during construction will not be able to be used for any other purpose during that time. Fish habitat in the Arctic may be lost due to this consumption.

10) Land where permanent facilities are constructed will be irretrievable at least for the life of the project.

7.OV.2 Resources Committed in Operation

The main resource committed is the gas itself, a non-renewable resource. The proposed pipeline project would transport the natural gas from the Prudhoe Bay area of Alaska and the Mackenzie Delta of Canada to delivery points in the contiguous United States and Canada. The proven reserves at Prudhoe Bay are estimated to be 22.5 trillion cubic feet. In addition to these proven reserves, speculative recoverable reserves have been estimated by the State of Alaska in the Alaska Open File Report Fifty issued by the Division of Geological and Geophysical Surveys (DGGS) of the State of Alaska in June 1974. The speculative additional gas recovery for the onshore area of the North Slope is 41.8 trillion cubic feet (tcf). For the offshore areas of Beaufort Province and Chukchi Province recovery is projected to be 13.5 tcf and 33.0 tcf respectively. This makes 88.3 tcf total estimated additional supplies. The DGGS Report states that "speculative recoverable petroleum resources are here defined as those petroleum resources which are completely undiscovered, and which after discovery can reasonably be expected to be produced using present technology and economic conditions."

Proven reserves in northwestern Canada are estimated to be 3.9 trillion cubic feet. Additional speculative gas reserves are in excess of 50 tcf. Potential gas reserves for the onshore Mackenzie Delta region and the adjoining offshore areas of the Beaufort Sea to a water depth of 36 feet are expected to be in the order of 40 to 50 tcf. When the offshore area of the Beaufort Sea beyond a water depth of 36 feet is also taken into consideration, the potential of both areas should be well in excess of 50 trillion cubic feet (J.C. Sproule and Assoc., 1974).

Additional second phase irreversible or irretrievable commitments of resources include:

1) An unknown amount of fuel, lubricating oil and grease will be used to supply and maintain compressor stations, microwave towers, and pumping stations.

2) Wilderness values will be decreased or destroyed in northeastern Alaska and northwestern Yukon.

3) Aesthetics will be decreased in areas of low relief, as in the Arctic tundra and North Dakota Badlands, by the presence of pipeline related structures and topographic changes.

8.OV Alternatives to the Proposed Action

This Overview volume points out the consequences of the entire proposed action and the Alternative volume considers various alternatives to that proposal. Among the volumes are included discussions of the application to grant rights-of-way across Federal land for the construction of the proposed Alaska Natural Gas Transportation System and the options open to the Secretary of the Interior in making such a decision. Included also are data on domestic and imported natural gas, other alternative energy sources, and alternative systems of transportation, which are presented to document background and other alternative information needed to make a sound decision. However, only in the Overview volume are the route alternatives assembled in a complete system sense covering the main route alternatives to the proposal and options within each route. The next two sections in this chapter capture a very brief sense of the energy and transportation mode alternatives, which are more fully treated in the Alternative volume.

The remainder of this chapter is devoted to a full system presentation, summarily presented, for the route alternatives and their options. This presentation is based on the segmented parts of the Environmental Impact Statement presented by geographic area.

8.OV.1 Alternative Energy Sources

The major energy sources suggested as possible replacement for natural gas to be supplied by the proposed Alaska Natural Gas Transportation System are coal, petroleum, synthetic natural gas and oil, geothermal energy, hydroelectric power, oil shale, and nuclear energy. Alternative energy sources are further described and analyzed in section 8-E of the Alternatives volume.

8.OV.2 Alternative Transportation Systems

Alternative systems of transportation of the Alaska gas include: conversion of gas to LNG or methanol and transportation by ice-breaking tanker, submarine, airplane, Helifloat, dirigible railway, monorail; a dense-phase or methanol pipeline; transformation of gas to electricity and transmission by high voltage lines; and some combination of these various systems. These alternative systems are further described and analyzed in section 8-F of the Alternatives volume. Additionally, the viable alternative of pipeline-LNG tanker combination system is described and analyzed in detail in section 8.2 of the Alternatives volume.

8.OV.3 Alternative Pipeline Systems

The Applicant's proposal is identified in the EIS as "The Alaska Natural Gas Transportation System." The environmental impact statement addresses this proposal by geographic areas (Alaska; Canada; West Coast-San Francisco, West Coast-Los Angeles and North Border). Each geographic area analysis includes a section on route alternatives available within the specific geographic area it addresses.

The purpose of this section is to provide a broad overview of the alternative natural gas pipeline routes available for transporting gas by pipeline from Prudhoe Bay and the Mackenzie Delta across Canada to the delivery points in Canada and the United States. The alternative pipeline delivery routes described in this section are the main viable alternative routes; for example, Fort Yukon and the Fairbanks routes are capable of transporting natural gas from Prudhoe Bay to Delmont, Pennsylvania and to terminals on the West Coast.

The alternative routes, along with the Applicants' proposed pipeline route, are shown on the map, Figure 8.OV.3-1. Also shown are the major options available to each route. For instance, in the Arctic the option available to the Applicants' proposed route is the Cross Delta option. In the South Canada/Northern Border area, options available to the proposed route are the Laird River-Red River, Moose Jaw, Brandon, Dome and Missouri River North options. Although the Future Route and Antioch opticn are shown on the map in the West Coast area, they only relate to a future situation when more gas is made available for southern California markets and if the "Future Route" is applied for by the Applicant companies. Minor route alignments discussed in the alternative section of several geographic area analyses are not included.

The information and data used in this section were taken from the geographic area analyses parts of the EIS. The table and narrative are designed to provide broad displays of data. The Table 8.OV.3-1 presents data that can be expressed in common units such as miles and numbers of units. The narrative analyzes only the more significant impacts resulting from construction of the various alternative systems. For a more detailed analysis of the alternative routes, see the alternatives section in each geographic part.

Many types of impacts are common to all pipeline construction. For instance, regardless of which route and/or option(s) is chosen, construction work starts with right-of-way clearing, the excavation of a trench, and successive, related construction. This is true whether the construction is across tundra, grasslands, cultivated areas, or deserts. The impacts, however, are different. Analyses of impacts are useful where there is a choice of route, such as that involved in crossing a grassland versus a cultivated area; a wilderness area versus a developed area; a permafrost area versus a non-permafrost area; or a high hazard area (earthquake) versus a relatively stable area. The choice may involve a cultivated area of high recovery potential versus a cultivated area of low recovery potential. The significant differences in kind or magnitude of choice are analysed.

There are 43 possible variations in the pipeline system that can be derived from combinations of routes with options. Each of the 43 pipeline systems are listed in table 8.OV.3-1 and can be identified and tracked on Figure 8.OV.3-1 (map). Since the West Coast proposals present no pipeline route or option alternative, none was shown on the table.

