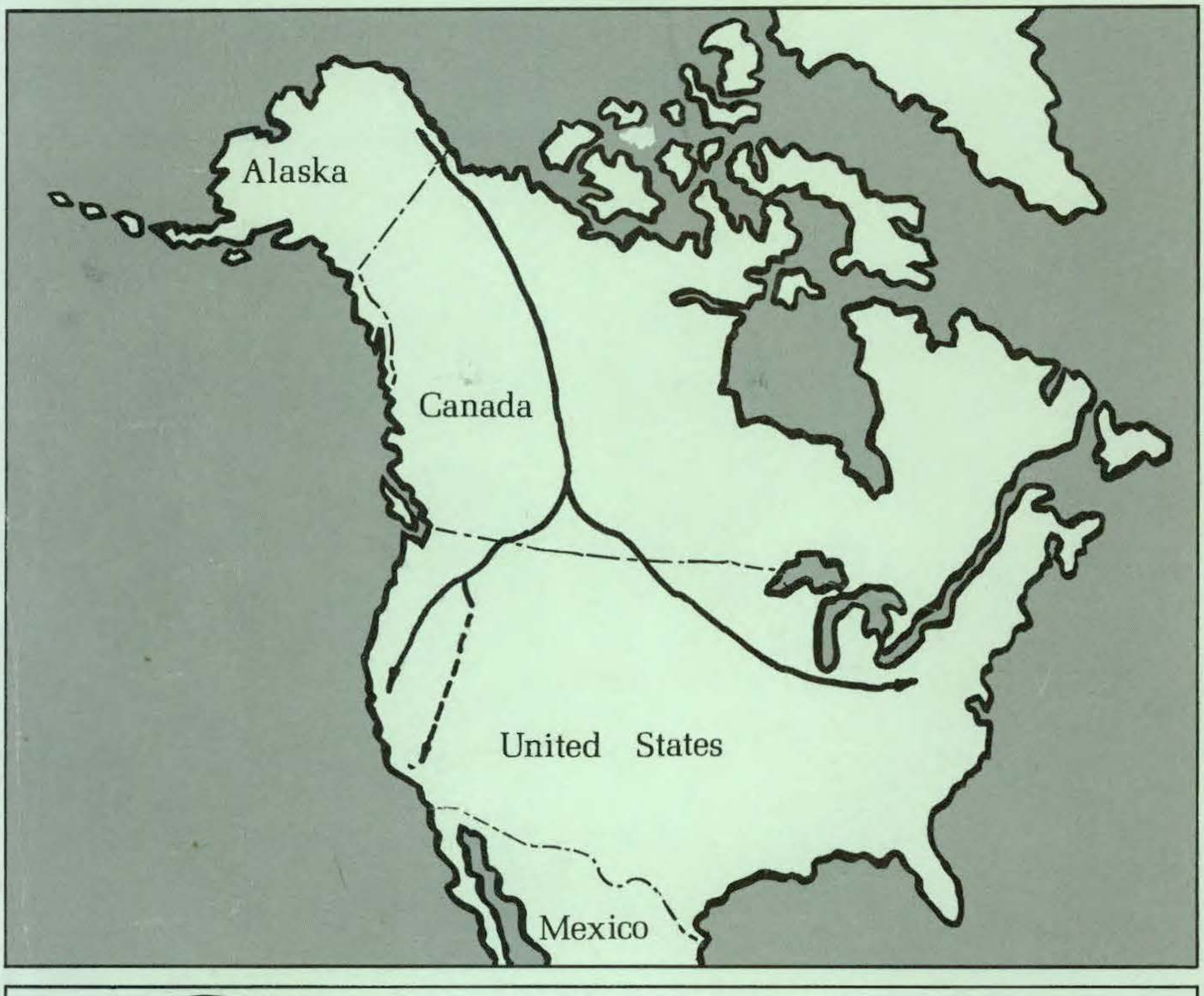
ALASKA NATURAL GAS TRANSPORTATION SYSTEM
Final Environmental Impact Statement

ALASKA



MARCH 1976

U.S. DEPARTMENT OF THE INTERIOR

WASHINGTON, D.C. 20240

ALASKA NATURAL GAS TRANSPORTATION SYSTEM

Final Environmental Impact Statement

March 1976

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 DESCRIPTION OF THE PROPOSED ACTION

1.1 ARCTIC GAS PIPELINE PROJECT

1.1.1 Alaska Arctic Pipeline

1.1.1.1 Introduction

The Alaska Arctic Pipeline is a part of the proposed Alaska Natural Gas Transportation System (ANGTS) which will initially have the capacity to transport 4.50 bcf/d (billion cubic feet per day) of natural gas, 2.25 bcf/d from the Prudhoe Bay Field in Alaska, and 2.25 bcf/d from the MacKenzie Delta area in the Northwest Territories, Canada, to industrial and population centers in Canada and the United States. The revised applications from the applicants are based on the assumption that the 2.25 bcf/d from the MacKenzie Delta area will be transported to Canadian markets and the 2.25 bcf/d from Prudhoe Bay will be transported to market areas in the United States. The Canadian Arctic gas mainline can deliver 4.50 bcf/d when fully powered while delivery and supply laterals have greater capacity. The total capacity of connecting facilities applied-for also exceeds 4.50 bcf/d. Quantities above this will require additional facilities.

The Alaska Arctic Pipeline will provide transportation for natural gas from the southwest shore of Prudhoe Bay, Alaska, to a point approximately 195 miles east of Prudhoe Bay on the Canada-United States border about 4.5 miles inland from the Beaufort Sea coast where it will interconnect with the Canadian Pipeline.

The Alaska Arctic Pipeline is proposed by a consortium doing business in Alaska as the Alaskan Arctic Gas Pipeline Company.

The initial capacity of the proposed Alaska Arctic Pipeline will be 2.25 bcf/d which can be increased to 4.5 bcf/d by the addition of four compressor stations. The ultimate capacity of 4.5 bcf/d would serve a residential community with a population of approximately 38.6 million or about 10.1 million residences.

Refer to Overview, Section 1.OV.1, for additional discussion of the ANGTS, natural gas reserves, energy needs, and energy demands.

1.1.1.2 Location

Specific Route

Information presented in this section is based on the Map Alignment Sheets submitted by the Applicant and from USGS topographic maps. (See Figures 1.1.1.2-1 and -2.)

Origin and Terminus

The proposed pipeline originates at the southwest shore of Prudhoe Bay, Alaska, in the southeast quarter of Section 11, T. 11 N., R. 14 E, Umiat Meridian, where natural gas would be compressed to 1,680 psig, chilled to a temperature of approximately 25°F (-3.8°C), and delivered to the pipeline system.

The proposed terminus in Alaska is approximately 195 miles (314 km) east of Prudhoe Bay, Alaska, at the United States-Canada border about 4.5

miles (7 km) inland from the Beaufort Sea coast. At this point, the gas would enter the Canadian segment of the pipeline system.

Distance and Route Description

Leaving the origin at Mile Post (M.P.) 00, the proposed route heads southeasterly through the developing Prudhoe Bay area, passing about one-half mile southwest of the Prudhoe Bay airfield.

Between M.P. 00 and 61, the proposed route crosses the flat, treeless, arctic coastal lake- and pond-dotted plain where pingos and oil and gas exploration facilities provide the only visual relief to an otherwise flat terrain.

The west bank of the Canning River (M.P. 61.45) is the western boundary of the Arctic National Wildlife Range. From this point, the proposed route climbs to an elevation of approximately 400-500 feet (122-152 m) and continues easterly through the gently rolling foothill country until it reaches the Sadlerochit River at M.P. 111.12, where the proposed route climbs to an elevation of between 500 and 600 feet (152-183 m), descending to an elevation of approximately 350 feet (107 m) at the Egaksrak River (M.P. 161.00). From this point, the proposed route continues eastward through very flat terrain, passing within 3 miles (5 km) of Demarcation Bay before entering Canada at M.P. 194.80.

In general, the proposed pipeline route is inland and roughly parallel to the Beaufort Sea coastline at distances ranging from 3 to 30 miles (5 to 48 km).

Regional Description

Parks, Forests, Recreation Areas, etc.

The Federally-administered Arctic National Wildlife Range, the largest unit in the National Wildlife Refuge System, is located in the northeastern corner of Alaska. It extends 150 miles (241 km) north and south across the Brooks Range and west from the U.S.-Canada border about 133 miles (214 km) to the west bank of the Canning River. The Range encompasses approximately 14,000 square miles (36,260 sq. km). Established in 1960, the Range is intended to preserve "...unique wildlife, wilderness, and recreational values..." (PLO 2214, Dec. 6, 1960). Approximately 30 percent of the existing Range is located on the Arctic Coastal Plain and Arctic Foothills. This part of the Range is a diverse wilderness habitat of coastal lagoons, barrier beaches, treeless tundra, and thaw lakes, bordered on the north by the Beaufort Sea and on the south by the Brooks Range.

The Department of the Interior has submitted proposals to expand the existing Range by some 6.217 square miles (16,102 sq. km) to the south and southwest. However, these additions are not associated with the proposed AAGPC pipeline route.

No existing or proposed State or local parks, forests, or recreational areas are associated with the proposal.

State and Borough Boundaries

The proposed AAGPC pipeline is entirely within the 88,281 square mile North Slope Borough, created July 1, 1972. (Boroughs in Alaska are similar to counties.) The borough office is in Barrow, Alaska, 177 nautical miles air distance, west and north of Prudhoe Bay.

Major Urban Areas

No major urban areas are directly associated with the proposed project in Alaska although a village of approximately 150 people is at Kaktovik which is located on Barter Island. Also on Barter Island is an active DEW Line station, manned by approximately 50 people.

Fairbanks, in the Interior of Alaska, is 327 nautical miles air distance to the south of Prudhoe Bay, and is a community of approximately 32,975 (July 1975). It serves as a transportation and communications center for the Alaskan North Slope exploration and development activity.

Anchorage, [estimated population 175,697 (Alaska Dept. Community and Regional Affairs, pers. comm., 1976)] is some 555 nautical miles south of Prudhoe Bay, and is similar to Fairbanks in its role as a transportation-communications center for the Alaskan North Slope development. Anchorage will be the location of the operations headquarters for Alaskan Arctic Gas Pipeline Company.

Location of Ancillary Facilities

This section describes the proposed location of the facilities in Alaska for the proposed AAGPC pipeline system. Except as noted, information presented in this section has been drawn from the AAGPC Environmental Report, Chapter II and Exhibit F, Map and Alignment Series, The Wildlife Map Series, and supplemental data submitted as a part of its application to the Department of the Interior and Federal Power Commission.

Compressor Station Sites

The four designated sites are numbered by AAGPC as CA-01 through CA-04 (Figure 1.1.1.2-1 and 2). These four sites each cover approximately 15 acres and are located from 35.7 to 53.2 miles (58 to 86 km) apart. Initially they will be used as construction camps, storage sites, communication sites, and maintenance stations. A primary communication tower and a 2,400-foot (732 m) gravel airstrip are proposed for each site. Compressor stations will be constructed when the volume of natural gas available to the pipeline system exceeds 2.25 bcf/d.

Site CA-01, located at M.P. 43.4, will be about one-half mile (0.8 km) north of a tributary of the Kavik River on lands owned and administered by the State of Alaska.

Sites CA-02, -03, and -04 are all proposed for location within the existing Arctic National Wildlife Range: CA-02 (M.P. 83.0) about one-half miles (2 km) east of Tamayariak River; CA-03 (M.P. 129.2) about 0.5 mile (0.8 km) west of the Jago River; and CA-04 (M.P. 176.0) about 3 miles (5 km) east of the Kongakut River.

Meter Station

The only meter station in Alaska will be at M.P. 00 at the input end of the pipeline system. This location is on the southwest side of Prudhoe Bay in Section 11, T.11 N., R.14 E, Umiat Meridian on lands owned and administered by the State of Alaska.

Material Stockpile Sites

Seven sites are proposed for storage of materials to construct, operate, maintain, and repair the proposed natural gas pipeline. These sites are of two major types: ports and sites on the pipeline right-of-way; each will be associated with an airstrip.

Ports

The existing port facilities at Prudhoe Bay will be used and two new port facilities will be constructed, one at Camden Bay and the other at Demarcation Bay. These port areas on the Beaufort Sea coast of Alaska will receive the majority of supplies for the proposed project. The two new port areas are respectively 85 and 190 miles (139 km, 206 km) east of Prudhoe Bay. Each will be equipped with wharves (Figures 1.1.1.2-3 and 4). Demarcation Bay is 6 miles (10 km) west of the U.S.-Canada border. Specific locations for the new port sites are not available.

Material Stockpile Sites on Pipeline Right-of-way

These four sites are located at the previously described compressor station sites CA-01 through CA-04.

Aircraft Facilities

Twenty new aircraft facilities will be developed as part of the natural gas pipeline project. These are of two types: helipads and airstrips.

Helipads

Locations of the 14 helipads are listed in Table 1.1.1.2-1. Helipads are associated with ports, block valves, and repeater communication sites.

Airstrips

A 2,400-foot-long (73 m) fenced, gravel airstrip site is proposed within 1 mile (1.6 km) of each of the four compressor station sites. Similar airstrips will be constructed near the port sites at Camden Bay and Demarcation Bay. Exact locations for the new airstrips have not been specified by the Applicant. Table 1.1.1.2-2 lists the general location of the six proposed airstrips.

In addition to the new airstrips, several existing airstrips probably will be used. Two private airstrips are quite close to the proposed pipeline. They are located at M.P. 13.8 and one-half mile (0.8 km) south of M.P. 28.0. Refer to Table 1.1.1.2-3 for a complete list of the existing airport facilities in the area of the proposal.