A review of the table provides information on the various routes and options in terms of miles. For instance, the Fairbanks Alternative with the Moose Jaw-Brandon-Laird River and Red River Dome Options is about 1,001 miles longer than the Applicant's proposed route. Analysis indicates that the longer the route, the more acres of land must be dedicated for the right-of-way to accommodate the increased number of compressor stations, block valves, communication towers, etc. One obvious conclusion is that the longer the route the greater the number of environmental impacts. However, complete analysis requires analyzing the data outlined in the table together with the impacts noted in the following narrative.

For this discussion it has generally been concluded that the selection of a proposed route which parallels an existing transportation or utility corridor results in less environmental impacts than construction through undeveloped areas. This conclusion is based upon the assumption that the area involved is already impacted by the original construction, less right-of-way width which is required for similar utilities. Also, access generally already exists. See map, Figure 8.OV.3-2, showing drainage systems and road development along the routes in the Arctic.

Further, it is assumed that all of the alternative routes and options identified are acceptable to the Canadian Government and therefore feasible.

In the following discussion, impacts are first listed by name only, then an analysis of the routes and options follows. The discussion on the West Coast Option Area is somewhat different since no true alternative pipeline route is presented. The only viable opportunity is to combine the two proposals into a single pipeline system. This is discussed with the future possibility of moving more gas to southern California markets.

Narrative Discussion of Environmental Impacts of Alternative Routes and Options

The Alaska-Northwest Canada Route Option Area

The following routes and options are included in this area: the Applicant's proposal as far as Travaillant Lake; the Cross Delta Option; the Offshore Route; the Coastal Route; the Interior Route; the Fort Yukon Route as far as Watson Lake, Y.T; and the Fairbanks Route as far as Watson Lake, Y.T.

The Applicant's Proposed Route would impact:
- Calving and migration of the Porcupine Caribou herd on the coastal plain of the Arctic National Wildlife Range and northwestern Canada
- Polar bears and musk oxen
- Waterfowl (especially geese and swans along the coastal portion in Alaska and Canada)
- Fish populations
- Wilderness qualities of the Arctic National Wildlife Range
- Wilderness qualities of the proposed Canadian Arctic Wildlife Range and Old Crow Flats
- Subsistence resources and traditions of the Native populations
- Multiple river crossings on the coastal plain

The Cross Delta Option (Mackenzie River Delta-Canal) would impact:
- Waterfowl, especially geese and swans
- Estuary fisheries
- Baluga whales

The Offshore Route would impact:
- Marine ecosystems related to the inshore, estuary environment, with possible impact on nearshore fish habitat
- Polar bear and barren ground grizzly
- Waterfowl and shore birds (nesting habitat)
- Wilderness qualities of the Arctic National Wildlife Range along the coastline
- The same impacts as the Applicant's proposed route and the Coastal Route prior to leaving the shore and after joining the Applicant's proposed route in Canada

The Coastal Route would impact:
- Marine ecosystems related to the inshore, estuary environment
- Polar bear and barren ground grizzly
- Waterfowl and shore birds (nesting habitat)
- Wilderness qualities of the Arctic National Wildlife Range along the coastline

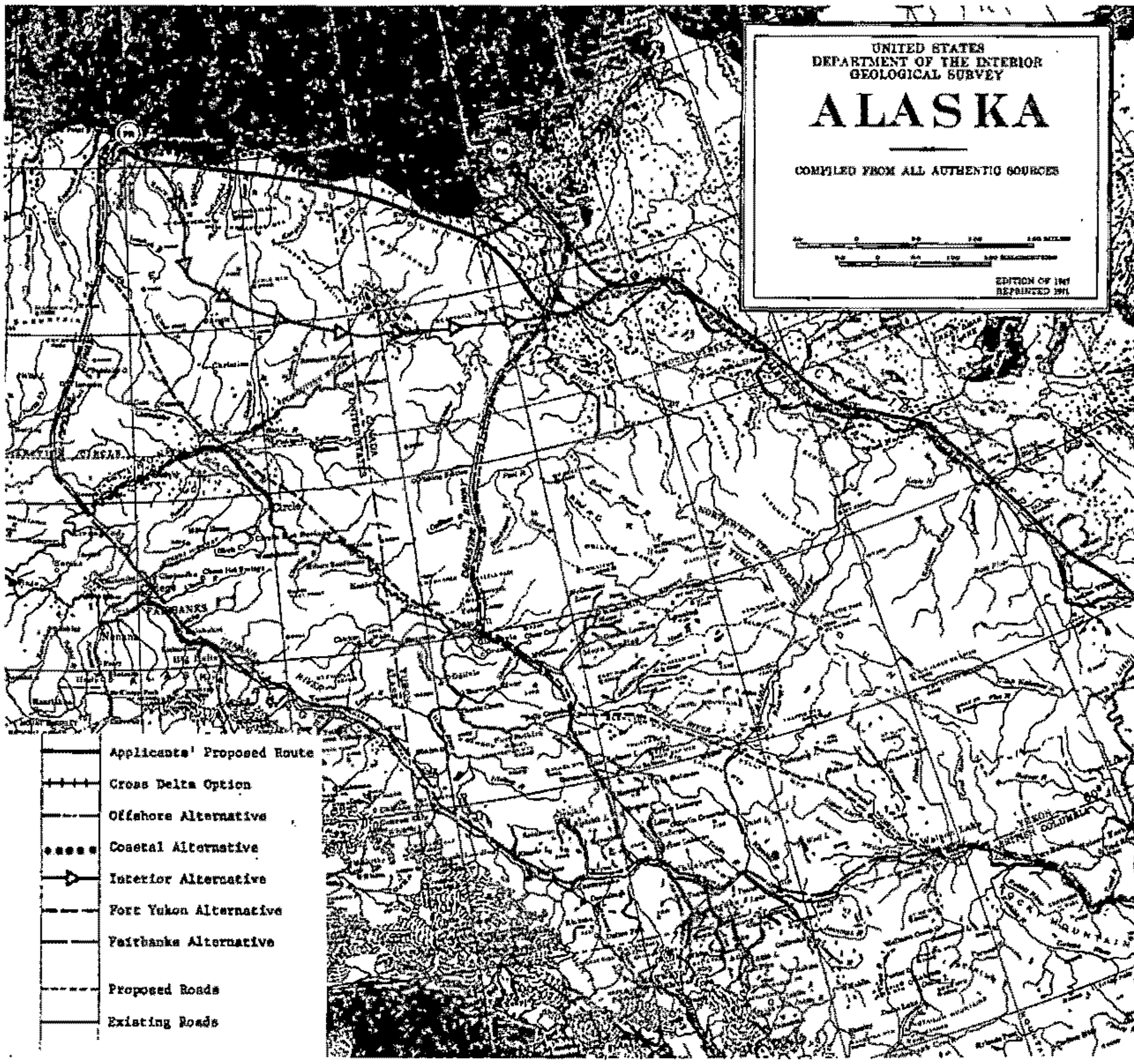

Figure 8.OV.3-2 Drainage systems and roads along the routes in the Far North

Subsistence resources and traditions of Native populations
Same impacts as the Applicant's proposed route after joining the Applicant's proposed route in Canada

The Interior Route would impact:
- Caribou migration
- Waterfowl in the Crow Flats area
- Fish populations
- Subsistence resources and traditions of Native populations
- Wilderness qualities of proposed extensions of the Arctic National Wildlife Range and the proposed Canadian Wildlife Range
- Dall sheep in the Canning River drainage
- Mountain topography

The Ft. Yukon Route would impact:
- Peregrine falcon (about 90 miles of critical nesting habitat) in Alaska and Canada
- Waterfowl (floodplains of Yukon and Porcupine Rivers)
- Areas with wilderness qualities in Alaska and Canada
- Subsistence resources and traditions of Native populations

The Fairbanks Route would impact:
- Air quality at Fairbanks
- Fish populations
- Areas of wilderness qualitites

- Socio-economic conditions in Fairbanks

Analysis

The Cross Delta Option located wholly in Canada would leave the Applicant's proposed route at about milepost 291, cross the Mackenzie River Delta, join and follow the Richards Island Supply, and rejoin the Applicant's proposed route at Travaillant Lake. Its major impacts would be on the migratory waterfowl, fisheries (many fishes overwinter in this area, for others it's a prime migration route), and marine ecosystem (Baluga whales use the offshore area in the summer).

The Offshore Route (may not be technically feasible and therefore possibly not a viable option). It would have most of the impacts associated with the Coastal Route. The Offshore Route probably would have a greater impact on the offshore marine ecology than the Coastal or Applicant's proposed route.

The Coastal Route would follow the coast to Canada where it then joins the Applicant's proposal near the Alaska-Canada border. Prior to leaving and after rejoining the Applicant's proposed route, the impacts of this route would be the same as those of the Applicant's proposed route. Along the coast the impacts would be similar to the impacts associated with the Offshore Route. This route would have less impact on the Porcupine Caribou herd than the Applicant's proposed route, but it would still have an impact. It would also have a greater impact on the environment at river crossings (mainly in delta areas), marine ecology, and migratory bird nesting areas. The impact of this route would be similar to the Offshore Route because of the connection of the Offshore pipeline to the coast where compressor stations would be located.

The Coastal Route would generally avoid the heavy wildlife impacts associated with the Interior Route but would affect waterfowl more. In Alaska the Fairbanks and Fort Yukon Routes would avoid the marine and offshore ecology, polar bear, and shore bird impacts associated with the Coastal Route. The Applicant's proposed route would avoid those impacts directly associated with the coastline.

The Interior Route effects on the Alaskan Coastal Plain would be similar to that portion of the Applicant's proposal as far as the Canning River. From there on, the impacts would not be the same since it passes through and follows along the south side of the Brooks Range, traverses along the south side of the Crow Flats area, and then crosses the Richardson Mountains. This option would avoid traditional caribou calving grounds impacted by the Applicant's proposal, but it crosses the Porcupine Caribou herd migration routes in both Canada and Alaska and could have a severe impact on these animals on a year around basis. The Interior Route would not affect the major waterfowl nesting region of the Mackenzie River Delta, but would cross the important Crow Flat waterfowl area in northwestern Canada. A large population of Dall Sheep in the Canning River drainage would be impacted. This route would probably be more detrimental to grizzly bear and raptor species.

Also, the Interior Route would have a central impact on the wilderness quality of the proposed Canadian Arctic Wildlife Range but would follow a designated utility corridor south of the Arctic Wildlife Range in Alaska influencing it around the perimeter. The Interior Route would not impact the wilderness qualities associated with the coastal portion of the Arctic Wildlife Range, but would impact the east and south border area of the Range. Since it does pass through the proposed southeast extension of the Range, it would prevent uniform wilderness continuum within the Range.

The Fort Yukon Route also follows the Alyeska Oil Pipeline for a portion and intermittently follows other transportation routes in Canada. However, it does pass through areas not presently impacted by development. This route would have an impact on areas in Alaska and Canada having wilderness qualities, about 90 miles of critical peregrine falcon nesting habitat in Alaska and Canada and the floodplains of the Yukon and Porcupine Rivers, as well as important nesting habitat for waterfowl and other migratory bird species.

The Fairbanks Route, because it follows the Alyeska Oil Pipeline and other transportation routes through Alaska and Canada, would avoid some of the impacts associated with the Applicant's proposal, the Offshore, Coastal, Interior, and Cross Delta Routes.

The South Canada-North Border Route Option Area

The following routes and options are included in this area: the Applicant's proposal starting at Monchy, Saskatchewan; the Liard River-Red River-Dome Option; the Moose Jaw-Brandon-Liard River-Red River-Dome Option; the Moose Jaw-Dome Option; and the Missouri River North-Dome Option.

The Applicant's proposal starting at Monchy, Saskatchewan would impact:

- Badlands in the vicinity of the Little Missouri River
- Killdeer Mountains, a unique geologic, topographic and aesthetic area
- The Pothole and Wetland area, both in North and South Dakota (important for waterfowl and other wildlife)
- Wapsipinicon River (two crossings having aesthetic as well as wildlife values)
- Starved Rock area including the State Park at the Illinois River crossing

The Liard River-Red River-Dome Option would impact:

Cultivated areas generally
Minnesota River (a difficult crossing) after joining the Dome route near Benson, Minnesota

The Moose Jaw-Brandon-Liard River-Red River-Dome Option would impact:
Cultivated areas
Minnesota River (a difficult river crossing)

The Moose Jaw-Dome Option would impact:
James River lowland which has a high water table in North Dakota
Two areas having sandy soils that are highly susceptible to wind erosion
Minnesota River (a difficult crossing)

The Missouri River North-Dome Option would impact:
Wetland areas having a high watertable in North Dakota
Areas having sandy soils which are highly susceptible to wind erosion after the North Missouri joins the Dome Option near Carrington, North Dakota
Minnesota River (a difficult crossing) after the North Missouri joins the Dome Option near Carrington, North Dakota

Analysis

The Liard River-Red River-Dome Option starts in Canada at the Liard River and traverses southeasterly across Canada near Emerson, Manitoba. It then follows the Red River route to Benson, Minnesota; then via the Dome Route to near Kankakee, Illinois where it joins the Applicant's proposed route. No significant terrain features are crossed other than rivers, and there are no significant elevation changes. Until this option joins the Red River portion, it would not follow an existing pipeline or other transportation system. Accordingly, it would have all of the impacts normally associated with pipeline construction crossing a new area. In this respect it is similar to the Applicant's proposal and the Missouri River North Option, i.e., crossing an area not yet impacted by any pipeline construction.