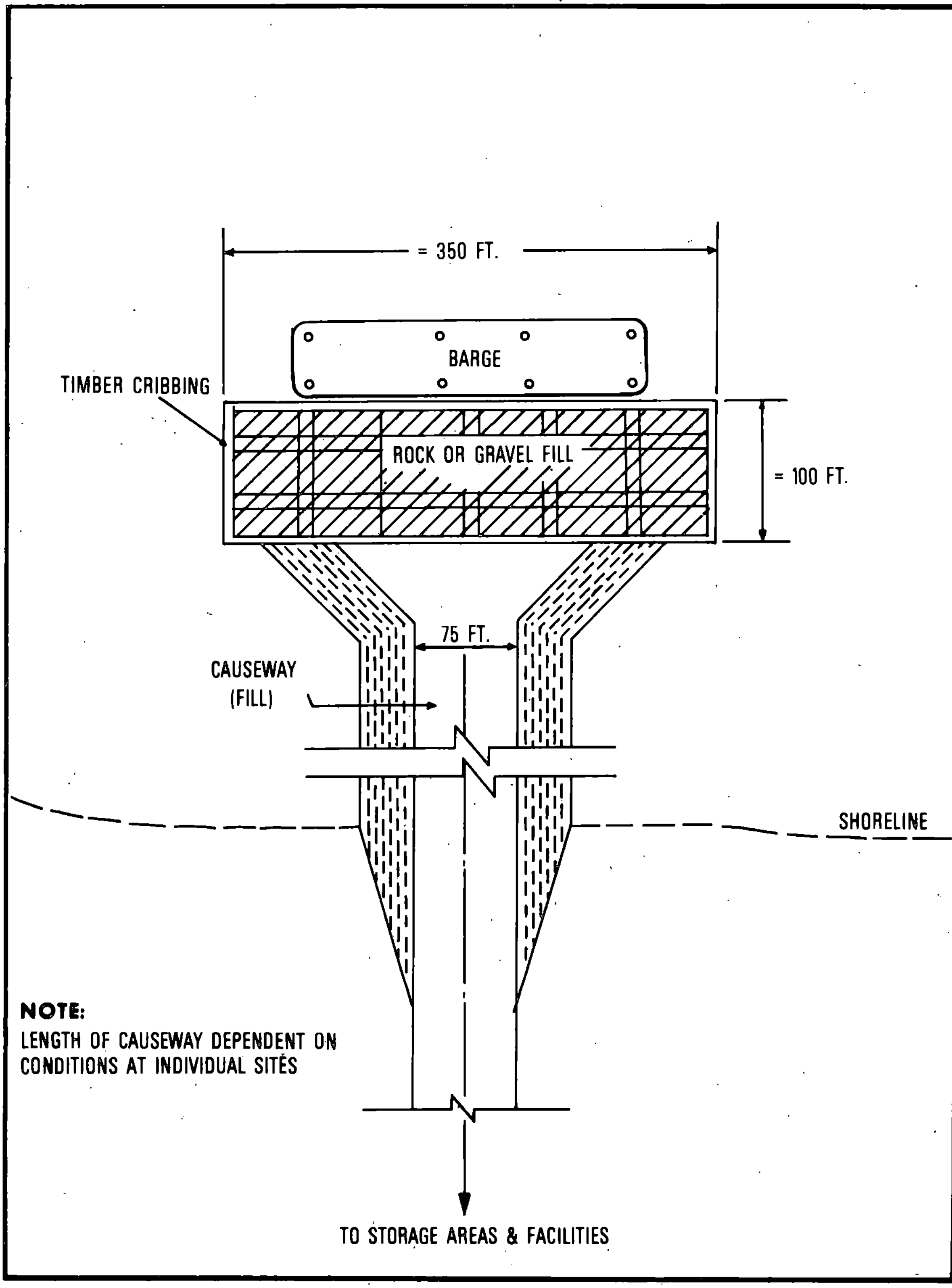


Figure 1.1.1.2-3 Camden Bay and Demarcation Bay typical deep draft wharf

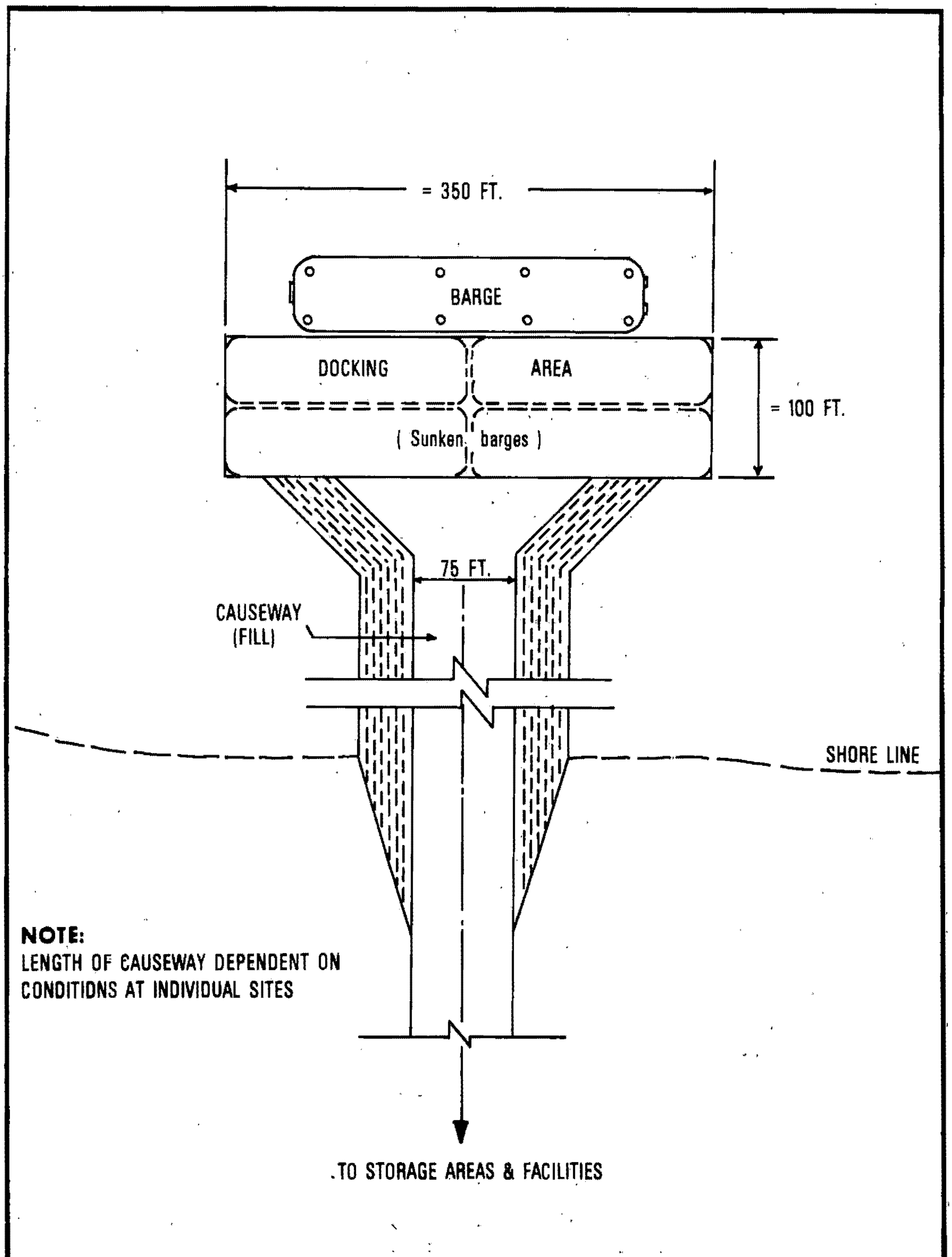


Figure 1.1.1.2-4 Camden Bay and Demarcation Bay typical lighter wharf

Table 1.1.1.2-1 Helipads

Location	Facilities with Helipads	Name and background*
1. Head of Gas Pipeline	Pumping Facility & Primary Communication Site	January
2. M.P. 13.8	Block Valve	February
3. M.P. 29.2	Block Valve	March
4. M.P. 56.7	Block Valve	April
5. M.P. 69.9	Block Valve	May
6. M.P. 98.4	Block Valve	June
7. M.P. 113.7	Block Valve	July
8. M.P. 144.7	Block Valve	August
9. M.P. 160.7	Block Valve	September
10. M.P. 191.5	Block Valve	October
11. 8 mi. S. of M.P. 25.0	Communications site (TWR)+ (R)#	Bell, (Alexander Graham Bell, 1847-1922)
12. 4 mi. S. of M.P. 69.9	Communications site (TWR) (R)	DeForest, (Lee DeForest) 1873-1961)
13. 4 mi. S. of M.P. 100.	Communications site (TWR) (R)	Marconi, (Guglielmo Marconi, 1874-1937)
14. 1/2 mi. N. of M.P. 147.0	Communications site (TWR) (R)	Morse, (Samuel Finley Breese Morse, 1791-1872)

* - All sites are named for administrative convenience.

+ (TWR) = Tower; (R)# = Repeater

Notes: Intervening block valves, should they prove to be necessary, should be named II, III, and so on, following sequentially west to east (as "May II," "May III," June, etc.)

Other Primary (P) Communciations sites are at named airstrips/ Compressor stations.

Table 1.1.1.2-2 Airstrip locations and site names

Location	Airstrips	Name & background*
Camden Bay	Amundsen	Roald Amundsen, Norwegian explorer and arctic navigator (First successful navigation of Northwest Passage 1905-6) 1872-1928.
Demarcation Bay	Pataktak	Eskimo: "Place where ducks fly low." (D.A.P.N.+ p. 266)
M.P. 43.4	Arrowsmith	Aaron Arrowsmith, English map publisher, 1750-1823 (A.B.T.#)
M.P. 83.5	Brue'	Adrien Hubert Brue', French geographer, 1786-1832 (A.B.T.)
M.P. 129.2	Devine	Thomas Devine, Deputy Surveyor-General of Canada, 1873-1879. 1823- (A.B.T.)
M.P. 176.0	Berghaus	Hermann Berghaus, German cartographer, 1828-1890. (A.B.T.)

+ - D.A.P.N. = Dictionary of Alaska Place Names, 1971

- A.B.T. = Alaska Boundary Tribunal, 1903

* - These airstrips are named for administrative convenience.

Table 1.1.1.2-3 Airdrome facilities available in the Arctic region

Name	Location	Elevation (feet)	Operational status	Runway length	Surface	Runway lighting	Fuel	Emergency services	Approximate distance from coast (miles)	Tower or airport advisory services or unicom at sites
Point Barrow	71°20' 156°38'	9	NARL	5000	Steel Plank	Yes	--	Emergency services and	On coast	No
Wiley Post/Will Rogers	71°17' 156°46'	44	Public	6500	Asphalt	Yes	No	equipment wholly inade-	On coast	Yes
Cape Simpson	71°03' 154°42'	--	Abandoned(Navy)	--	--	No	No	quate at all arctic	On coast	No
Lonely DEW Station	70°55' 153°14'	29	Air Force	3800	Gravel	Yes	--	coastal airports. No	On coast	-- ‡
Kogru	70°35' 152°15'	--	Abandoned(Navy)	--	--	No	No	aircraft firefighting	On coast	No
Itkillik River	70°04' 150°50'	36	Private	1700	--	No	--	equipment at any	25	No
Knifeblade Ridge	69°09' 154°45'	1380	Public	3600	Gravel	No	No	location. Doctors	135	No †
Airport	69°01' 153°54'	--	Uncertain	--	--	No	No	unavailable or only	120	No
Prince Creek	69°22' 153°17'	1000	Public	3600	Gravel	No	No	available infrequently.	95	No †
Airport	69°34' 153°16'	--	Uncertain	--	--	No	No	Other medical personnel	80	No
Umiat	69°23' 152°10'	351	Public	5400	Gravel	Yes	Ltd.	present in limited	80	No †
Anaktuvuk Pass	68°08' 151°44'	2100	Public	4400	Gravel	No	No	numbers. Aircraft not	160	No ‡
Galbraith Lake Camp	68°28' 149°32'	2670	Private	2500	Gravel	No	--	always available for	150	--
Toolik Camp	68°38' 149°34'	2400	Private	2500	Gravel	No	--	evacuation. Marginal	140	--
Happy Valley Camp	69°09' 148°49'	975	Private	1500	Gravel	No	--	weather conditions	90	--
Sagwon	69°22' 148°42'	650	Public	5800	Gravel	No	Yes	during winter and lack	75	Yes
Kavik River	69°41' 146°54'	640	Private	5900	Gravel	Yes	No	of instrument landing	40	Yes
West Kavik	69°45' 147°11'	410	Private	5200	Gravel	No	--	systems may preclude	35	No
Oliktok DEW Station	70°30' 149°53'	16	Air Force	4000	Gravel	Yes	--	arrival of emergency	On coast	-- ‡
Kuparuk	70°17' 149°04'	41	Private	1900	Gravel	No	--	supplies, equipment and	12	--
West Kuparuk	70°20' 149°17'	41	Private	5000	Gravel	Yes	--	personnel for several	10	No
North Kuparuk	70°22' 149°02'	24	Private	2000	Gravel	No	--	days to weeks.	5	--
Point McIntyre	70°24' 148°41'	15	Uncertain	1500	Gravel	No	--		On coast	No
Hull	70°15' 148°55'	67	Private	2000	Gravel	No	--	Pt. Barrow--doctor, fire	12	No
Deadhorse	70°12' 148°28'	55	Public §	6500	Gravel	Yes	Yes	equipment at NARL.	12	Yes§
Prudhoe Bay	70°15' 148°21'	45	Private	5500	Gravel	Yes	--	Happy Valley--medic?	4	--
Coastal	70°12' 148°10'	45	Private	2300	Gravel	No	--		10	--
Kadler	70°08' 143°04'	67	Private	2400	Gravel	No	--	Sagwon--medic?	8	--
East Fork	70°12' 147°56'	20	Private	6000	Gravel	No	--		5	--
Kad River	70°05' 147°38'	60	Private	5400	Gravel	No	--	Prudhoe/Deadhorse--medics	8	--
Pingo	70°02' 147°43'	118	Private	6000	Gravel	Yes	--	and dry chemical fire	12	-- ‡
Brownlow Point	69°59' 144°50'	8	Private	2000	Gravel	No	--	truck at ARCO.	On coast	--
Barter Island DEW Station	70°08' 143°35'	5	Air Force	4800	Gravel	Yes	Yes		On coast	No
Demarcation Bay	69°48' 142°20'	24	Uncertain	1800	Gravel	No	No	Barter Island--medical services.	On coast	No

*East of Barrow
†Tie-in FSS Barrow
‡Tie-in FSS Fairbanks
§Combined Station/Tower
(Underlining indicates facilities close to the proposed AAGPC pipeline system)

Communication Sites

Primary Communication Sites

One of the five proposed sites is located at an unspecified site on State-administered lands at Prudhoe Bay near M.P. 00.

The remaining four proposed sites are at compressor station sites (CA-01 to 04) along the proposed pipeline.

Repeater Communication Sites

All four of the proposed repeater sites, each containing a tower, are within 10 miles of the proposed pipeline and generally are spaced halfway between the primary sites. The repeater site locations and names are summarized as follows:

Location	Name*
8 mi south of M.P. 25.0	Bell, (Alexander Graham Bell, 1847-1922)
4 mi south of M.P. 69.9	DeForest, (Lee DeForest, 1873-1961)
4 mi south of M.P. 100.1	Marconi, (Guglielmo Marconi, 1874-1937)
0.5 mi north of M.P. 147.0	Morse, (Samuel Finley Breese Morse, 1791-1872)

* All facility sites are named for administrative convenience.

Applicant is seriously considering satellite communications, thus avoiding the requirement for any towers.

Borrow Areas (minimum of sixteen)

The Applicant selected borrow sources to supply sand, gravel, and/or crushed rock for construction along the pipeline and at facility sites (compressor stations, staging areas, stockpile sites, wharves, communications towers, roads, airstrips, meter stations, and operations and maintenance areas). AAGPC has no plans to obtain gravel from the barrier beaches, spits or lagoons; and AAGPC does not propose to construct wharf sites on the barrier beaches or spits.

The Applicant has identified a preferred and alternative borrow site wherever large quantities of borrow will be needed. Where small quantities are required, e.g., intermediate borrow areas between compressor station sites, only one borrow site has been chosen. Hauling distance between the borrow site and place of use usually is less than 8 miles. Borrow sites, located on active flood plains, are intended to supply about 2.4 million cubic yards of sand and gravel for construction of pads, airfields, and related facilities. The locations of these proposed borrow sites are shown on Figures 1.1.1.2-1 and 2 and Table 1.1.1.2-4.

Table 1.1.1.2-4 Borrow sites for the proposed AAGPC pipeline system

SITE IDENTIFICATION	BORROW LOCATION			DESCRIPTION OF DEPOSIT						PROPOSED BORROW			
AREA NUMBER*	MILE POST	FACILITY	REQUIRED VOLUME ($10^3 yd^3$)	MATERIAL	LANDFORM	ICE CONTENT	DRAINAGE	DIMENSIONS OF DEPOSIT (FT)	EST DEPTH (FT)	EST RECOVERY DEPTH (FT)	EST AVAILABLE VOLUME ($10^3 yd^3$)	OVER-BURN (FT)	SITE EVALU-ATION
GM-52	N/A	staging area Prudhoe Bay	103	g,s,si	active flood plain	low to medium	mid channel	extensive	10+	10	2,500	0 to 3	P
GM-53	N/A	staging area Prudhoe Bay	103	si,s	marine	medium to high	poor	extensive	30+	20	5,000	0 to 1	A
GM-102	9	staging area Prudhoe Bay and Row	25.1	s,g	active flood plain	low	mid channel	6,400	10+	10	2,500	0 to 3	P
GM-59	N/A	staging area	470	g,s,si	fossil flood plain	medium	fair to channel	extensive	20+	10	2,500	1 to 3	P
GM-60	N/A	staging area Demarcation Bay	470	s	marine(?)	high	poor	extensive	10+	10	2,500	0 to 1	P
GM-109	N/A	repeater communication	2	s,g,si	fossil flood plain	low to medium	fair to channel	6,000 x 2,000	10+	10	2,500	1 to 3	P
GM-103	28.5	Row	2.1	s,g	fossil flood plain	medium to high	fair to channel	2,600	20+	10	2,500	2 to 5	P
GM-54	43.51	Compressor Station	320	s,g, (SP)	active flood plain	medium to high	mid channel	600	10+	10	2,500	0 to 3	P
GM-104	62	Row	4	g,s, (GM)	fossil flood plain	low to medium	fair to channel	extensive	20+	10	2,500	2 to 5	P
107	81.6	Compressor station	325	g,s,si	fossil flood plain	low	fair into channel	600	10+	10	2,000	1 to 3	P
GM-56	82	Compressor station	325	g,s (GW)	outwash plain	low	fair to surrounding ter.	extensive	20+	20	5,000	0 to 2	A
GM-114	100	Repeater Communication Site	2	g,s,si (GM)	fossil flood plain	low to medium	fair to channel	2,000	20+	10	2,500	2 to 8	P
GM-105	111	Row	3.9	s,g(SW)	fossil flood plain	medium	fair to channel	1,200	20+	10	2,500	2 to 5	P
GM-57	130	compressor station	330	g,s,si	fossil flood plain	medium	fair to channel	extensive	20+	10	2,500	1 to 3	A
113	130	CA-03	330	g,s,si (GP-GM)	active flood plain	medium	mid channel	800	10+	10	2,500	0 to 3	P
GM-106	151	Row	5.2	s,g	active flood plain	low to medium	mid channel	2,000	10+	10	2,500	0 to 3	P
GM-58	173	CA-04	395	g,s,si	fossil flood plain	medium	fair into channel	extensive	20+	10	2,500	1 to 3	A
121	174	CA-04	395	ls,ss,sh	plateau	low	downslope	extensive	50+	20	5,000	0 to 2	P

Source: Northern Mg. Serv. Lot., 1974

*See maps, Figures 1.1.1.2-1 and -2.