The Dome Route is a pipeline route scheduled for construction in 1976 by the Dome Pipeline Corporation of Calgary, Alberta, to bring petrochemicals from the Edmonton area to Detroit, Michigan.

The Moose Jaw-Brandon-Liard River-Red River-Dome Option, except for about 110 miles in west central Minnesota, follows existing or proposed pipeline routes to where it joins the Applicant's proposed route near Kankakee, Illinois. In addition to having less environmental impacts because it follows an existing pipeline route, it would avoid the principal impacts associated with the Applicant's proposed route, i.e., the two crossings of the Missouri River, crossing the Badlands in the vicinity of the Little Missouri River, crossing the Killdeer Mountains (a unique area), crossing pothole and wetland areas for substantial distances, the two crossings of the Wapsipinicon River and the crossing of the Illinois River in the Starved Rock area. This option would cross more cultivated lands than any of the options considered. The Dome portion of the Route includes a "difficult crossing" of the Minnesota River but would cross the Mississippi River in a more environmentally acceptable place than the crossing selected by the Applicant.

The Moose Jaw-Dome Option parallels an existing pipeline and the proposed Dome Route as far as Kankakee, Illinois; there it joins the Applicant's proposed route. It would avoid most of the impacts associated with the Applicant's proposed route; the exception being it would also cross wetland areas having a high water table in North Dakota, especially the James River lowlands. However, the impacts in the areas crossed are not expected to be as heavy as in the wetland and pothole areas crossed by the Applicant's proposal because only a widening of the Dome corridor would be involved. This option would cross sandy soils subject to high wind erosion. It would also cross the Minnesota River, considered to be a difficult crossing, but would cross the Mississippi River at a more environmentally acceptable place than the crossing selected by the Applicant.

The Missouri River North-Dome Option would also avoid most of the impacts attributed to the Applicant's proposed route, i.e., Badlands, Killdeer Mountains, etc. Also, like the Applicant's proposed route it would not follow an existing pipeline route and would go through areas not yet impacted by this type of development. After joining the Dome Route near Carrington, North Dakota, impacts would include crossing sandy soils highly susceptible to wind erosion and the Minnesota River crossing.

West Coast Route Option Area

Whereas the Alaska-Northwest Canada and the South Canada-Northern Border Route Option Areas each involved only one delivery system, the West Coast Route Option Area contains two delivery systems.

The following routes and options to the San Francisco and Los Angeles proposals are included in this area:

1. The San Francisco Proposal. (PGT-PG&E) from Kingsgate, British Columbia to Antioch, California was the only route considered by this analysis for gas delivery to Antioch, since it follows, and is an augmentation of, an existing PGT-PG&E pipeline system.

2. The Los Angeles Proposal. (ITAA) from Kingsgate to Rye Valley, Oregon. This proposal is a separate pipeline system which parallels the proposed San Francisco pipeline to Stanfield, Oregon, where the two pipelines separate. The ITAA proposed line follows an existing pipeline to Rye Valley, Oregon where the gas would enter another existing pipeline system and be displaced to southern California markets in the Los Angeles area.

3. The Stanfield Option. This alternative would combine the San Francisco and Los Angeles proposals from Kingsgate to Stanfield into a single pipeline system of sufficient capacity to achieve the combined delivery capacity required by PGT-PG&E and ITAA.

4. The Los Angeles Future Option. This proposal was previously submitted by ITAA and SoCal as the Applicant's proposal for a new pipeline system to ship larger volumes of gas from Rye Valley, Oregon, through Nevada to Cajon, California. The application has since been amended, and the Rye Valley to Cajon pipeline is now regarded as only a future possibility when greater volumes of gas are contracted by the ITAA-SoCal system.

5. The Antioch Option. This alternative would combine the San Francisco and the Los Angeles proposals into a single pipeline system to Antioch, California and from Antioch transport the gas to the Los Angeles area following existing pipeline systems. This option would be designed to achieve the combined delivery capacity required by PGT-PG&E and the ITAA-SoCal proposals, and include greater volumes contracted by the ITAA systems.

Analysis

All of the routes and options follow existing pipelines except the Los Angeles Future Option. Accordingly, exclusive of the Los Angeles option, there would not be significantly different types of impacts associated with any of these routes or options. Difference in length of systems could result in a difference in the total number of impacts associated with the various routes and options. For instance, there would be more pipe and associated facilities, i.e., compressor stations, etc., required for the San Francisco and Los Angeles proposals and Los Angeles Future Option than required by the Stanfield and Antioch Options. There would also be less total environmental impacts involved in combining the proposals into one larger pipe from the British Columbia-Alberta border to Stanfield, Oregon and/or to Antioch, California.

The Los Angeles Future Option does provide some significant differences in types of impacts. The Los Angeles Option would impact on: Four river crossings (while not major or difficult crossings, they are important in the area crossed); areas in Owens Valley, California important for unique or endangered plants or animals; the desert--long-term impact on aesthetics of the desert area; and archaeology of the Owens Valley.

Environmentally, the Stanfield Option would have less total environmental impacts than the San Francisco and Los Angeles proposals since it combines two separate systems into one.

If greater gas volumes are delivered to the West Coast area requiring some action on the Los Angeles Option, then the Antioch Option presents less total environmental impacts.

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Appendix

Pictorial Appendix

This appendix graphically displays how certain of the project facilities and the revegetated pipeline right-of-way might appear upon completion of the project. The photographs show a pipeline right-of-way in various types of terrain and vegetative associations, for example upland forest and prairie. Also included in the selection of photographs are various problem areas that will be encountered during pipeline construction. Among these are areas that are highly susceptible to wind and water erosion and difficult stream crossings. Since much of the right-of-way crosses agricultural lands, crossings of irrigation canals and farms are illustrated. These photographs have been selected to show areas where successful restoration of a pipeline right-of-way has been accomplished as well as where adverse impacts are likely due to unsuccessful attempts at rehabilitation.

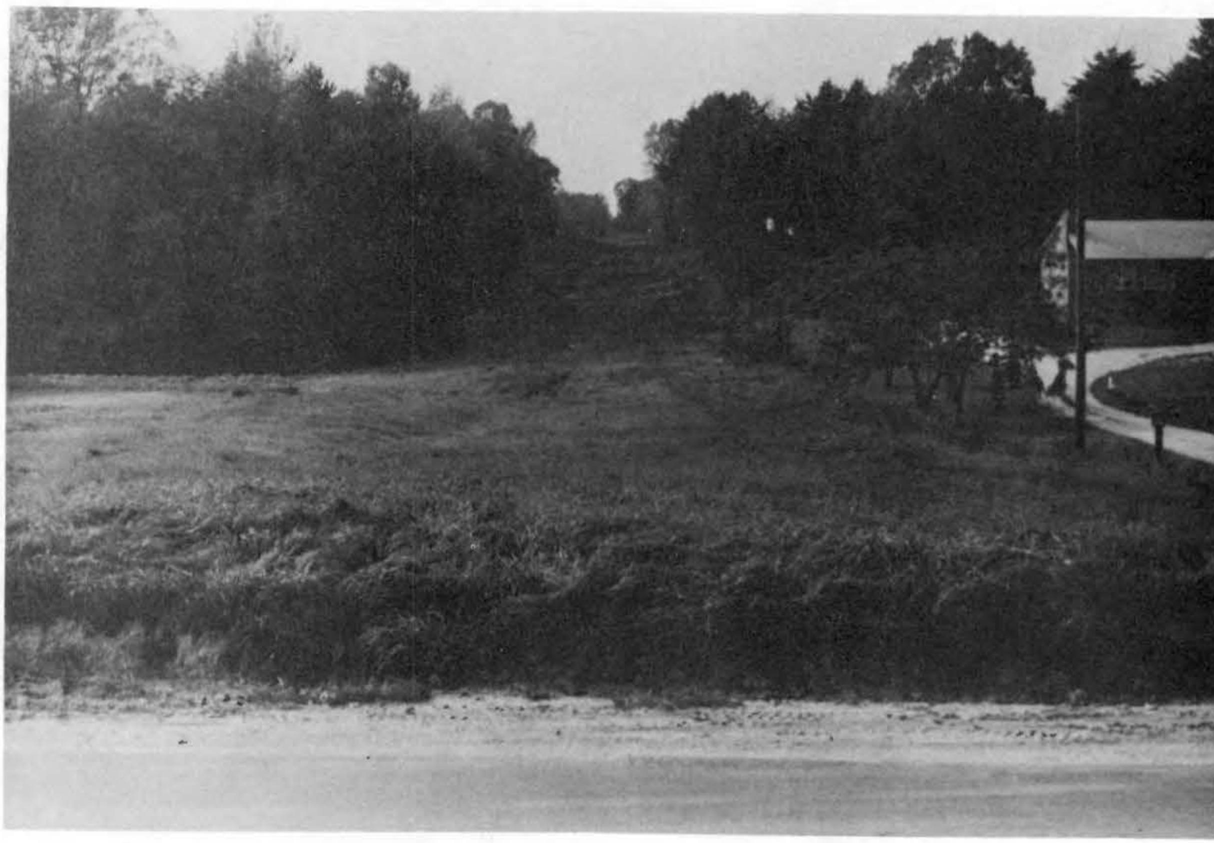
Gerber Compressor Station
The Gerber Compressor Station is located in farmland on the existing PGT San Francisco pipeline in southern Oregon. This photograph illustrates the amount of land taken out of production for a typical compressor station.

Kingsgate Metering Station
Shown is the Kingsgate Metering Station on the existing San Francisco pipeline. This gives an indication of the amount of land permanently cleared for such facilities. Also shown is the revegetated right-of-way running from left to right through forest. (Vertical clearing from top to bottom of the photo in the International Boundary.)

Pit River Crossing
The Pit River (California) crossing on the existing San Francisco pipeline is mounted on an abandoned railroad fill and bridge supports. A second parallel security section is buried in the riverbed.

Common Corridor in the Sacramento Valley
This corridor includes two pipelines and two powerlines through croplands. The photograph shows what appears to be fill subsidence over the buried pipelines.

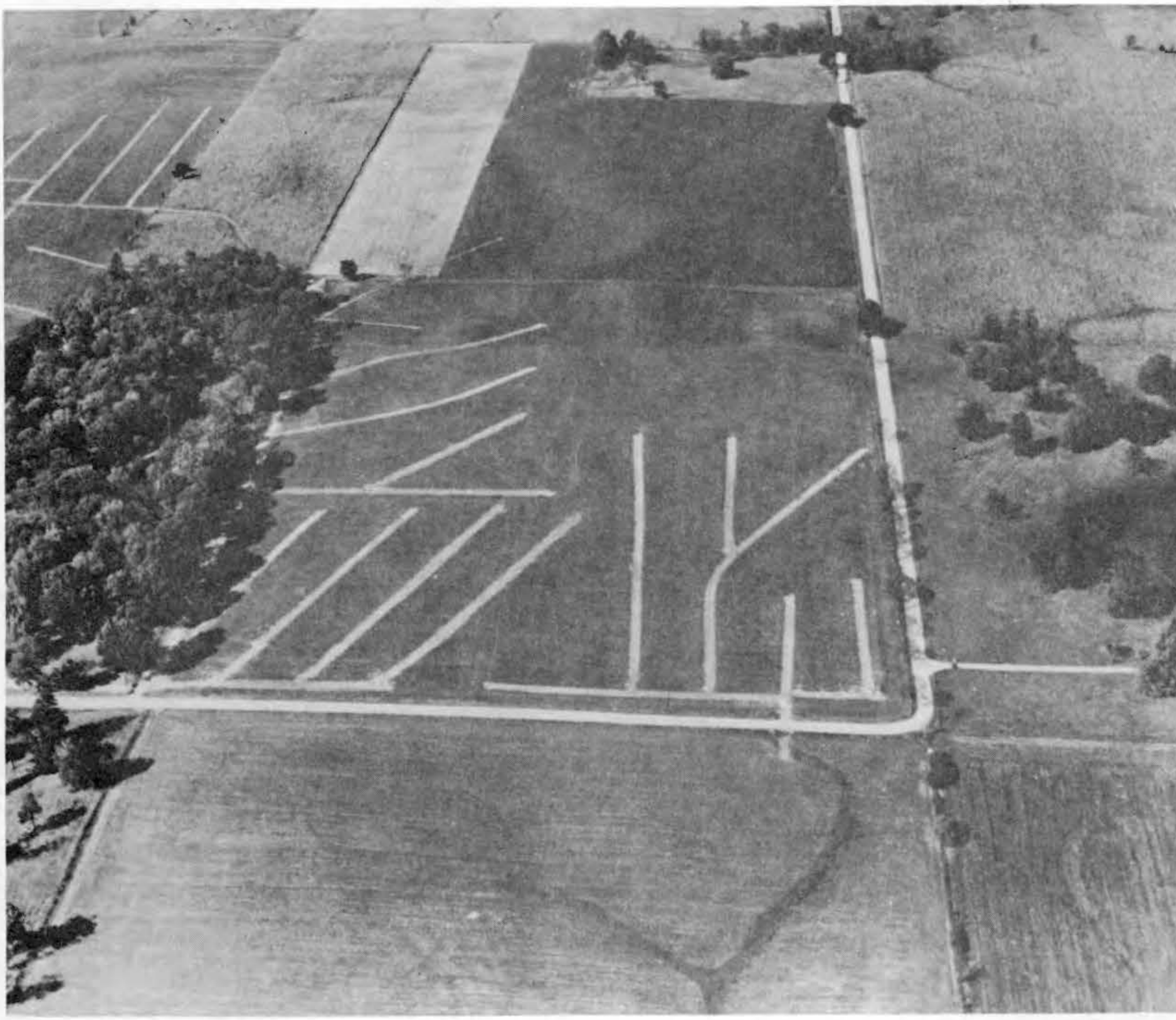
Sherman Island Canal Crossing
This above ground canal crossing is located between the Sacramento and San Joaquin Rivers in the Sacramento Valley. This is typical of irrigation canal crossings.