MILE POST: Mileage location of borrow pits along the pipeline route. N/A denotes pits not on the pipeline right-of-way.

FACILITY AND REQUIRED VOLUME ($10^3 yd^3$): Facility for which the corresponding borrow is needed and the amount of material required.

MATERIAL: Types of material available in borrow pit. Abbreviations used: g-gravel; s-sand; si-silt; cl-clay; t-till; gr-granite; ls-limestone; ss-sandstone; dol-dolomite; sh-shale; sis-siltstone; arg-argillite; ch-chert; cgt-conglomerate; q-quartzite. The Unified Soil Classification System group symbol is also shown if determined by drilling results. Geologic age of bedrock is also indicated where determined from geologic investigations.

LANDFORM: Physical feature of the terrain where borrow pit is located.

ICE CONTENT: Measure of excess ice in deposit according to the scale: Low-5 to 15%; Medium-15 to 50%; High-50%.

DRAINAGE: General assessment of drainage of surface water from the borrow deposit.

DIMENSIONS (ft): Area of deposit expressed as a product of length and width.

a) When one dimension of deposit is in excess of 2 miles (3km), e.g. alluvial flood plains, only one dimension is shown.

b) Deposits which cover more than 2 mi^2 (5 km^2) "extensive."

ESTIMATED DEPTH AND ESTIMATED RECOVERY DEPTH (ft): Average thickness of deposit and the average depth to which material contained in deposit will be exploited.

ESTIMATED AVAILABLE VOLUME ($10^3 yd^3$): Figure based on the product of the estimated recovery depth and the area of a typical borrow pit which is defined as 0.25 mi^2. This includes area used for camp, equipment, waste material stockpile, and washing and sorting. In cases where deposits are less than 0.25 mi^2, only small amounts of borrow will be required and these smaller deposits should be adequate.

OVERBURDEN: Thickness of organic and silty material covering borrow material.

10^3=1,000; yd^3 = cubic yard; mi^2 = square mile

Initial locations of borrow sites were made by the Applicant based on aerial surveys and examination of aerial photographs. Final locations will depend upon field examination to determine the quantity and quality of gravel and whether the anticipated amounts can be removed. Accordingly, it is expected that there will be major changes in the number and location of borrow sites as detailed information becomes available.

In supplemental information provided by the Applicant, a need was identified for an additional 700,000 cubic yards of select sand or gravel for use in backfilling the pipeline ditch. The Applicant has not indicated the source of this additional borrow.

Roads

Permanent Roads [approximately 2 miles (3 km)]

The only permanent roads proposed by the Applicant are those between the airstrips and adjacent compressor station or port sites. Permanent roadways also will be located between the compressor sites and the primary communication sites. Permanent "pathways" will be provided between the repeater sites and adjacent helicopter pads.

Temporary Roads [approximately 250 miles (403 km)]

Temporary snow or ice roads will be located along the right-of-way, between the port material stockpile sites and the pipeline right-of-way, and between the compressor station sites and their respective borrow sites. The Applicant states there is adequate experience to justify the proposed use of snow roads.

Unprepared winter trails are proposed for use by sleighs and low ground-pressure vehicles near the proposed pipeline. The Applicant proposes to use winter trails of this type for surface access during construction of the four repeater communication sites.

Operations Headquarters

The Applicant's main operations headquarters will be located in Anchorage, Alaska, and its field operating headquarters at an unspecified site on State-administered land in the Prudhoe Bay area. Other Primary (p) Communications sites are at named airstrips/compressor stations.

Relationship to Existing or Potential Energy Sources/Systems

The proposed AAGPC pipeline system is directly related to the extraction and transportation of oil from the Prudhoe Bay Field. The oil pipeline system is not connected to the proposed AAGPC natural gas pipeline system except through common collection and processing facilities owned and operated for the production of oil. The volume of natural gas available for the AAGPC system is a function of the rate of oil extraction.

Construction of the proposed AAGPC pipeline will enhance development of other potential energy resources along the route and especially the eastern Beaufort Sea Province. It is expected that future energy transportation systems would also be located close to the proposed AAGPC pipeline system as well as to the trans-Alaska oil pipeline system.

Other Pipelines and Power Facilities

The trans-Alaska oil pipeline, now being constructed by Alyeska Pipeline Service Company, begins in the Prudhoe Bay area about 4 miles (6.4 km) south of the Applicant's proposed pipeline. The Alyeska pipeline is the only major hydrocarbon transmission facility in the Alaska portion of the Applicant's proposed pipeline system.

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 mutiple-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 and compressed through two stages to 4,500 psig. This high pressure gas then enters the injection-gas pipeline system. This pipeline system 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 Applicant's 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 users within the field. 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, Prudhoe Bay Field, Central Compressor Plant and Field Fuel Gas Unit - November 14, 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.

Local generators supply electricity to the village of Kaktovik and Prudhoe Bay facilities; there is no regional power grid.

1.1.1.3 Facilities

Pipeline Description

AAGPC states that the line pipe will be fabricated in accordance with its specifications to meet or exceed the requirements of: (1) the American Petroleum Institute Specification for High-Test Line Pipe (API Sec. 5 LX), Nineteenth Edition, and/or (2) the American Petroleum Institute Specification for Spiral-Weld Pipe (API Spec. 5 LS), Seventh Edition (AAGPC, 1974b, Exhibit G-II, p. 35).

The details of the proposed 194.8 miles (314 km) of line pipe to be installed are that the pipe will have a 48-inch (122 cm) outside diameter, an 0.8000-inch thick wall, minimum yield strength of 70,000 pounds per square inch (psi), with a maximum operating pressure of 1,680 pounds per square inch gage (psig). Ultimate tensile strength will be 82,000 psi or

10,000 psi plus the actual yield strength, whichever is greater. The buried pipe will be designed to withstand temperatures of -10°F (-23°C).

The pipeline will be buried except for short portions at the compressor station sites. The aboveground portions of the pipeline are necessary for launching and receiving mechanisms for periodic cleaning with "pigs" (specially designed devices for cleaning pipeline) and testing of the system. This pipe will have a wall thickness of 1.034 inches.

The Applicant proposes to use conventional buried construction mode design. The ditch generally will be 6 to 7 feet (2 m) wide and about 7 feet deep, with the top of the pipe a minimum of 2.5 feet (0.8 m) below the original ground surface. The ditchline will be backfilled with excess spoil and shaped to a crown or backfill mound above the preconstruction grade along the pipeline centerline. At all river crossings, the pipeline will be buried below the scour depth of the riverbed, and either bolt-on weights or a continuous coating will be used to resist buoyancy. Therefore, the ditch (at river crossings) will be somewhat wider and deeper than 6 by 7 feet. The dimensions of the ditch at river crossings are not known and the Applicant has not provided data sufficient to make these determinations.

Loops and Laterals Description

No pipeline looping has been proposed. The Applicant indicates, however, that the proposed system would encourage additional development of oil and gas in northern Alaska. The proposed AAGPC system has an ultimate capacity of 4.5 bcf/d and is expected to operate at full capacity. Looping of the proposed AAGPC system would permit quantities larger than 4.5 bcf/d to be transported.

Description of Compressor Station Sites and Ancillary Facilities

Compressor Station Sites

A compressor station site (Figure 1.1.1.3-1) will be constructed on a 15-acre, 5-foot (2 m) thick gravel pad, placed directly on the undisturbed organic layer or on insulating materials. The pads will be used as construction campsites and as operation and maintenance centers for the pipeline during its initial operation (first 2 to 5 years). Included will be: a) liquid fuel storage (unspecified construction or dimension; b) equipment storage; c) garage and repair facilities; d) living quarters (construction camp and operation/repair personnel; e) water storage; f) sewage treatment facilities; g) incinerator building; and h) open storage areas for equipment, spare pipe, and various materials.

After construction is completed and before compressors are installed, the stations will be unmanned except for periodic use by inspection and maintenance crews. The living quarters, which will be built and maintained at the sites, each will accommodate 30 people.

Each station will have electric generation facilities located in the water storage building. The turbine-generator will be dual-fuel-powered in the 250- to 300-KW capacity range. Natural gas will be the primary fuel and in case of an emergency, the generator equipment will switch automatically to liquid fuel.

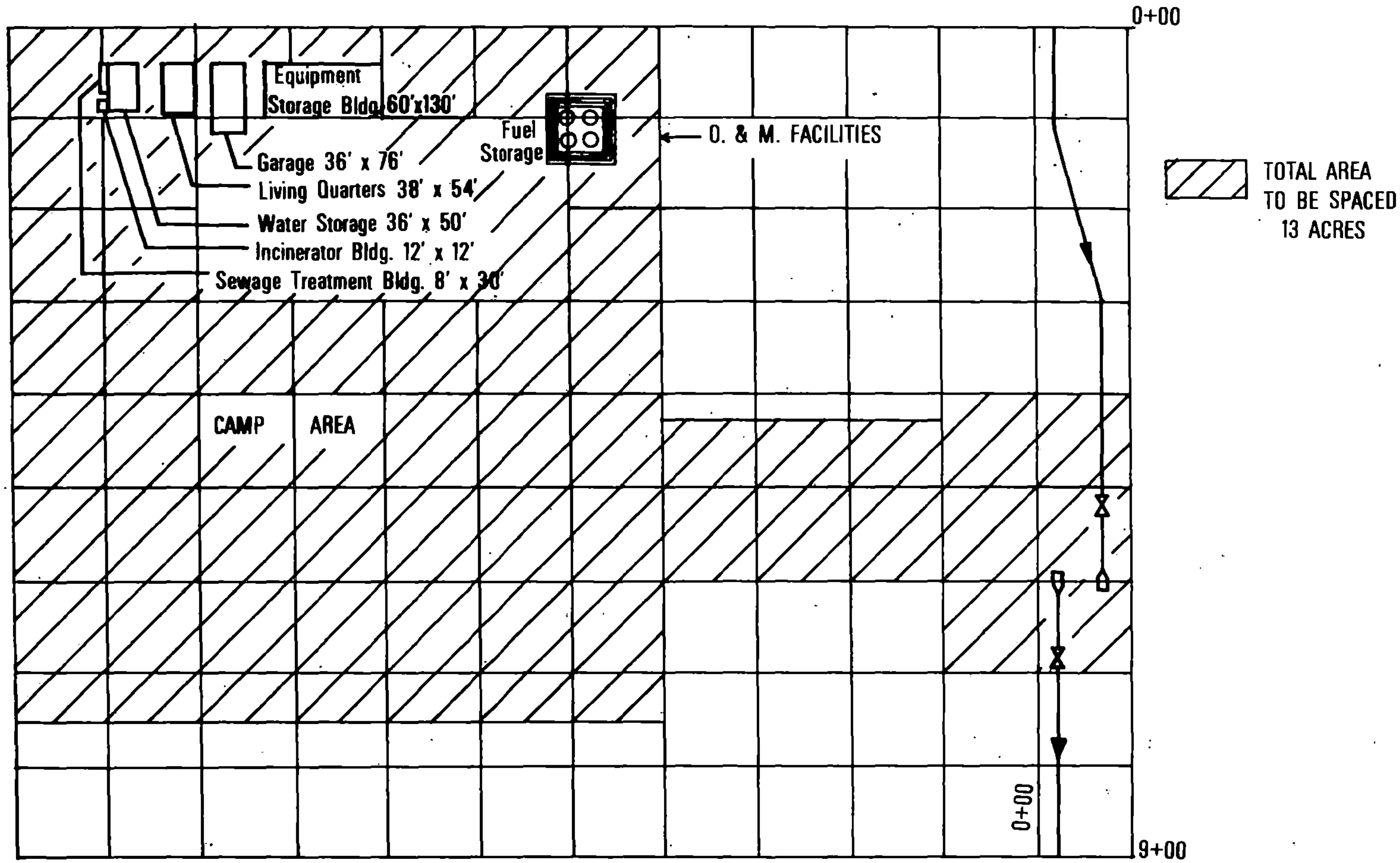


Figure 1.1.1.3-1 Typical plan of a maintenance station site

The heating systems at each site will be dual-fueled, with natural gas as the primary fuel and liquid fuel as the secondary. Safety, fire-detection, and fire-extinguishing devices will be provided.

Various materials and equipment needed for the operation, maintenance, and repair of the proposed pipeline system will be stored at the four compressor station sites.

The development of future compressor sites is described in 1.1.1.8.

Ancillary Facilities

As proposed, all permanent ancillary (support) facilities are to be constructed on gravel pads about 5 feet thick, placed directly on the undisturbed organic layer to maintain the integrity of the permafrost. Where required, a layer of insulating material may be placed between the original surface and the pad.

Each of the three port sites will be provided with a wharf, large material storage area, equipment storage area, camp area, fuel storage area, and associated facilities (Figures 1.1.1.2-1 and 2).

Most of the material and equipment are to be shipped to stockpile sites at Prudhoe, Camden, and Demarcation Bays by barge in the summer and transported from these three port areas to the required locations over snow or ice roads during winter.

A microwave communication system of five primary and four repeater sites will be used for long-distance communication along the pipeline route. The five primary communication sites each will be equipped with a guyed antenna tower, from 140 to 280 feet (43.6 to 85 m) in height, and a small, equipment-storage building. Access from the compressor pad to the tower will be via a permanent roadway. Electric power will be provided by on-site generators. The repeater site design will be similar to the primary, and will have emergency living facilities of unspecified size. Access to repeater sites will be by helicopter.

The six, new, 2,400-foot (732 m) long, gravel airstrips are intended to serve only STOL (short take-off and landing) aircraft. Each airstrip will have a small building, fuel-storage facilities, nonglare runway-indicating lights, floodlights in the area of the building and fuel tanks, a wind indicator, and other support facilities required for safe operation of aircraft. The entire facility will be fenced. Electric power will be provided by onsite generators.

The 14 helipads will be provided with nonglare indicating lights, floodlights, and wind socks.

The Applicant states that all fuel will be stored in a specifically established area. Bladder tanks will be used to store up to 47,250 gallons (178,860 liters) of fuel. For larger amounts, steel tanks with up to 157,500-gallon (596,202-liter) capacity will be used. All tanks will be surrounded by impermeable dikes. The Applicant has not indicated the type of fuel or where it will be stored.

Field offices will be constructed on State-owned land at an unspecified location in the Prudhoe Bay area. Here, a permanent staff of 39 people required for operation, surveillance, and maintenance activities will be housed. Facilities include housing, office space, repair shop, maintenance and equipment storage, utilities and service building, aboveground diesel fuel storage tank, underground storage tank for gasoline and pumps, graveled storage area, vehicle parking area with electrical outlets, and unspecified ancillary facilities.

Permanent roads will be constructed between the airstrips and the sites they serve. Generally, these roads will have two traffic lanes and will be about 30 feet (9 m) wide. They will have gravel surfaces constructed over gravel pads.