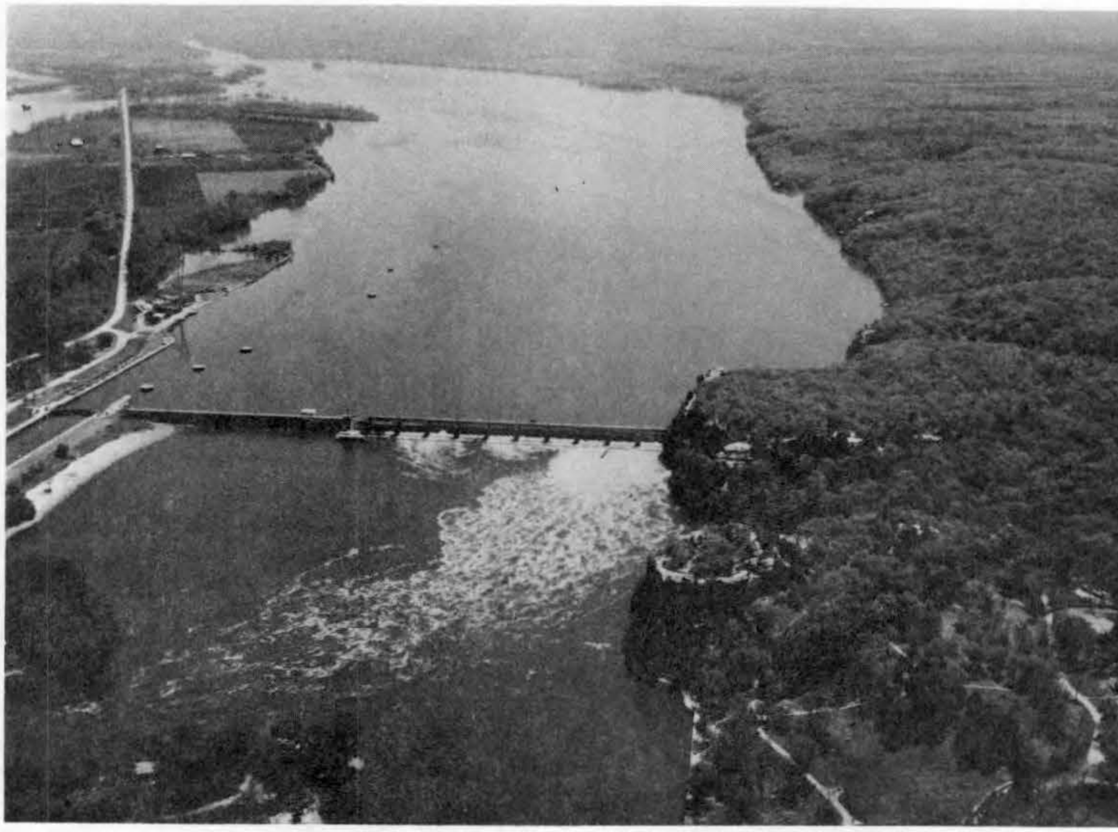
Existing pipeline in deciduous forest

North Central Oregon
The existing PGT pipeline is shown as it traverses the rugged juniper woodlands through north central Oregon. The pipeline right-of-way is quite visible in this area.

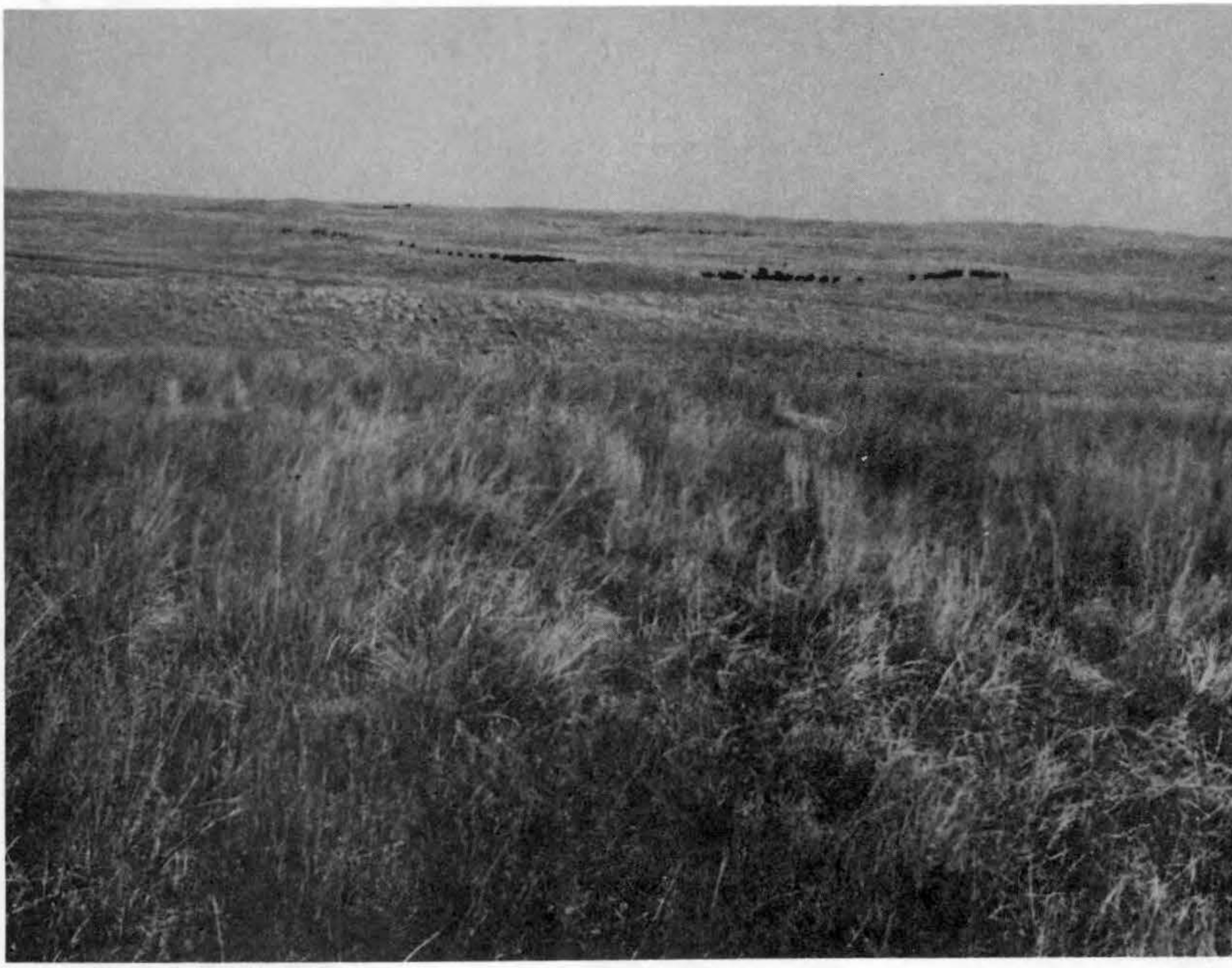
Prairie Pothole Country



Tile Drainage System
Newly installed tile drain system on Ohio farm. Drains are 100 feet apart. This system is typical of those found throughout the Midwest.