The AAGPC program for construction in Alaska is predicated on winter construction using snow roads. The Applicant states that the basic principles for successful snow road construction are: (1) do not level off or disturb the tundra; (2) build up an adequate layer of compacted-consolidated snow over the frozen tundra before subjecting it to traffic; (3) adequately and constantly maintain the snow road during use; and (4) cease traffic as soon as the surface starts to soften in the early breakup period.

A successful snow road requires constant maintenance. Once construction of a snow road starts, the normal drifting effect on the North Slope provides snow for maintenance. Maintenance consists of continual dragging and grading with prompt repair of weak spots by filling and consolidating with water. To augment snow during the early season, if necessary, Applicant will use snow-making methods proven in ski areas and in northern Canada at low temperatures.

Snow fences will be installed at times planned to avoid interference with caribou movements. They are required in early fall to trap the first snows. Their placement is not continuous and is generally parallel to caribou movements.

Snow/ice roads will be approximately 30 feet (9 m) wide and will have two traffic lanes. Snow/ice roads will be located as follows: (a) along the right-of-way; (b) between Camden Bay and Demarcation Bay material stockpile sites and the pipeline right-of-way; and (c) between the stockpile and maintenance station sites and their respective borrow areas.

The locations of the preferred borrow areas have been shown in Figures 1.1.1.2-1 and -2. Access will be by snow/ice roads.

Cost of Facilities

The Applicant estimates that the initial facilities will cost approximately $495.9 million at 1974 cost levels (AAGPC, 1974c, Dec. 30, 1974 - appendix K). These costs are shown in Table 1.1.1.3-1. Pipeline facilities are estimated to cost $362.7 million or 73 percent of the total costs. The estimated costs of other pipeline system facilities are also shown in Table 1.1.1.3-1.

It is emphasized that the initial operating phase of the pipeline system proposed by AAGPC does not include compressor stations in Alaska. Therefore, the throughput of the system will initially be limited to a maximum of 2.25 bcf/d. Construction of four compressor stations in Alaska will not take place until 2 to 5 years after the initial system is operational. The added cost of compressor stations in the time period of 1982 to 1985 is unknown at this time.

In addition to the capital cost associated with the 208,300 tons of 48-inch steel pipeline and related permanent facilities, the Applicant will require the following equipment during the construction period: a) 30

Table 1.1.1.3-1 Alaska Arctic Gas Pipeline Company construction cost estimates for total facilities

Engineering Format
Calendar Years Un-
escalated from 1974

Description	Costs by Calendar Year+ ($000)					Total in service 1980
	1976	1977	1978	1979	1980	
Land						
Pipeline	2,907	31,963	107,563	121,973	98,297	362,703
Compressor Stations (None required)						
Ancillary Facilities	4,919	4,504	11,421	14,437	5,583	40,864
Measuring Station			288	1,733	1,452	3,473
Operations & Maintenance Facilities		23	1,135	6,801	8,538	16,497
Communications Facilities	820	946	2,679	2,626	374	7,445
Sub-total direct costs	8,646	37,436	123,086	147,570	114,244	430,982
Pre Permit Costs	10,000					10,000
Operations Prior to Service	3,433	3,393	3,563	3,258	1,441	15,088
Engineering	519	2,246	7,385	8,854	6,855	25,859
Contingencies	281	1,216	4,001	4,796	3,713	14,007
TOTAL COSTS (Excludes Allowance for funds used during construction)	22,879	44,291	138,035	164,478	126,253	495,936

*Source: AAGPC, Dec. 30, 1974 (appendix K)
+Winter construction period involves portions of 2 calendar years

crawlers, 100-200 hp; b) 100 crawlers, over 200 hp; c) 50 pipelayers; d) 100 units major earth-moving and excavating equipment; e) 110 units compressor drills, etc.; f) 195 units welding equipment (less if automatic equipment is available); g) 6 pipe benders; h) 9 crushing units; i) 21 speciality items such as line-up clamps, cleaning and coating machines, backfill augers, compactors, etc.; j) 110 tractor-trucks with float, lowboy, tanker, van and pipe hauler trailers; k) 120 trucks, 5-16 ton class; l) 240 trucks, 1/2-to-5-ton class; m) 47,000 tons fuel and lubricants for equipment; n) 1,800 tons repair and replacement parts; o) 275 tons welding supplies; p) 850 tons explosives; q) 445 tons fertilizers and seed for revegetation; r) 2,100 tons food for construction workers; s) 17,500 tons cement and reinforcing steel; t) 6,000 tons methanol; and u) 125 tons lumber.

The Applicant proposes to transport most of its supplies to the port sites at Prudhoe, Camden, and Demarcation Bays during the 6-week summer navigation season. Primary movement of these supplies is intended to be through Canada via the Mackenzie River to the Beaufort Sea and then westward along the Arctic Coast. A significant number of marine vessels will be involved. Aircraft, both fixed-wing and helicopter, will be required for the transportation of people.

1.1.1.4 Land Requirements

The Applicant's proposed activities during construction will disturb approximately 4,631 acres. Approximately 3,233 acres lie within the Arctic National Wildlife Range [principally in a 133-mile-(214 km) long strip, the full east-west distance of the Wildlife Range] between the Arctic Foothills and the Beaufort Sea. The specific land uses for the proposal are tabulated below:

<u>Right-of-Way</u>

Construction Right-of-Way (as applied for)

Facility	Land	Length	Width	Acreage
Pipeline	State	61.8 miles (99.5 km)	120 ft	898.91 ac
	Federal	133.2 miles (214.3 km)	120 ft	1,938.34 ac
	Alaska total	195.0 miles (313.8 km)		2,837.25 ac

No Native or private lands are involved.

Permanent Right-of-Way

Public Law 93-153, Title I, Section 101 amends the Mineral Leasing Act of 1920 to read in 28 (d) as follows:

> "(d) The width of a right-of-way shall not exceed fifty feet plus the ground occupied by the pipeline (that is, the pipe and its related facilities) unless the Secretary or agency head finds, and records the reasons for his finding, that in his judgment a wider right-of-way is necessary for operation and

maintenance after construction, or to protect the environment or public safety. Related facilities include..." (P.L 93-153)

Final determination has not been made at this time concerning what related facilities will be included in the final right-of-way grant.

Existing Rights-of-Way to be Utilized

No right-of-way exists that could be utilized.

Plant, Maintenance, and Ancillary Facilities Site Acreage

The information below is a summary of uses that are shown in more detail in Table 1.1.1.4-1. Facilities listed are outside the 120-foot construction right-of-way. For locations, see Figures 1.1.1.2-1 and -2.

Related Land Areas Affected

Roads

Two road segments would be affected by hauling equipment and supplies for this proposed project: the North Slope haul road, built by Alyeska, which may become a State highway and the local private service roads in the Prudhoe Bay area.

Housing

The only existing housing near the proposed AAGPC pipeline is in construction, exploration, and development camps and at Prudhoe Bay on lands leased from the State of Alaska. These facilities have been built and are operated by oil and gas companies developing the Prudhoe Bay Field. Use of these facilities would continue to be similar to that during construction of the trans-Alaska oil pipeline.

Housing in Fairbanks and Anchorage will be affected as long as the construction of the proposed project keeps large numbers of people in Alaska.

Airstrips

Existing major aircraft facilities at Deadhorse and Prudhoe Bay would continue to be used heavily as long as large volumes of supplies and numbers of construction workers need to be transported.

Fairbanks and Anchorage airfields would also receive heavy use during peak construction periods.

1.1.1.5 Schedule

Duration and Phasing of Project Construction

The Applicant's proposed construction plan (see Table 1.1.1.5-1) calls for the pipeline to be ready to receive the first natural gas for transport

Table 1.1.1.4-1 Plant, maintenance, and ancillary facilities site acreage

Landowner	Facilities	No. of sites	Perman. (acres) */	No. of sites	Temporary (acres) t/
State of Alaska	Meter station	1	2.41		
	Compressor Station sites	1	31.00		
	Communications Sites	2	11.00		
	Airstrips	1	100.00		
	Roads (50' or wider)	1	2.76/0.2 mi.	1	3.00/0.5 mi.
	Trails (33' wide)	0		3	34.00/8.5 mi.
	Helipads - Included in acreage for communication sites				
	Borrow pits	0		7	280.00
	Staging sites (existing)	1	30.00		
	Other operation	1	6.84		
	Maint. site	–	--	–	--
STATE OF ALASKA SUBTOTAL		8	184.01	11	317.00
Federal	Meter station	0			
	Compressor Station sites	3	93.00		
	Communication Sites	3	16.50		
	Airstrips	5	500.00		
	Roads (50' or wider)	5	30.00/2.06 mi.	10	187.70/30.5 mi.
	Trails (33' wide)	0			48.10/11.0 mi.
	Helipads - Included in acreages for communication sites				
	Borrow pits			9	360.00
	Staging sites	2	60.00		
	Other				
	FEDERAL SUBTOTAL	18	699.50	19	595.80
GRAND TOTALS (STATE AND FEDERAL)		26	833.51	30	909.80

*/ Permanent herein is assumed to mean lands the Applicant will require throughout the operation and maintenance phases of the proposed project.

t/ Temporary herein is assumed to mean lands that Applicant will utilize during the preconstruction and construction phases.

Table 1.1.1.5-1 Proposed construction schedule, AAGPC pipeline system *

Summer 1976 */	- Prudhoe Bay, Camden Bay, and Demarcation Bay: Material and equipment moved into these three stockpile sites during summer shipping season. Develop flood plain borrow areas.
Summer 1977	- Prudhoe Bay, Camden Bay, and Demarcation Bay: Stockpile site construction completed. Continue to develop flood plain borrow areas.
Winter 1977 1978	- Compressor station sites CA-02 and CA-04: Station pads, airstrips, and roads under construction.
Summer 1978	- Compressor station sites CA-02 and CA-04: Station pads, airstrips, and roads completed. Continue to develop flood plain borrow areas.
Winter 1978 1979	- Compressor station sites CA-01 and CA-03: Station pads, airstrips, and roads under construction. Meter station under construction. Pipeline ditching and pipe laying.
Summer 1979	- Compressor station sites CA-01 and CA-03: Meter station, station pads, airstrips, and roads completed. Field operating headquarters at Prudhoe Bay completed. Restore borrow areas.

* - AAGPC, 1974a, II, Fig. II.F-1

*/ - Based upon application as filed. On November 15, 1974, the Applicant announced that all dates were moved to one year later. This was reconfirmed on February 5, 1975.

by May following the third winter (November through April) of the overall project schedule.

The Applicant is confident the construction schedule can be met. The proposed plan calls for phased completion over the entire 3-year period for material/equipment distribution, port site construction, compressor station site construction and, finally, the actual pipeline construction. The proposed schedule begins the first summer after the project is approved, and ends the third winter. A single winter period is allocated for actual ditching, installation, testing, and charging of the buried pipe along the 195-mile route. The Applicant has concluded that a single winter season is judged ample time to complete the pipe installation portion of the project.

The proposal specifies that all heavy construction activities will be conducted during winter (November through April). But the following associated construction activities will not be limited to the winter period: borrow operations on active flood plains; construction survey; receive material at port and stockpile sites; double jointing of pipe; snow/ice roads; mobilization for pipeline construction; clean up after pipeline construction; and restoration and revegetation after pipeline construction.

To facilitate understanding of the proposed construction schedule, the Applicant discusses the plan in terms of three 65-mile "spreads," indicating the three individual concurrent construction programs along the 195-mile pipeline route. The Applicant's bar graphs of the proposed three construction spreads illustrate the time schedule of the various construction activities. These three graphs are presented as Figures 1.1.1.5-1, -2, and -3. AAGPC states that borrow operations will be conducted on active flood plains during the summer and early winter. Depth of borrow pits will not exceed the natural depth of the stream bottom.

Figure 1.1.1.5-4 shows the relationship between the various proposed construction activities and the resulting proposed pipeline system.

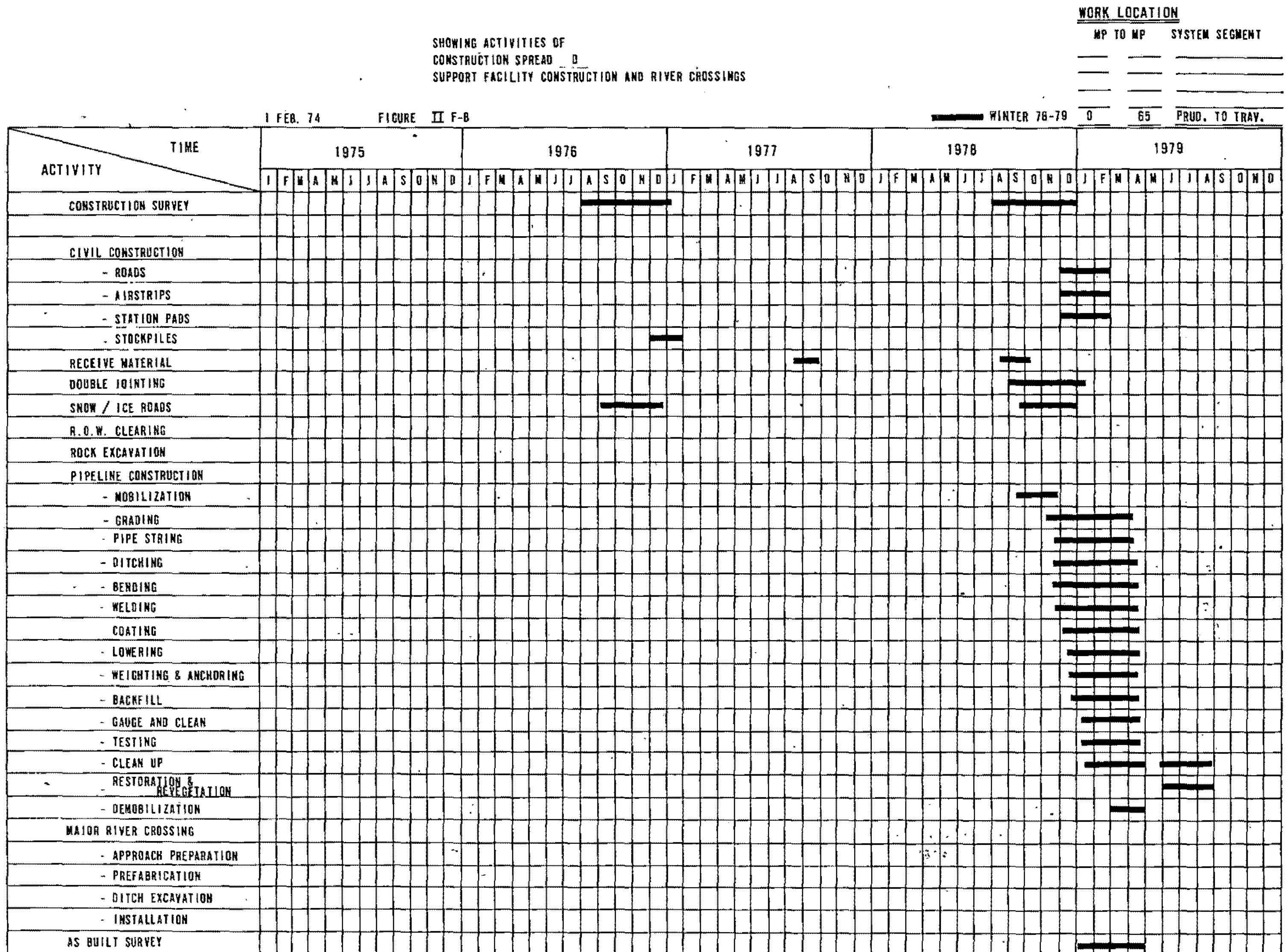
Dates shown on the proposed schedules are those submitted by the Applicant in March, 1974. On November 15, 1974, the Applicant announced the dates (1976-1979) shown on the schedule "...now seem optimistic and its planning is now based upon a schedule which moves all dates to one year later." The Applicant's schedule is based upon a series of assumptions including: (1) time of year authorization is received to start construction, (2) availability of pipe and materials, (3) availability of construction equipment, and (4) availability of construction personnel.

Proposed Future Construction

The Applicant proposes to operate the pipeline without compressor plant facilities in Alaska until the transport gas volume rate exceeds 2.25 bcf/d. At that time, the Applicant proposes to construct compressor-chiller stations at each of the four station sites identified as CA-01, -02, -03, and -04 to increase the transport gas volume to 4.50 bcf/d.