Illinois River
Illinois River showing locks and dam. Starved Rock is in lower center with Starved Rock State Park occupying right bank. The crossing of this river will be one of the more difficult on the entire route.



Example of Mixed-Grass Prairie

Little Missouri Badlands
Panoramic view of the Little Missouri Badlands, North Dakota. The steep slopes and shallow soils are highly susceptible to erosion when disturbed and revegetation is difficult.

Wind and water erosion
This photograph illustrates a sandy range site in South Dakota. Such areas have a high potential for both wind and water erosion and revegetation is difficult.

Foldouts

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Table 8.OV.3-1 Alternative pipeline systems

	Miles of Pipeline 1/	Miles Along Existing Roads or Pipelines 2/	Miles of Permafrost		Number of Major Rivers Crossed 3/	Miles Through Undeveloped Areas 4/	Miles Through Cultivated Areas	Miles Through Tile Drainage	Number of Major Mountain Pass Crossings	Earthquake Potential (magnitude) (Richter Scale)	Native Villages 6/		Miles Through Sensitive Wildlife Areas		
			Total	Ice Rich							Number	Population	Caribou Calving Grounds	Caribou Migration Routes	Waterfowl Habitat 9/
Applicant's Proposed Route	5557	2360	1370	665	113	1044	1845	934	7	Low	13	3315 (118)	252	380	755-785
Cross Delta Option	5398	2360	1232	613	110	971	1845	934	7	Arctic -			252	380	646-676
Cross Delta-Liard River Red River-Dome Option	5461	2787	1460	613	123	1175	1980	899	6	Mackenzie			252	380	626-721
Cross Delta-Moose Jaw-Brandon-Liard River Red River-Dome Option	5483	3474	1232	613	114	971	2089	849	7	Delta 7.0)			252	380	626-721
Cross Delta-Moose Jaw-Dome Option	5406	3508	1232	613	108	971	1979	890	7				252	380	751-846
Cross Delta-Missouri River North-Dome Option	5430	3098	1232	613	107	971	1864	890	7				252	380	801-896
Liard River Red River-Dome Option	5599	2787	1598	665	126	1246	1980	899	6	Low 5, Arctic -			252	380	735-830
Moose Jaw-Brandon-Liard River Red River-Dome Option	5621	3474	1370	665	117	1044	2089	849	7	Mackenzie Delta (7.0)			252	380	735-830
Moose Jaw-Dome Option	5544	3508	1370	665	111	1044	1979	890	7	Richardson Mts.			252	380	860-955
Missouri River North-Dome Option	5568	3098	1370	665	110	1044	1864	890	7	(6.5)			252	380	910-1015
Offshore Alternative	5546	2360	1380	625	95	1034	1845	934	7	Low 5	13	3315 (118)	0	120	805-925
Offshore-Cross Delta Option	5408	2360	1242	573	92	961	1845	934	7	Arctic -			0	120	696-816
Offshore-Cross Delta-Liard River Red River-Dome Option	5472	2787	1470	573	105	1165	1980	849	6	Mackenzie			0	120	676-771
Offshore-Cross Delta-Moose Jaw-Brandon-Liard River Red River-Dome Option	5493	3474	1242	573	96	961	2089	849	7	Delta (7.0)			0	120	676-771
Offshore-Cross Delta-Moose Jaw-Dome Option	5416	3508	1242	573	90	961	1979	890	7				0	120	801-896
Offshore-Cross Delta-Missouri River North-Dome Option	5540	3098	1242	573	89	961	1864	890	7				0	120	851-946
Offshore-Liard River Red River-Dome Option	5610	2787	1608	625	108	1236	1980	849	6	Low 5, Arctic -			0	120	785-880
Offshore-Moose Jaw-Brandon-Liard River Red River- Dome Option	5631	3474	1380	625	99	1034	2089	849	7	Mackenzie Delta (7.0)			0	120	785-880
Offshore-Moose Jaw-Dome Option	5554	3508	1380	625	93	1034	1979	890	7	Richardson Mts.			0	120	910-1005
Offshore-Missouri River North-Dome Option	5578	3098	1380	625	92	1034	1864	890	7	(6.5)			0	120	960-1055
Coastal Alternative	5547	2360	1381	675	112	1034	1845	934	7	Low	13	3315 (118)	188 7/	120 8/	773-893
Coastal-Cross Delta Option	5409	2360	1243	623	109	961	1845	934	7	Arctic -			188	120	664-784
Coastal-Cross Delta-Liard River Red River-Dome Option	5472	2787	1471	623	122	1165	1980	849	6	Mackenzie			188	120	644-739
Coastal-Cross Delta-Moose Jaw-Brandon-Liard River Red River-Dome Option	5494	3474	1243	623	113	961	2089	849	7	Delta (7.0)			188	120	644-739
Coastal-Cross Delta-Moose Jaw-Dome Option	5417	3508	1243	623	107	961	1979	890	7				188	120	769-864
Coastal-Cross Delta-Missouri River North-Dome Option	5441	3098	1243	623	106	961	1864	890	7				188	120	819-914
Coastal-Liard River Red River-Dome Option	5610	2787	1609	675	125	1236	1980	849	7	Low 5, Arctic -			188	120	753-848
Coastal-Moose Jaw-Brandon-Liard River Red River-Dome Option	5632	3474	1381	675	116	1034	2089	849	7	Mackenzie Delta (7.0)			188	120	753-848
Coastal-Moose Jaw-Dome Option	5555	3508	1381	675	110	1034	1979	890	7	Richardson Mts.			188	120	878-973
Coastal-Missouri River North-Dome Option	5579	3098	1381	675	109	1034	1864	890	7	(6.5)			188	120	928-1023
Interior Alternative	5582	2577	1416	608	98	1053	1845	934	10	Low 5, Arctic -	13	3333 (136)	68	480	565-590
Interior-Liard River Red River-Dome Option	5645	3005	1644	608	111	1255	1980	849	9	Mackenzie Delta (7.0)			68	480	545
Interior-Moose Jaw-Brandon-Liard River Red River-Dome Option	5667	3692	1416	608	102	1053	2089	849	10	Richardson Mts.			68	480	545
Interior-Moose Jaw-Dome Option	5590	3726	1416	608	96	1053	1979	890	10	(6.5)			68	480	670
Interior-Missouri River North-Dome Option	5614	3316	1416	608	95	1053	1864	890	10				68	480	720
Fort Yukon Alternative	5933	3278	1112	590	133	583	1940	934	11	Low 5.5	11	3628 (828)	0	90	680-715
Moose Jaw-Brandon-Liard River Red River-Dome Option	6003	4392	1112	590	137	583	2184	849	11	Arctic -			0	90	680-675
Moose Jaw-Dome Option	5926	4426	1112	590	131	583	2074	890	11	Richardson			0	90	785-800
Missouri River North-Dome Option	5965	3951	1112	590	130	583	1959	890	11	Mts. (6.5) 5/			0	90	835-850
Fairbanks Alternative	6467	4523	1365	713	147	128	1940	934	11	Low 5.5, Arctic -	18	1891 (691)	0	170	585-630
Moose Jaw-Brandon-Liard River Red River-Dome Option	6537	4890	1365	713	151	128	2184	849	11	Richardson Mts. (6.5) 5/			0	170	565-585
Moose Jaw-Dome Option	6460	5671	1365	713	145	128	2074	890	11	Alaska - Yukon border			0	170	690-710
Missouri River North-Dome Option	6205	5261	1365	713	139	128	1959	890	11	to Whitehorse (7.0)			0	170	740-760
										Fairbanks (7.0)					

1/ Applicant's proposed route mileage is based on actual miles of pipe to be used. All other pipeline systems mileage is based on estimated map distances of the pipeline. Mileage of each pipeline system is based on distances from Prudhoe Bay and Richards Island to delivery destination points at Antioch, California, Rye Valley, Oregon, and Delmont, Pennsylvania.

2/ Mileage along existing roads or pipelines based on measured distance through which pipeline system lies within 0.5 miles of roads or pipelines shown on 1:250,000 maps or other known sources.

3/ Generally all stream crossings having a drainage basin larger than 300 square miles along point of crossing.

4/ Distance along pipeline route more than 10 miles from existing developments (cities, towns, roads, airfields and cultivated areas). The mileages for the Proposed Route and the Offshore, Coastal and Interior alternatives do not reflect the use of the Mackenzie River as an established barge route.

5/ This applies to the Richard's Island lateral pipeline segment.

6/ Only those villages within 50 miles of the corridor and with 50% or more native populations were included. Numbers in parenthesis are for Alaska only. No data is available for the options.

7/ Passes only through the coastal fringes of the calving grounds. This applies to all of the Coastal alternatives and options.

8/ This number is for Canada only; in Alaska only those individuals moving to the extreme outer fringes of the traditional calving grounds would cross the line. This applies to all of the Coastal alternatives and options.

9/ The figures for the options do not include data for Canada south of Fort Simpson.

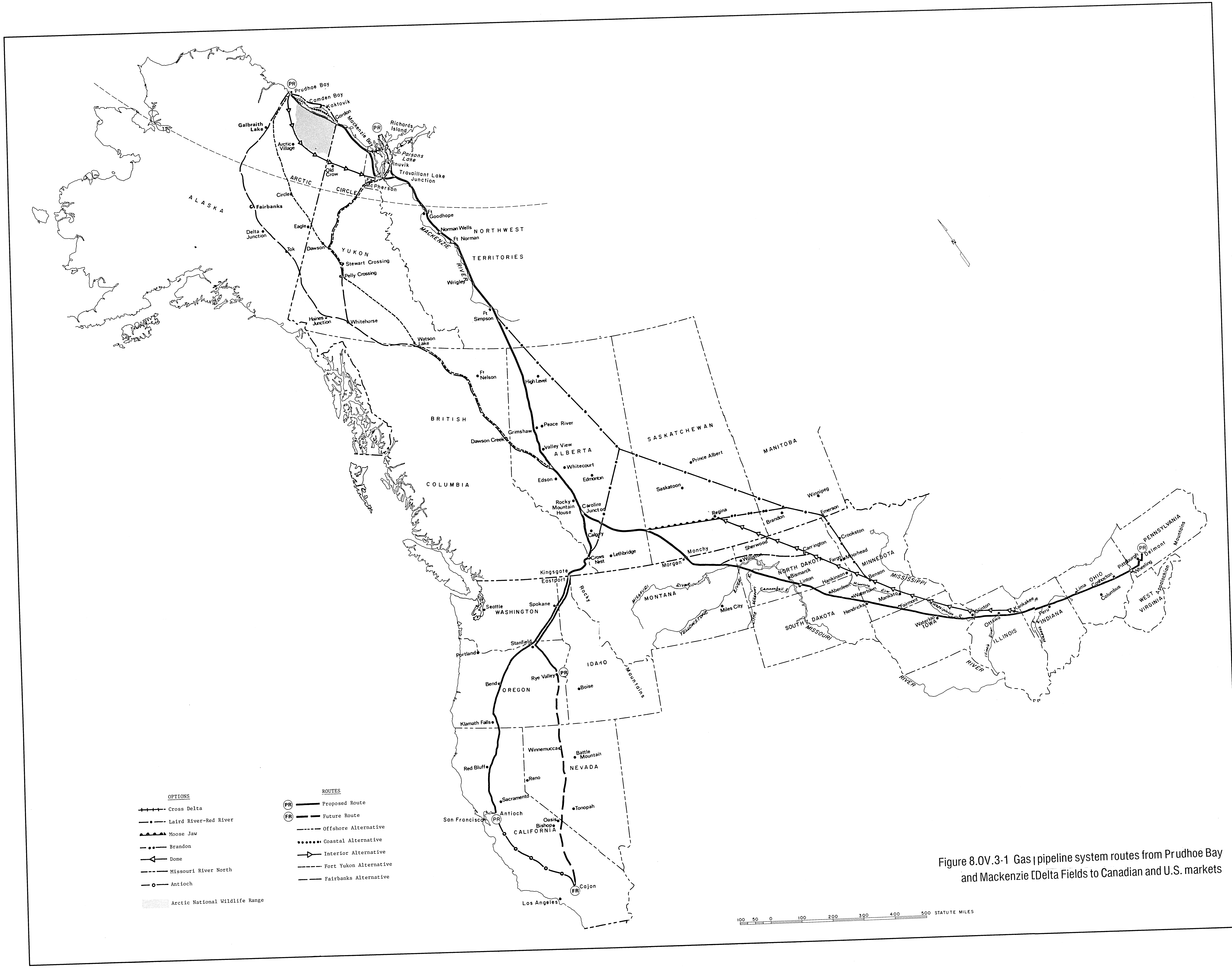

Figure 8.0V.3-1 Gas pipeline system routes from Prudhoe Bay and Mackenzie Delta Fields to Canadian and U.S. markets