The Applicant estimates that construction of the four compressor stations in Alaska will take place as early as 2 years or as late as 5 years after initial gas transport begins. Development of additional gas reserves will be keyed to the decision.

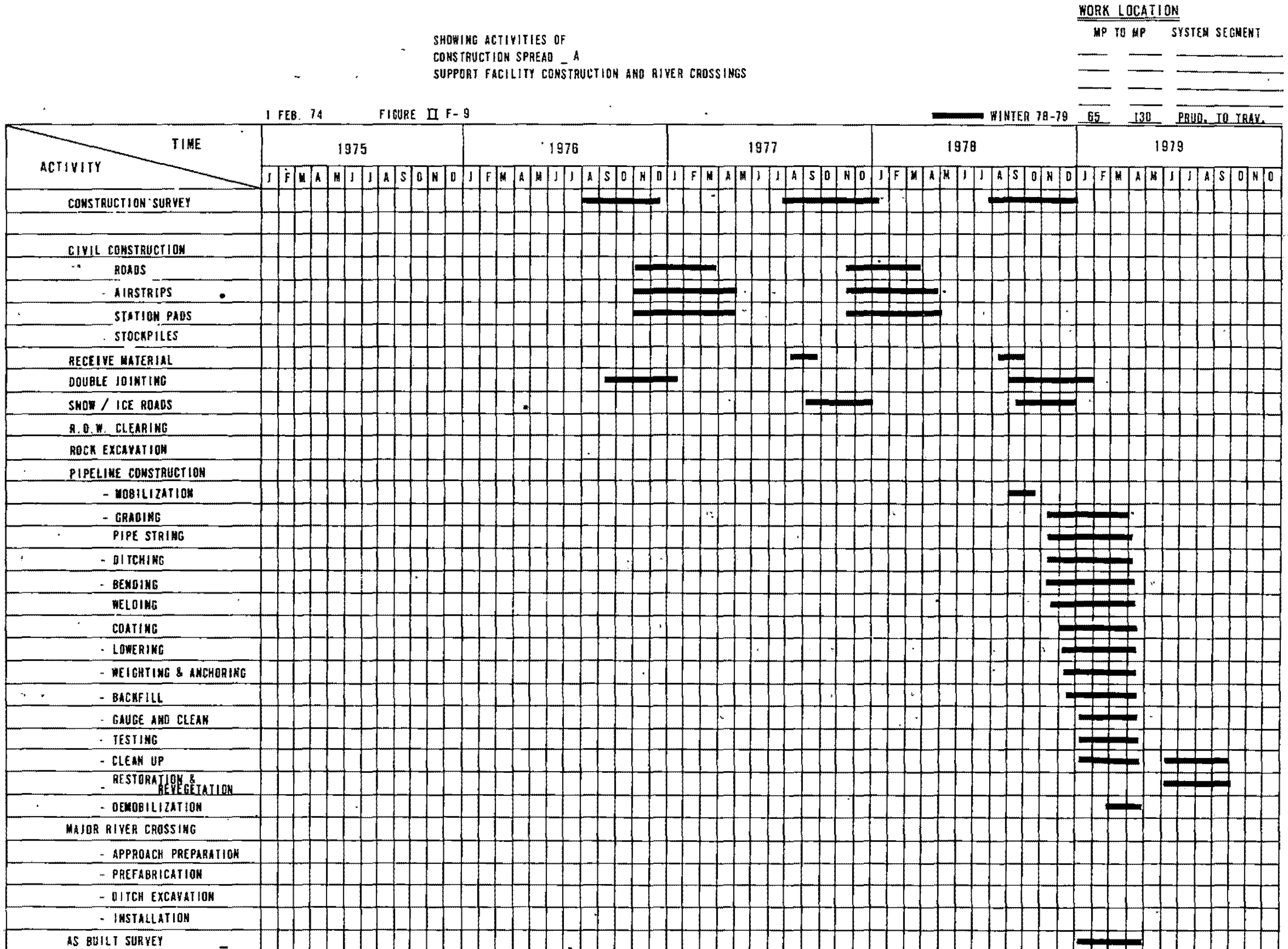
No specific construction schedule for plant facilities is contained in AAGPC's applications. The Applicant does state, however, that the materials and heavy equipment for the construction of future compressor stations will be transported to the sites over snow and/or ice roads during winter.



Dates shown are one year earlier than now anticipated.

Figure 1.1.1.5-1. Pipeline Construction Schedule.

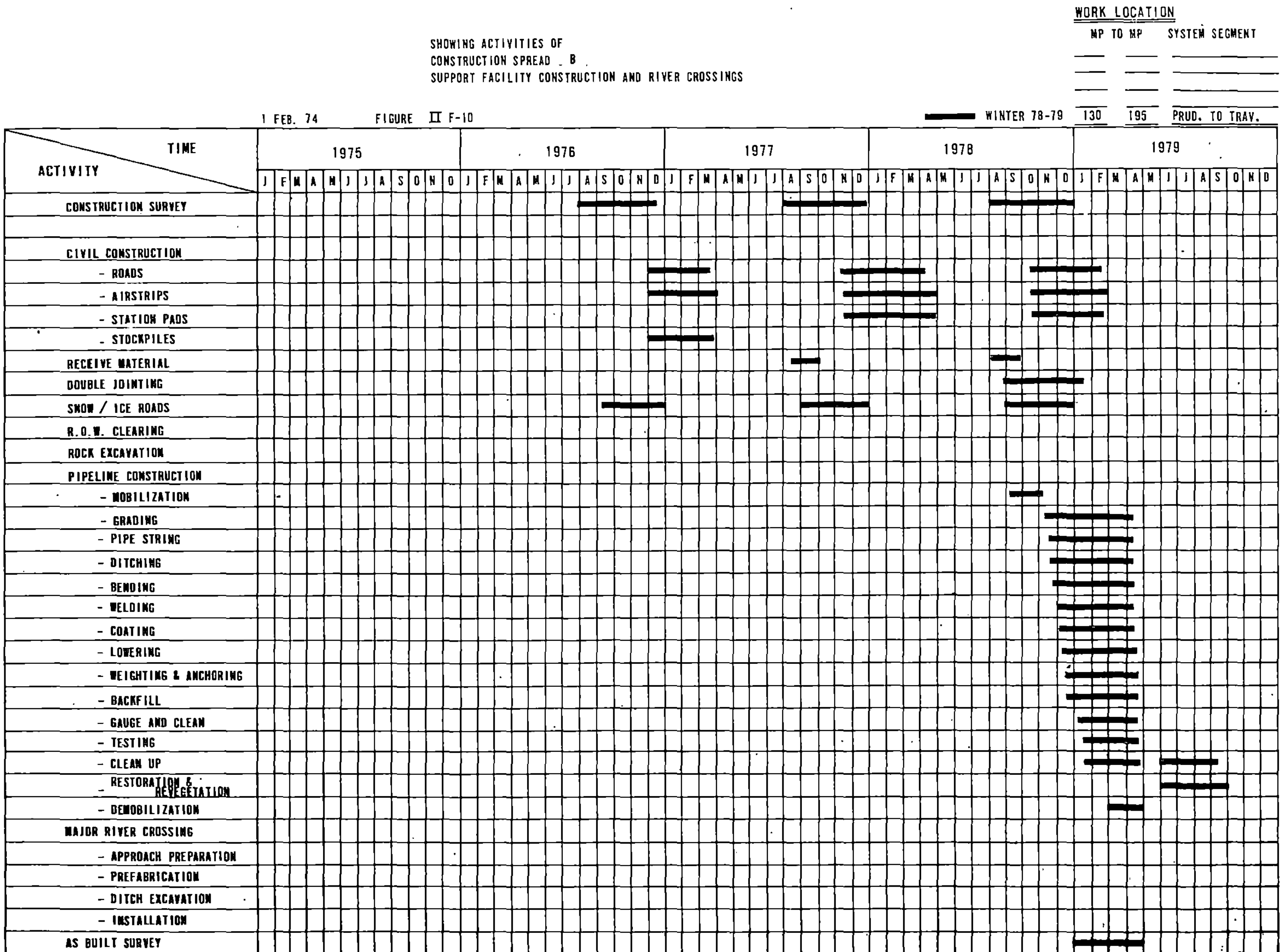
Figure 1.1.1.5-1 Pipeline construction schedule (spread D)



Dates shown are one year earlier than now anticipated.

Figure 1.1.1.5-2. Pipeline Construction Schedule.

Figure 1.1.1.5-2 Pipeline construction schedule (spread A)



Dates shown are one year earlier than now anticipated.

Figure 1.1.1.5-3 Pipeline construction schedule (spread B)

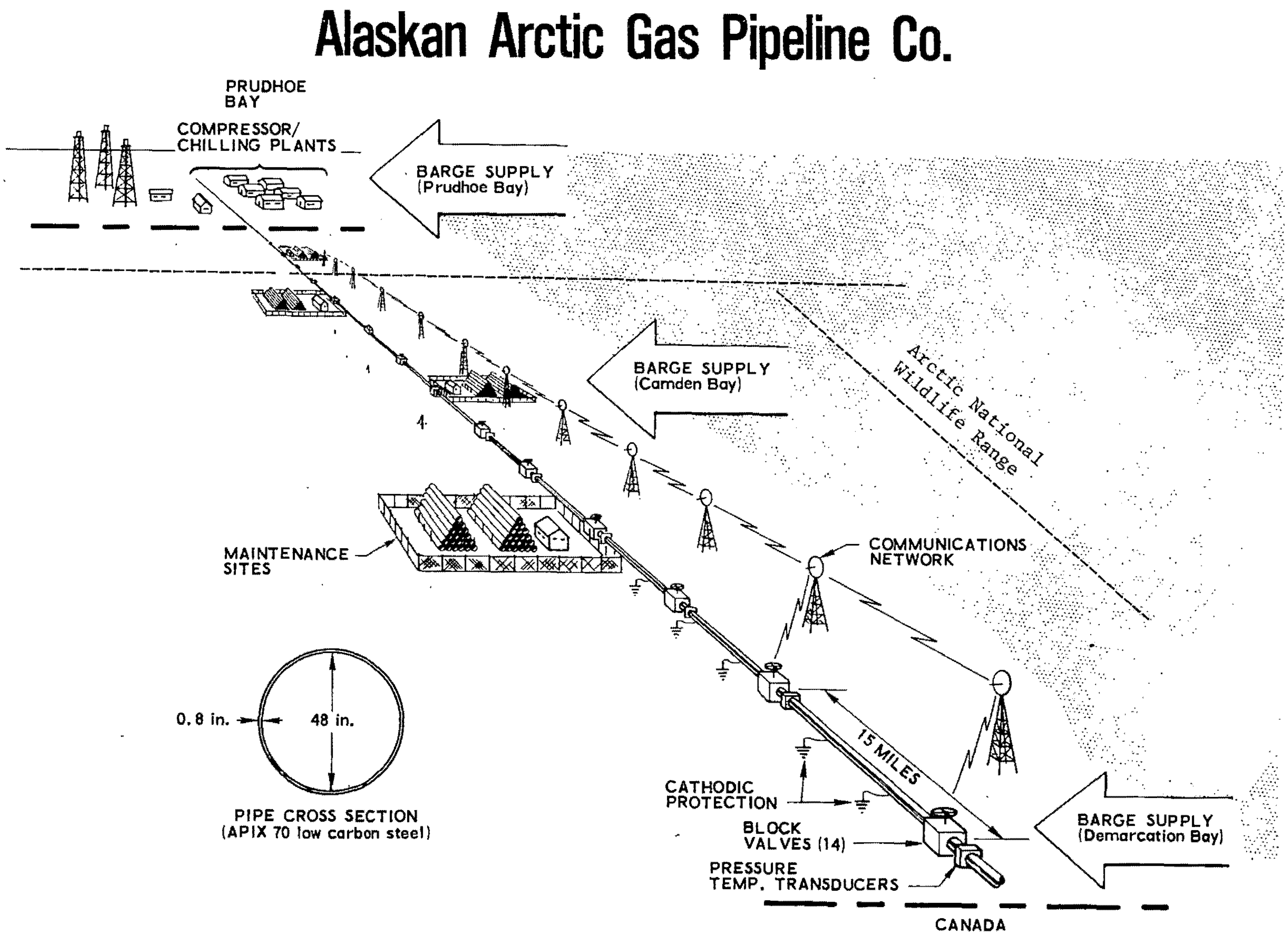


Figure 1.1.1.5-4 Schematic diagram of gas pipeline system

Airplanes and helicopters will also be utilized for transporting construction workers and some lighter items.

It should be noted that the Applicant addresses the possibility of achieving further increased gas volume transport capacity by "looping," a term generally defined as laying a separate pipeline parallel to the existing pipeline. This, in turn, would be considered only if the daily transport volume in excess of the stated 4.50 bcf/d were sufficient to justify the cost. The Applicant does not view the possibility of "looping" with the certainty that it places on the future construction of the four compressor stations. In its application, AAGPC provides no specific construction schedule for future "looping."

1.1.1.6 Construction Procedures

Activities Prior to Pipeline Construction

Summer Activities

Summer activities proposed by the Applicant are the following: a) surveying--conventional survey methods will be used to stake the boundaries of the pipeline right-of-way, compressor station sites, airstrips, borrow areas, and wharves, etc. Due to the topography and landscape, no clearing will be required. Survey personnel will be helicopter supported. b) double-ending (welding joints of pipe together at the pipe storage yards); c) construction of port areas; d) extraction and storage of sand and gravel; and e) barging material to the Prudhoe Bay port site and to the proposed port sites at Camden and Demarcation Bays.

Winter Activities

Winter activities proposed by the Applicant are to construct snow/ice roads to provide access to rights-of-way, borrow pits, stockpile sites, and wharves, and to provide traffic lanes for construction traffic along the working side of the pipeline right-of-way.

The Applicant proposes to commence snow road construction in October with low ground pressure vehicles. Provision will be made for erecting snow fencing at the start of the snow season, as needed, to augment snow collection and manufacture. At this time of the winter season, water demand is at its greatest; the Applicant states that most lakes and rivers would not be frozen to the bottom and the water supply would be readily available. In addition, there is the possibility of water being available from subsurface aquifers in some of the rivers.

The proposed pipeline traverses well north of Shublik Springs (40 miles) and the Applicant has stated that it will not, under any conditions, take water from this location for its needs.

AAGPC does not plan to indiscriminately withdraw water from fish over-wintering areas. Water will be withdrawn from such areas only if it is determined that the fish population can withstand the removal of a specified amount of water. Studies in this regard are presently underway.

Snow roads will be of two general types: High volume access roads and the traffic lane on the pipeline right-of-way; and the working surface along the pipeline ditch (see Figure 1.1.1.6-1). The first will be wide enough for two lanes of traffic [approximately 32 feet, (9.8 m)]; the other will be

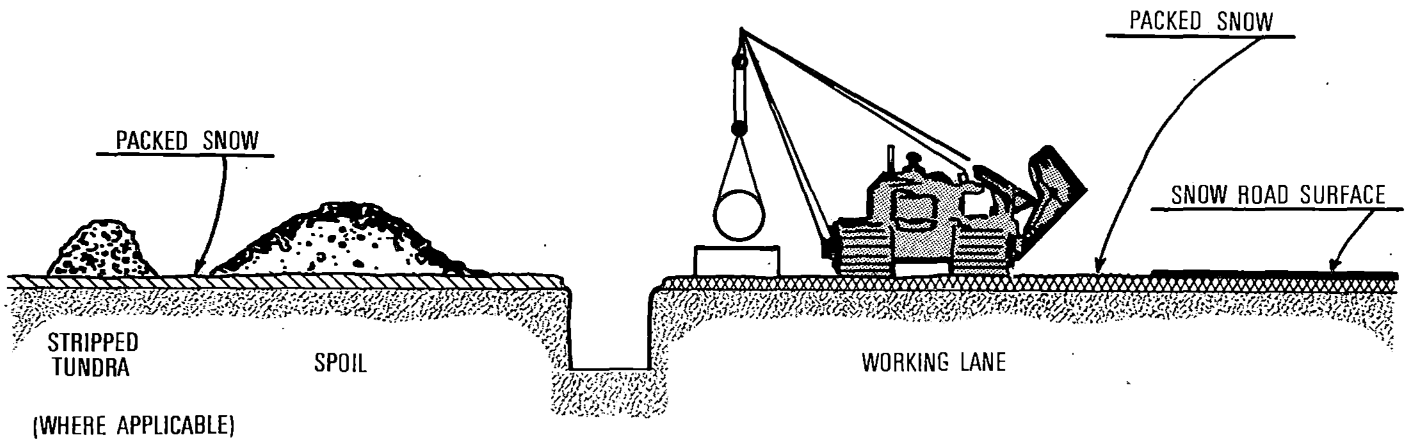


Figure 1.1.1.6-1 Cross section configuration of right-of-way

less dense and smooth, since it will be used as a working pad by slow-moving construction equipment.

If not enough snow is available, or if processing and compaction do not produce a hard enough surface, water will be added to form an ice-cap about 5 inches (12.7 cm) deep in the snow surface. Snow/ice roads will be maintained by adding snow or water or both to rutted or broken areas.

Borrow Areas

The Applicant has identified primary and secondary material sites (see Figures 1.1.1.2-1 and 2) from which he proposes to acquire 3.1 million cubic yards of granular material. Of this, 2.4 million cubic yards will be used to construct the compressor station pads, airstrips, helipads, wharves, concrete aggregate, permanent roads, and communication sites; 0.7 million cubic yards will be used as select backfill material in the pipe trench. Conventional construction techniques for the excavation, removal, hauling, and placement of borrow material have been proposed by the Applicant. In addition, the Applicant states that siltation due to borrow operations in active flood plains is not expected to occur owing to special design criteria which have been developed; for example, a berm will be constructed around the entire borrow pit, thereby preventing any silt from reaching the actively flowing watercourse. AAGPC does not plan to remove gravel from any areas where flowing water is present. Also, these areas will be revegetated upon closure of the pit.

The Applicant is aware of the importance of the barrier beaches to the ecology of the Beaufort Sea coast. The Applicant has no intention of using gravels from the barrier beaches, and every emphasis will be placed on the protection of these features along the coast.

Camps

Camps will be of various sizes and configurations but all will be self-sufficient, with appropriate sanitary waste and water treatment facilities, electric generators, heat systems with operating characteristics suitable for the arctic conditions.

Small camps (10-50 men) will use module camp units designed to be transported by helicopter, low ground-pressure vehicles, or sleds. These camps will generally be at one location for periods ranging from a single day to several months. The camps will support preconstruction activities such as surveying, materials testing, soils exploration, environmental research, and will receive initial material and equipment shipments. They will be served by helicopter, barge, or surface vehicles.

The Applicant proposes to operate small camps at Prudhoe, Camden, and Demarcation Bays, prior to installation of the pipeline. The time of year and approximate duration of occupancy are as indicated in Table 1.1.1.6-1.

Intermediate camps (50-200 men) will be composed of prefabricated module units placed on granular pads. They will be used during construction of compressor station sites, wharves, access roads, airstrips, and granular pads. Intermediate sized camps eventually will be expanded to form camps for major construction activities. They will be served by barge, permanent roads where available, snow or ice roads, helicopters or fixed-wing aircraft.

Table 1.1.1.6-1 Period of use and location of small camps

Location	Season	Approximate duration
Prudhoe Bay	Summer 1977	4 weeks
	Summer 1978	4 weeks
	Winter 1978-79	6 weeks
CA-01	Winter 1978-79	4 weeks
CA-02	Winter 1977-78	8 weeks
Camden Bay	Winter 1976-77	6 weeks
	Summer 1977	4 weeks
	Winter 1977-78	3 weeks
	Summer 1978	4 weeks
CA-03	Winter 1978-79	11 weeks
CA-04	Winter 1977-78	13 weeks
Demarcation Bay	Winter 1976-77	10 weeks
	Summer 1977	4 weeks
	Summer 1978	4 weeks

Note: Dates shown are one year earlier than now anticipated.

Large camps (500-800 men) will be located either on major unloading sites or on compressor station sites. Actual size of these camps will vary, depending on the functions being accommodated at any given time. These camps will be used during mainline construction.

Fuel Storage

Fuel types include natural gas, diesel fuel, gasoline, aviation fuel, heating oil, and propane.

The Applicant proposes to store the fuel (diesel fuel, gasoline, aviation fuel, propane) supply required for construction activities at ports, compressor station sites, or at campsites. Each fuel storage site will have a specific area for storage tanks with impermeable dikes around them.

Small volumes of liquid fuel will be stored in bladder tanks (up to 1,500 bbl capacity). For larger amounts, steel tanks (up to 5,000-bbl capacity) may be used instead of, or with, bladder tanks. The final selection of tank type will depend on: volume of storage; available land; length of storage time; foundation conditions; costs of moving tanks; and whether tanks will be retained for permanent operations and maintenance.

Propane fuel will be stored in cylindrical pressure vessels (approximately 900-gallon capacity).

Stations

Metal-clad, insulated, prefabricated buildings will house major pipeline components. The Applicant proposes to design and erect permanent buildings that blend with the landscape. No procedures or techniques for design or color criteria have been identified.

Mainline Construction Procedures

Pipelines are constructed in segments (sometimes called spreads). Three 65-mile segments are proposed by the Applicant. During mainline construction, large camps (500 to 800 men) will be located at compressor station sites. The Applicant proposes to construct the mainline in one winter construction season; therefore, the below listed aspects of pipelaying will occur along the entire route during wintertime.

Right-of-Way Grading

Right-of-way grading is required to provide a safe working surface. Sideslopes exceeding 3° will require a combination of cutting or filling techniques to provide a working surface. The cutting technique can cause permafrost degradation; therefore, the Applicant proposes to primarily utilize the fill technique. Fill material will be compacted snow supplemented with water to provide sufficient density to carry construction traffic. A secondary source of fill material proposed by the Applicant is ditch spoil or borrow materials placed over a snow or ice layer.

Stringing Pipe

During stringing, distribution of individual pipe joints along the right-of-way, the pipe will be transported on the graded right-of-way by trucks, all-terrain vehicles, or tracked vehicles. Transportation from the pipe storage yard port facilities will be over snow/ice roads.

Bending

Bending will be performed in the field utilizing the cold stretch method with conventional bending machines. Pipe will be bent as required to fit the contours of the ditch bottom.

Ditch Excavation

Ditch excavation is to be done with wheel-type equipment designed for the Arctic. This type ditching method has not proved effective and additional testing is required on new ditcher components. Recent tests of special heavy-duty teeth, made from alloys never before used in teeth, show encouraging success. Ditching machines used in these tests were new generation prototype machines weighing approximately 200,000 pounds and having total power of approximately 1,110 hp. These tests have been conducted in frozen ground in northern Manitoba, Canada, and also in digging hard shales in Alberta, Canada.

Further development of new teeth is being carried on to arrive at equipment which will have greater productivity in excavating permafrost. Manufacturers involved in tooth development are based in the United States, Canada, and Sweden. To take full advantage of this new capability, AAGPC has invited bids on an even larger, more powerful ditching machine prototype. This machine weighs approximately 350,000 pounds and has a total power of approximately 3,500 to 4,000 horsepower. In areas where wheel ditchers cannot be used, some combination of blasting, ripping, and backhoeing will be used for approximately 20 percent of the 195-mile segment in Alaska. The ditch will be excavated to a 6-foot minimum width and to a depth to allow 30 inches of cover. The Applicant proposed to remove and stockpile the tundra and replace it on top of the backfill mound.

Welding

The Applicant does not indicate the specific welding process to be used but proposes to use a combination of state-of-the-art procedures that will meet the requirements of the welding specifications. The Applicant proposes to conduct welding procedure tests under adverse temperature and weather conditions to establish detailed welding procedures for such matters as preheating, use of particular types of filler metals, electrical setting of welding machines, operating precautions (e.g., line-up and protection from the elements), sequencing of weld beads, safety and fire precautions, and clean up.

The Applicant states that all welds will be subjected to both visual and nondestructive testing, utilizing radiographic and/or ultrasonic techniques. Specific procedures for repair of welds containing defects have not been established.

Coating and Wrapping

The Applicant states that external coating and wrapping will be applied as part of the corrosion control program. Two basic and industry standard coating systems are described by the Applicant, either of which may be used on different sections of the pipeline. One technique is to apply a continuous polyethylene tape to the pipe suspended over the ditch with an unbonded outerwrap of polyethylene rockshield. The alternative coating system is to use pipe precoated with a fusion-bond epoxy and then field coat the girth welds with either polyethylene tape, shrink sleeves, or direct application of epoxy material equivalent to the precoat. Integrity of the coating will be checked using full encirclement holiday detectors. When concrete weighting (installed to control buoyancy) is used, the line will be coated with double thickness tape and an outer shield. All unbonded outerwrap will be taped down at the start of each roll and at suitable intervals.

The surfaces of valves and other irregularly shaped fittings which are not pre-coated will be coated with conformable polyethylene tape or other coating material which can be adapted to the irregular surface to give full coverage and a good bond. Mainline valves will be shop coated.

Lowering-in

Generally, lowering-in of the pipe will be conducted simultaneously with coating and wrapping. Prior to lowering-in, the ditch will be cleared of debris, drifted snow, and ice. The Applicant states that if an otherwise smooth ditch bottom cannot be completely cleaned, a 6-inch (15.2-cm) layer of bedding material will be placed in the ditch bottom. The pipe will be lowered into the ditch using side-boom tractors equipped with rubber-tired cradles and/or slings and belts to prevent damage to the pipe coating. The pipe, when laid in the ditch, will conform to the bottom of the ditch so that it will be uniformly supported.

Tie-in

Girth welding will connect welded pipe sections. Sections will vary from a few hundred feet to several thousand feet in length depending on the number of bends in the section, river crossings, and valve installations.

No special procedures are proposed for cutting, aligning, and welding pipe ends.

Buoyancy Control

The Applicant recognizes that at some places the pipeline will be partially or fully submerged in water or a soil-water slurry medium. In such areas, the buried pipeline will be subjected to buoyant forces. Specific location of these areas is unknown at this time.

Methods for buoyancy control being considered by the Applicant include: a) deeper burial. b) continuous concrete coating at such locations as major river crossings, certain minor river crossings, and predetermined areas having high water tables. c) bolt-on river weights on small water course crossings. Rockshield or two layers of outerwrap will be placed under all weights. The pipe between bolt-on weights will be protected with wooden lagging and slats held in place by metal banding. d) saddle weights in other wet areas, such as muskeg, where weighting is required. The pipe will be coated and protected as described for bolt-on weights. e) pipe anchors in lieu of river or saddle weights, in areas where underlying soil or rock will maintain anchorage. Grouted, expanding, and frost type anchors will be used; and f) selected granular backfill where the pipe trench walls are of material sufficiently stable to resist lateral yielding.

Backfill

Where rock, gravel, frozen fill, or other material in the trench might damage the pipe, one or both of the following will be used to protect the pipe: a) a minimum of 6 inches of selected processed spoil or borrow around the pipe; or b) rockshield.

According to the Applicant, remaining backfill will be placed in a crown over the ditch centerline to compensate for settlement, with openings in the completed crown to permit lateral surface drainage.

The Applicant indicates that some native backfill potentially is unsuitable and will be disposed of at unspecified locations. An estimated 700,000 cubic yards of select borrow will be needed to replace unsuitable native backfill and for: a) backfill at bends; b) drainage, erosion, and buoyancy control; c) areas of potential frost heaving and settlement; d) areas of potential seismic activity; and e) grade restoration.

Where the tundra surface has been removed before pipeline construction, it will be stockpiled and subsequently placed on the surface of the backfilled crown of the pipeline ditch to assist the revegetation process.

Cathodic Protection

The cathodic protection system will be comprised of an impressed direct-current source and ground-bed anodes at or near each maintenance station, test leads at approximately 1-mile intervals, and galvanic anodes where specifically required. The type of ground-bed construction to be used will depend upon the conditions at each site, determined by detailed testing. Cable trenches will be 24 to 30 inches (61 to 76.2 cm) deep and up to 2 feet (0.6 m) wide. The Applicant proposes to have a cathodic protection system operational as soon as practicable after construction of the pipeline section.

The Applicant has not determined the exact location and type of cathodic protection system to be used. This information is usually developed as part of the detailed engineering design which depends upon such things as exact soil information on areas immediately adjacent to the buried pipeline. The Applicant states that tests have been performed which determined that buried structures can be successfully cathodically protected in permafrost; a description of the tests and the results was not submitted for analysis.

Adherence to the Federal Regulation (DOT, 49 CFR, Part 192) covering cathodic protection systems will generally insure adequate pipeline protection. Such regulations are minimum standards, however, emphasizing monitoring test requirements and providing no design information. Most gas transmission companies conduct quarterly surveys.

Block Valves and Scraper Traps

The Applicant states that scraper trap and block valve assemblies will be pre-assembled if transportation and handling arrangements permit.

Installation will be carried out as follows: a) the pipe trenches widened to allow space for installation of foundations and below-grade pipe work; b) foundations installed; c) pipe and fittings welded into place, and the assembly tied into the mainline; and d) backfilling and restoration completed.

Revegetation

The Applicant proposes to provide the initial plant cover on disturbed portions of the right-of-way, borrow areas, and haul roads by seeding during the first spring after disturbance. As the backfill crown settles and compacts, the Applicant proposes to reseed during the fall of the first post-construction year. Fertilization is planned at the time of seeding followed with a light maintenance fertilization in the spring of the second or third year.

The Applicant proposes to do some stripping so that native sod can be replaced in disturbed areas. There is, however, no specific plan to accomplish stripping nor has the Applicant indicated how much, if any, of the route in Alaska can be stripped.

Cleanup

The Applicant proposes to collect and return surplus construction material to the original construction stockpile points or to other storage areas. All waste construction material will be removed. Combustible waste will be burned; other material will be buried on the right-of-way, at stations or other facility sites, or at abandoned borrow pits. All buried material will be covered with at least 24 inches of fill.

Testing Procedures

The Applicant states that field testing will be of the hydrostatic proof pressure type. The procedures will be conducted according to detailed specifications which will be developed prior to start of the testing program in conformance with applicable codes. Proof pressure testing of a line segment would be conducted after construction and backfilling of the segment. No gas testing or warm water testing is planned; instead, a solution of water containing methanol as a freeze depressant is currently being considered. The Applicant proposes to use a 26 percent concentration of methanol. This solution of methanol and water was selected on the basis of a minimum expected subsurface temperature of 0°F (-17.8°C).

In the relatively flat terrain, test section lengths of 3 miles (4.8 km) are planned by the Applicant. The test fluid would be mixed before entering the first test section and moved from section to section as construction proceeds. Reserve fluid for about 2 miles (3.2 km) of pipeline will be prepared. Approximately 55,600 barrels of solution are needed to fill 5 miles (8.1 km) of 48-inch (122-cm) pipe.

The Applicant indicates that if test medium containing methanol is accidentally spilled, it will be allowed to pond; then, suction pumps will be used to recover as much of the spill as practicable. The recovered fluid will be stored in bladder-type storage tanks.

After completion of a test and transfer of fluid from the section, methanol will be used to dehydrate the pipeline. Finally, the menthol test solution will be distilled after use and the resulting residue spread over land surfaces.

Operations relating to leakage determination, and activities relating to safe operations involving the handling and use of methanol have not been discussed by the Applicant within the hydrotest section.

Work Force

Number

During the construction phase, the Applicant states..."direct employment on pipeline related construction is planned to total 115 jobs in 1976 and 500 in 1977 in Alaska." During the 1978-1979 winter season..." at the time of peak employment, the Applicant will require approximately 2,400 direct pipeline workers. These jobs are expected to create approximately 3,600 additional second hand and indirect jobs."

The Applicant proposes to follow all local, State, and Federal health and safety requirements. Construction safety will be an important segment of the general training program. Construction workers who are not familiar with arctic survival techniques will be given instruction, with emphasis on the minimum requirements under the severest conditions. They will be given information and guidance on the preferred types of wearing apparel available when working on arctic projects. The Applicant indicates that instructors for safety training will include personnel familiar with the Alaska arctic climate.

Health Services

The Applicant will screen workers to ensure that each is physically fit and capable of coping with the psychological stress of being relatively isolated from his usual environment and placed where chill factors are extremely low with short daylight hours and long work shifts. According to the Applicant: "Routine immunizations must be up-to-date, and each individual should have a tuberculin skin test prior to entering the work area."

The needs for health services will be greater during construction than during operation and maintenance of the pipeline. The Applicant indicates its construction contractors will be responsible for providing suitable health services. The Applicant states that injured or ill persons will be evacuated by IFR-(Instrument Flight Rules) equipped helicopters or small turbine fixed-wing aircraft such as the Twin Otter. Both are capable of operating during conditions of low ceiling and poor visibility.

Health facilities are to include:

(1) A central dispensary at Prudhoe Bay where the physician responsible for health services will be based. This facility will have up to a four-bed capacity and contain an X-ray laboratory, an electrocardiograph and related emergency equipment, and pharmacy facilities. The dispensary will also be staffed with a physician's assistant trained in emergency procedures and

simple laboratory procedures and who will have authority to dispense medications.

(2) First-aid stations manned by a physician's assistant at each campsite during the pipeline construction. Direct communication with the dispensary at Prudhoe Bay will permit the physician to guide the assistant, and help speed evacuation of seriously ill or injured persons.

(3) Transportation by air for evacuation to the Prudhoe Bay dispensary or, when necessary, to Fairbanks or Anchorage.

1.1.1.7 Operational, Maintenance, and Emergency Procedures

Technical and Operational Description

Valves, Controls, and Pipeline

The operations and maintenance planning of the Applicant is based on the use of automatic, unattended equipment at the measurement and maintenance stations, communication sites, and mainline block valves. A communication system extending along the entire length of the pipeline will provide voice services, data transmission for the supervisory control systems, and maintenance information related to equipment performance. Tentatively, a terrestrial microwave communication system with five primary communication sites has been selected. One will be at Prudhoe Bay and the other four near the compressor station sites; a repeater communication site will be located between successive primary sites. The system will tie together the Applicant's operations headquarters in Anchorage, field operating headquarters at Prudhoe Bay, and the gas control center in southern Canada.

Mainline full-opening block valves will be placed at the beginning of the pipeline, at each compressor station, and along the pipeline at approximately 15-mile intervals. Automatic controls are to close the valve when a rate of change in pressure is sensed that indicates a break in the pipeline. Applicant also refers to manual operation of these valves and the inclusion of the necessary blowdown valves and stacks.

Scraper trap assemblies will be located at the compressor station sites. Compressor units installed at the station sites will be designed for automatic, unattended operation. Discharge pressure, temperature set points, and unit start-stop will be controlled remotely or locally. Stations will be self-protecting, with safety devices to shut down the station when conditions become hazardous. The initial pipeline design will allow the compressor stations to be connected and activated with no significant interruption of gas delivery.

The proposed initial pipeline system does not provide for any processing or treatment of the flowing gas within Alaska after it is accepted from the oil-producers' gas treating facility at Prudhoe Bay for transmission at the proposed rate of 2.25 bcf/d (billion cubic feet per day). The gas will be subjected to pressure and temperature changes resulting from frictional losses and heat transfer with the pipe wall but this rate will not require any processing or treatment for gas quality control until it reaches the compressor station with refrigeration facilities across the border in Canada. The Applicant's projected gas volume rate increase to 4.50 bcf/d, estimated to occur between 2 and 5 years after starting the 2.25 bcf/d rate, will require the installation of compressors with associated refrigeration and gas-treating facilities.

Routine Operations

The Applicant's proposed operations headquarters in Anchorage will administer and coordinate such matters as personnel relations, employee training, public relations, engineering, and environmental protection. The preparation of contingency plans for line breaks, support facility outages, and fires will be a combined effort of both the operations and field operating headquarters. The Applicant estimates that there might be one break in the whole Alaska-Canada portion of the pipeline in 10 years.

A maintenance and inspection program will be an integral part of routine operations. The Applicant states that this program will be developed after the proposed pipeline system equipment has been selected and installed. This will include the inspection and servicing of valves, mechanical operations, power supply, automation points, gas measurement meter runs, recording devices, and all support facilities of the proposed pipeline.

Where the pipeline right-of-way cover is disturbed, the thermal balance will be restored by the use of backfill and revegetation. The Applicant proposes to stockpile gravel for any necessary backfilling of excavations at intervals along the right-of-way. The locations of these gravel stockpiles have not been identified.

In the event of a pipeline break, repairs would be required immediately and there would be disturbance for several miles along the right-of-way. The Applicant states, in general terms, that surface access along the right-of-way will be restricted during summer months and helicopter support will be substituted for overland travel whenever possible. Routine maintenance requiring use of surface vehicles will be delayed until after freezeup.

Start-up Plan

The Applicant has provided a brief description of the start-up sequence. The meter station at Prudhoe Bay will be commissioned first; all facilities and instrumentation necessary to measure operating parameters will be tested for accuracy and performance after installation. Piping in the meter station will be purged with nitrogen to eliminate all air.

Natural gas will be used to purge air from the mainline. The mainline will be purged in sections, using a pig to prevent mixing of the gas and air. The natural gas system for compressor station facilities will be purged and activated. All station water-handling facilities will be tested to assure correct chemical treatment and filtration. The emergency shutdown systems will be tested. The compressor station facilities will be manned until the system has been approved for unmanned operation.

Maintenance Procedures

Corrosion Checks

Routine monitoring of internal corrosion will be carried out using corrosion-rate monitoring probes at station inlet points. Corrosion of pipe, fittings, valves, and vessels exposed to the atmosphere will be inspected visually.

Route Surveillance

The Applicant proposes using small, fixed-wing, low-speed aircraft once or twice monthly for normal surveillance activity. During spring runoff, however, patrol flights may be required weekly. The Applicant has prepared regulations restricting aircraft overflights. These regulations state that all sensitive areas, such as the calving grounds of the Porcupine Caribou Herd, are to be avoided during critical times of the year, and in the event that flights are required in these areas, they are to be at altitudes above 2,000 feet. Moreover, it is a serious crime in Alaska to harass wildlife with aircraft.

Under some conditions, air patrols may be supplemented or replaced by specially trained ground patrols on foot or in small vehicles suited to the terrain conditions. The ground patrols will inspect all above-ground facilities on the right-of-way at river crossings including mainline block valves, backfill on the line, monitoring systems, and drainage control measures. The combined air and ground patrols will operate on scheduled programs. Ground patrols on foot will require helicopter support for intermediate transportation along the route.

Airstrips, helipads, communication sites, access roads, and related facilities will be maintained by the Applicant in a serviceable condition throughout the year.

The Applicant has not stated the surveillance schedule for communication towers, but inspection will include examination of the supporting structures, the tension of guywires, and the condition of foundations.

Warehousing and Storage

Spare parts, materials, and supplies for routine maintenance will be stored at each compressor station site. Modular spare parts kits will also be available for repairs resulting from major breakdowns.

Routine inspections will be made of the permanent wharf facilities to check for possible ice damage and for drainage conditions around storage areas.

Emergency Contingency Plans

The Applicant has not prepared contingency plans or emergency procedures, but general considerations and main courses of action have been presented. The Applicant states that contingency plans will be developed for the pipeline system on a section by section basis. These will contain information on the manpower, materials, and equipment needed to effect major line repairs and outline steps for their utilization. As an example, the Operating Manual will include a Mainline Break Repair Plan, which will consider the location, type of terrain, and weather conditions which will be encountered. Methods of repair will be preplanned and time required for repairs estimated. Other information in the plan will be type and location of stored equipment; recommended transportation and routing methods, considering seasonal and environmental constraints; assignment of supervisory and repair personnel; notification and reporting requirements.

The Applicant presented a discussion of equipment and procedures that would be used to repair a hypothetical "worst case" failure, using a location about halfway between the Prudhoe and Demarcation Bays with the repair being made when the ground was thawed. The discussion is as follows:

The failure assumed is a line break 220 feet long in the vicinity of Milepost 95, between maintenance stations CA-02 and -03. It is assumed to have happened during spring flood, or following a summer rain when the Katakturuk and Hulahula Rivers may be difficult to ford with large LGP (low ground-pressure) vehicles. The repair equipment which would be required and the uses of each are listed below.

Air-cushion Vehicle

The only undertaking by the Applicant to use air cushion vehicles would be due to this remote possibility of a pipeline break. In that event, the air cushion vehicle would be required to make one or two trips to move in heavy equipment from the closest compressor station site. If the rupture occurred in a pipe bend and a suitable bent pipe section were not available at an adjacent station, this vehicle would be used to transport a suitable bend from Prudhoe Bay where a bending machine would be available.

Helicopters

Several helicopters would move to the site to transport personnel and small equipment, such as aspirators, pumps, lighting plant, welding machines, cutting equipment, radio-graphic equipment, fuel, lube oil, groceries and other miscellaneous material and equipment.

Low Ground-Pressure (LGP) Vehicle Complete with Backhoe and Blade

Two LGP vehicles, each loaded with terrain protective mats, would proceed from stations CA-02 and -03 to the rupture site at the earliest opportunity. In addition to backhoe buckets, air or hydraulic hammers would be available to break the permafrost prior to excavation. The LGP vehicles would be used to excavate around the ruptured section, to assist in lowering the replacement section of the line into the prepared ditch, and to backfill after completion of repairs. These two vehicles could move to the site under their own power.

Sideboom Tractors

Two sideboom tractors would be required to place sections of pipe in position for welding and to assist in lowering the welded replacement section into the excavated ditch. Both of these tractors could be hauled from one station if time permitted; or one from each of the stations. They would probably be transported on 40-ton LGP vehicles. Transportation could be effected with the air-cushion vehicle if circumstances required.

LGP Crane, 20-ton

Although possibly not essential, one 20-ton LGP crane located at station CA-02 or -03 could be moved to the site to handle pipe, welding machines, pumps, etc., and to assist in lowering-in the completed repair section. The crane may require air-cushion vehicle assistance to cross rivers.

LGP Vehicle, 40-ton

After hauling the two sideboom tractors to the repair site, two (40-ton) LGP vehicles would return to the most convenient station site to haul in six 40-foot lengths of replacement pipe (three on each vehicle). Again, this could be accomplished with the air-cushion vehicle, depending on local circumstances.

LGP Vehicle, 10-ton

Ten-ton LGP vehicles may not be required, but depending on the availability of helicopters, they could be used to transport small tools and equipment to the repair site. Not more than one trip each way is anticipated.

AAGPC indicates that low ground pressure tracked and wheeled vehicles are available through Foremost International Industries Ltd., Calgary, and Canadair Flextrac Ltd., Calgary. Also, a 25-ton air cushion vehicle is available from Bell Aerospace Canada Ltd. and a 100-ton air cushion transporter is available from Arctic Systems Ltd. These vehicles have all been in use in the Canadian Arctic.

Miscellaneous

Portable camp equipment would be moved by helicopter sling from Prudhoe Bay to required locations. Some of the camp equipment would be placed at station CA-02 to augment the existing facilities and some would be moved to the repair site to provide meals for the shift workers. The main personnel accommodation would be provided at stations CA-02 and -03 or at Prudhoe Bay.

The heavy work equipment discussed above could be left on the site after completion of the repair and removed when winter conditions prevailed, in order to ensure that damage to the vegetation layer was held to a minimum.

It is clear, of course, that the movement of heavy equipment to the site of repair work, and work at the site, will cause some damage to the vegetation layer. The Applicant believes, however, that its surface restoration procedures are quite adequate to repair this type of disturbance in the same manner that surfaces will be restored and revegetated following the initial construction of the line.

Rupture incidents will require immediate and efficient repair methods and adequate equipment must be readily accessible to any location. The Applicant's Mainline Break Plan (a part of the Operating Manual) will consider the types of terrain, locations, and weather conditions which will be encountered. It will preplan methods of repair, materials, equipment required, and will include an estimate of time duration for a major line repair.

The major engineering, geotechnical and wildlife concerns and considerations which will influence pipeline maintenance with respect to off-road vehicular traffic are as follows:

1) The Applicant recognizes that it must preserve and, when damaged, repair the active surface layer. This requires the minimizing of vehicular traffic when the terrain is vulnerable to damage, the selection of equipment which will impose the minimum unit weight on the ground surface, and the

implementation of an on-going surface repair and revegetation program to restore ground cover if damage does occur.

2) It will be necessary to monitor the right-of-way for evidence of active layer damage, so that the Applicant will be in a position to effect early repairs.

3) The Applicant proposes to use aircraft, both fixed-wing and helicopter, to minimize ground traffic over sensitive areas, always respecting the presence of wildlife as outlined in the publication, "Corridor Wildlife Map Series," and the past and ongoing studies and site-specific examinations.

4) The Applicant will station approved types of heavy work and transport equipment at locations selected to avoid long hauls in sensitive terrain areas and isolated sections of the system.

All pipeline right-of-way work, scheduled routing, maintenance activities and possible emergency repair work will be planned and executed, recognizing the above concerns.

Existing equipment for use on sensitive terrain is undergoing constant improvement in design, and such improved equipment will be available when operations begin. The Applicant emphasizes that much design improvement work has been underway by equipment manufacturers for construction on this and other pipeline systems.

Finally, as indicated in materials filed by the Applicant, pipeline ruptures are a quite infrequent event, particularly with new lines constructed using modern techniques.

Health and Safety Measures

Water Treatment

Drinking water for construction camps and permanent operational facilities will be treated. The final design of each treatment installation has not been selected.

Waste Disposal

The Applicant proposes to bury noncombustible solids. Burial sites have not been selected. Combustible solids will be burned in incinerator units; the resulting ash will be buried with noncombustible materials.

Sewage wastes will be processed in sewage lagoons which include biological or physical-chemical waste treatment facilities for secondary treatment for all effluents discharged. The quality of effluent satisfies regulatory standards. The Applicant states that the effluent will be discharged in a regulated manner and during times of the year when it will be carried off during spring flood. In areas where discharge of treated effluent in this manner is impractical it will be drained onto the tundra. The Applicant states the details of this operation will be available when final design is complete.

Fire Protection

The Applicant states that all operations and maintenance personnel will be trained in fire fighting and fire protection. Heavy work equipment, such as graders, dozers, backhoes, etc., which are not involved in operating emergencies on the system, will be made available for emergency fire-fighting duties. Transportation equipment for fire fighting, including helicopters, service trucks, and heavy load-carrying trucks for highway travel in the Prudhoe Bay area, and soft-tracked and low-pressure, rubber-tired, personnel- and load-carrying vehicles for off-highway movement stationed at Prudhoe Bay and at the four compressor sites will be available.

A gas detection system will be installed in all buildings that contain pipes transporting natural gas. Detection of small amounts, approximately 20 to 25 percent of the lower explosive limit, will cause an alarm at the Gas Control Center and will activate the exhaust fans in the building where gas is detected. Detection of larger amounts of gas--approximately 50 to 60 percent of the lower explosive limit--will cause an emergency shutdown.

Ultraviolet and thermal detectors will activate automatic fire extinguishing systems in buildings containing gas piping. Manually operated fire extinguishers will be placed at strategic locations. An inert, clean-agent gas such as halon or carbon dioxide will be discharged automatically into the building where a fire is detected, displacing the air and extinguishing the fire. Office buildings and shops will also be supplied with portable fire-extinguishing and hose equipment in compliance with the latest National Fire Codes of the NFPA.

Pipeline maintenance crews will have portable fire extinguishing equipment when they are working on the pipeline right-of-way. All airstrips and helipads will be equipped with wheeled dry chemical fire extinguishers.

Storage and Handling of Fuel

Propane is required during construction for pipeline heating and for applying insulating tape on the outside of the pipe. A fenced storage area of approximately two acres with graded surfaces will be provided at each stockpile site for storing propane cylinders. The cylinders will be constructed with internal baffles and valve protectors to meet regulations regarding transport of propane.

At each fuel stockpile location, either wheel or track mounted, fuel tankers will be provided. Each tanker will be equipped with adequate pumps and piping for loading and unloading the tanker. During the construction season, liquid fuel will be pumped from the bladder tanks into the fuelers and transported to the actual job site.

1.1.1.8 Future Plans

Abandonment of Facilities

Salvage and Disposal of Equipment

In light of the huge potential reserves of gas in the Alaskan Arctic, it is certain that the proposed pipeline system will be operative for many decades. The Applicant assesses the physical life of the pipeline to be more than 50 years and, therefore, cannot predict the most favorable abandonment techniques.

Whenever abandonment of the facilities is required, such facilities can only be abandoned by authority of the Federal Power Commission issued pursuant to Section 7(b) of the Natural Gas Act, 15 U.S.C. Section 717f(b). Abandonment must conform to regulations prescribed by applicable local, state and Federal laws in existence at that time, including the regulations of the Materials Transportation Board.

The Applicant indicates, however, the pipe itself could be left in place with no disruption of surface stability. Only if recovery of the steel is economic at time of abandonment would such recovery be attempted. The Applicant states all the environmental safeguards which apply to the proposed installation procedures will be made applicable to any pipe recovery procedures. The Applicant anticipates that if the pipe is removed, the pipe trench will be restored to original contour with material from the right-of-way, from borrow areas agreed upon with landowners, or from commercial sources.

All structures and equipment owned and used by the Applicant during the operating life of the pipeline will most likely be disposed of, at the time of abandonment, by sale to local interests (i.e., residents of Kaktovik) or removal from the area.

With respect to camp and other structures required for construction of the proposed pipeline system, a condition of the Applicant's contracts with all construction firms will be the proper cleanup and removal of all structures and equipment to the satisfaction of the Applicant and of local authorities.

Site Restoration

Airstrips, station pads, and their interconnecting roads may serve some useful purposes 50 or more years in the future. If not, according to the Applicant, the sites can be treated so that they will support plant growth and their surfaces revegetated. The Applicant has no specific program, however, for cleanup and restoration of sites at the time of abandonment.

Future Expansion

1) Compressor stations will be constructed at the four sites CA-01 to -04 described in Section 1.1.1.2. Each compressor station will be similar in design and layout (Figure 1.1.1.8-1). Each would have a single 30,000 horsepower natural gas-driven turbine compressor and a closed loop propane refrigeration system, powered by a 17,000 horsepower natural gas-driven turbine. At these stations, the gas would be compressed to 1,680 psig (pounds per square inch gage) and subsequently would be chilled to a temperature in the 10°F to 30°F (-12.2°C to -1.1°C) range. They will be designed to operate by remote automatic control from the Gas Control Center.

With ultimate development of the four compressor sites, new buildings would be constructed for the scrubber, main compressor, chiller compressor, chiller, motor control center, fuel gas control, and utilities.

2) The major mechanical equipment to be installed includes:

a) Gas scrubbers to remove condensate from the gas as well as to protect the gas compressor against harmful intake.

b) Centrifugal gas compressor, driven by a natural-gas turbine of 30,000 horsepower. The prime move will have air-intake filters, an anti-

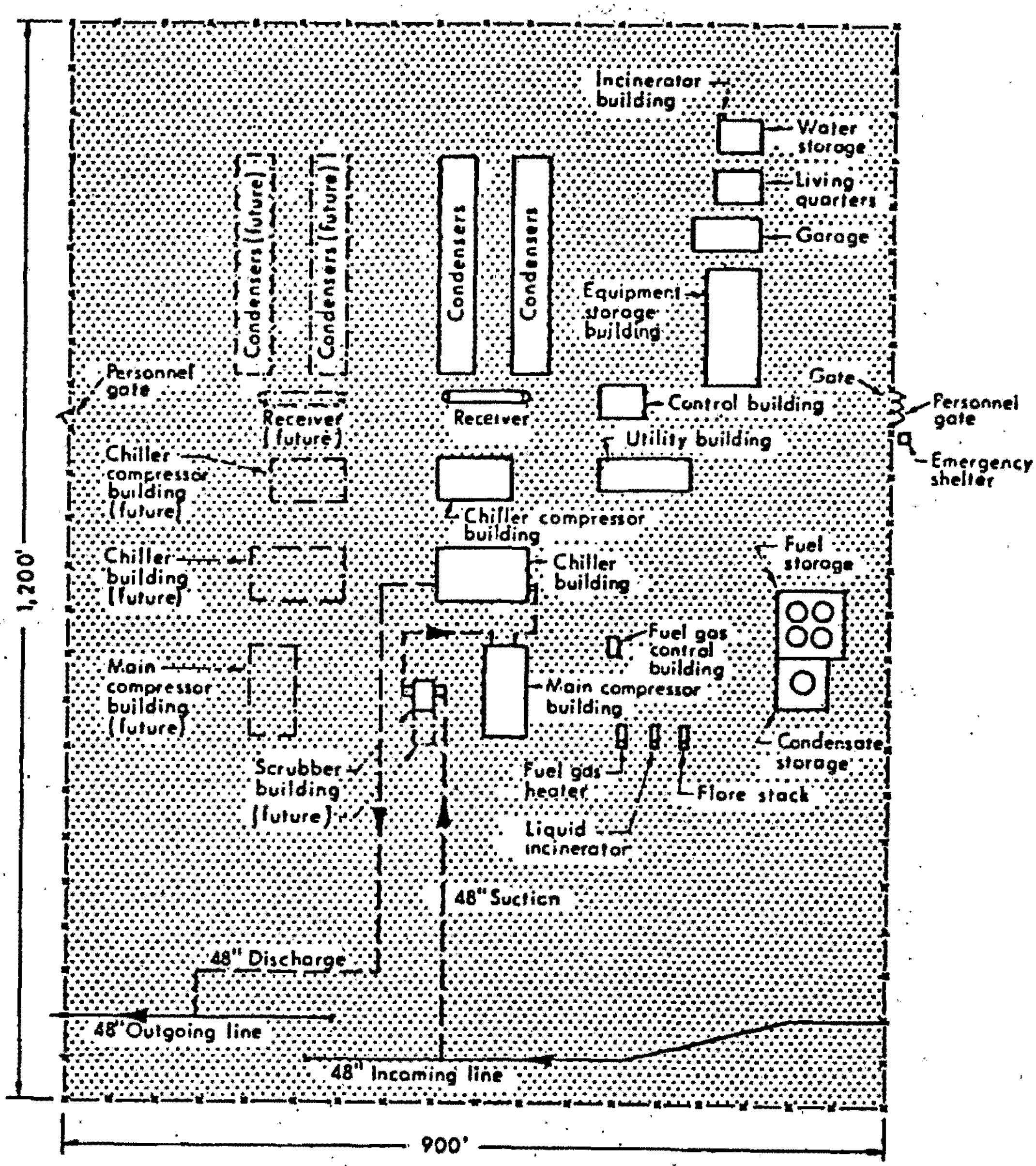


Figure 1.1.1.8-1 Typical compressor station site layout

icing system, and intake and exhaust silencers. The compressor will be equipped with a surge-control system.

c) Gas refrigeration system, installed on the discharge side of the compressor. The major elements of this system will include a turbine driven propane compressor, propane condensers (aerial coolers), a propane receiver, a refrigerant economizer, gas chillers, and a number of ancillary elements.

Generally, all mechanical equipment will be housed in heated buildings. Exceptions to this are the aerial coolers and the propane receiver, which will be constructed on the gravel pad and will not be housed.

3) Ancillary facilities to be incorporated at compressor stations are:

a) Additional electrical generation facilities to be housed in the existing utility building. These will consist of one or more natural gas-fueled turbine prime movers, each connected to an electrical generating unit. At that time, the dual-fuel turbine-generator, which is proposed for each maintenance site, would become the standby unit to be powered by a liquid fuel in cases of an emergency in which natural gas became unavailable.

b) Enlarged natural gas-fueled heating system, which in cases of emergencies would automatically switch over to liquid fuels.

c) Condensate storage facilities, located next to the existing fuel storage facilities.

d) Various additional piping associated with the installation of compression, chilling, and additional ancillary facilities.

e) A venting system for the gases. During a normal shutdown, the gas [about 200 Mcf (thousand cubic feet)] in the main gas piping between the block valve and the compressor will be vented to the atmosphere unburned. During a station emergency shutdown, the gas (about 3,750 Mcf) in the piping inside of the station block-valve will be vented in the same manner. The propane system will not be depressurized during normal shutdowns. During maintenance operation, only a portion of the system will have to be vented. Upon detection of fire in the propane compressor building, the propane between the compressor block-valves would be vented automatically. In all cases, the propane would be vented to a flare system (see item f below).

f) A closed flare and drain system. This system will be provided to dispose of all liquids removed from the main-gas and fuel-gas scrubbers, as well as the vapors vented from the propane system. Vapors will be flared directly into a hydrocarbon burner. Liquids will be drained into a condensate storage tank, then either burned or placed in portable containers for subsequent disposal.

g) Enlarged waste-disposal facilities to accommodate the expected increase in wastes. Generally, sewage wastes will be piped into two 190,000 U.S. gallon sewage lagoons and retained for 1 year before being released. (See discussion in Section 1.1.1.7.) Combustible compressor and equipment wastes will be flared. Organic solids, combustible solids, and industrial wastes will be burned in a high-temperature incinerator. Ash and noncombustible wastes will be buried.

The Applicant believes it should be possible to put a future compressor station into operation with little, if any, interruption in the gas flow.

The Applicant states that the "estimated sound pressure levels associated with a planned typical compressor station with standard silencing equipment installed are as follows: at the boundary of the compressor station, 66 to 71 dBA; 500 feet from the station, 59 to 61 dBA; 1000 feet from the station, 55 to 56 dBA; 1500 feet away from the station, 53 dBA; and 2000 feet away from the station, 50 dBA. The Applicant further states that these levels will result in an increase over existing levels which will range "from as high as 40 dB at the compressor station boundary to 24 dB at 2,000 feet."

Most station emissions will be from three main sources: (a) the main gas turbine, (b) the refrigeration compressor turbine, and (c) the electrical generation turbine(s). These turbines will burn natural gas, and the exhaust will contain mainly nitrogen, oxygen, carbon dioxide, water vapor, and small quantities of nitrogen oxides, oxides of sulfur, carbon monoxide, and unburned hydrocarbons. With a compressor station emitting approximately 1.8 million pounds of exhaust per hour, the expected rates would be:

Nitrogen oxides, NO_X - (primarily NO) - 14 to 50 grams/second

Carbon monoxide, CO - 1.1 to 1.4 grams/second

Sulfur dioxide, SO_2 - 0.3 gram/second

Unburned hydrocarbons - 0.4 gram/second

The Applicant calculates the resulting ground level concentration of SO_2 to be less than 0.0008 ppm. In addition, 7,200 gallons of water per hour will be emitted as vapor from the exhaust stacks.

1.1.1.9 Actions Involved

The scope of some of the obvious Federal and State actions required for the Applicant to acquire permits prior to construction activities are discussed. The actions listed are not intended to be all-inclusive but are herein stated as examples of required permit actions to be conducted by the Applicant. It is noted that any permit granted will require that Applicant comply with all applicable laws, rules, and regulations.

Several Federal actions are required before the proposed AAGPC pipeline system can be constructed in Alaska. In addition, the Applicant will need to obtain permits from the State of Alaska.

Federal Action

Several actions will be required prior to the issuance of a Certificate of Public Necessity by the Federal Power Commission and a right-of-way permit by the Department of the Interior.

The existing Arctic National Wildlife Range was established in 1960, "For the purpose of preserving unique wildlife, wilderness and recreational values..." The proposed AAGPC pipeline system involves Federal actions under various legislative and administrative authorities affecting land use decisions on the Range. These include recommendations of the Department on

December 18, 1973, to the President and the Congress that the existing Arctic National Wildlife Range be enlarged.

Several bills were introduced in the Congress at the request of the Department of the Interior and national conservation organizations at that time. Although there are differences on the recommended size of the Arctic National Wildlife Refuge that would be established, all bills include the area requested by the Applicant for the proposed AAGPC pipeline system. The recommendations of the Department to enlarge the existing Range were made under the provisions of Section 17, Alaska Native Claims Settlement Act. The Congress has not taken action on these recommendations. The Alaska Native Claims Settlement Act also provides that Federal lands recommended for inclusion in the National Wildlife Refuge System remain in a protected status until December 18, 1978, unless the Congress decides their ultimate status earlier.

The existing Arctic National Wildlife Range is subject to the provisions of the National Wilderness Act of 1964 (78 Stat. 890). That Act directed that certain federally administered areas be studied to determine their suitability for inclusion in the National Wilderness Preservation System. The Arctic National Wildlife Range met the requirements for study as established by the Congress and in 1972 the U.S. Fish and Wildlife Service concluded that the Range, with some exceptions along the seacoast, qualified for inclusion in the National Wilderness Preservation System. The exceptions were: 456 acres at Camden Bay, 420 acres at Beaufort Lagoon; 4,500 acres withdrawn at Barter Island for military use; 141-acre townsite at the village of Kaktovik; and, all lands selected by the villagers of Kaktovik under the provisions of the Alaska Native Claims Settlement Act. It should be noted that most bills to enlarge the existing Range also provided for wilderness suitability studies and recommendations to the President and the Congress on whether the lands should be included in the National Wilderness Preservation System.

Certificate of Public Convenience and Necessity

The Applicant proposes to construct and operate a natural gas pipeline and to transport natural gas in interstate commerce. Accordingly, Alaskan Arctic Gas Pipeline Company filed an application with the Federal Power Commission on March 21, 1974. Prior to start of construction of the proposed AAGPC pipeline system, the Applicant must obtain, from the Federal Power Commission, a certificate of public convenience and necessity pursuant to Section 7(c) of the Natural Gas Act.

Right-of-Way Permit to Cross Federal Lands

The Applicant proposes to construct and operate a natural gas pipeline system and ancillary facilities (including port sites, airfields, communication towers) on Federal lands in the State of Alaska. All Federal lands desired by the Applicant are situated within the existing Arctic National Wildlife Range. Prior to start of construction of the proposed AAGPC pipeline system, the Applicant must obtain, from the Secretary of the Interior, a right-of-way permit pursuant to Section 28 of the Mineral Leasing Act of 1920, as amended (30 U.S.C. 185) and other applicable provisions of law. Accordingly, AAGPC filed an application with the Department of the Interior in March 1974.

Permit to Construct, Operate, Maintain, and Connect Facilities on an International Boundary

The Applicant proposes to interconnect the AAGPC pipeline system with facilities of Canadian Arctic Gas Pipeline, Limited, (CAGPL) proposed for construction in Canada. Executive Order 10485 requires a Presidential permit to construct, operate, maintain, and connect facilities of AAGPC and CAGPL on the International Boundary between Alaska and the Yukon Territory of Canada so that Alaskan natural gas from the Prudhoe Bay Field can be transported and delivered to the proposed CAGPL pipeline system and subsequently redelivered by the proposed CAGPL pipeline system to the lower 48 states of the United States. AAGPC has filed an application with the Federal Power Commission for this approval to proceed with the proposed pipeline system.

Other Federal Permits and Approval

Numerous permits and approval from other Federal agencies will be required during the planning, construction, operation, maintenance, and repair of the proposed AAGPC pipeline system. The following discussion describes the general nature and scope of actions by other Federal agencies. It is not intended to be all inclusive.

Major actions will be required by the Department of Transportation on pipeline safety. The U.S. Army Corps of Engineers will be responsible for approving construction activities involving navigable waters. The Federal Aviation Administration is responsible for aircraft safety use and for air transportation of hazardous materials. The Department of Labor is responsible for aspects relating to safety and health standards. Actions close to the established military DEW (distant early warning)-line sites would require approval of the Department of Defense.

State of Alaska

The Prudhoe Bay Field is located on lands owned by the State of Alaska. Prior to the construction of the proposed AAGPC pipeline system, the Applicant would need several permits from the State of Alaska. These include, but are not limited to, a right-of-way to cross State lands; permission to use tidelands; permit to appropriate surface water for construction and human uses; approval to cross, use, obstruct or divert rivers, streams, or lakes; and approval of hiring practices, and health and safety precautions for workers.

The State of Alaska retains complete control and ownership of 12-1/2 percent of the natural gas in the Prudhoe Bay Field pool. In addition, the State of Alaska will establish production rates for both oil and gas from the Prudhoe Bay Field pool. This determination will control the volumes of natural gas and schedules for making it available for delivery to the proposed AAGPC pipeline system.

Joint and Complementary Federal-State Actions

Many actions will require joint or complementary actions by Federal agencies and the State of Alaska. These include, but are not limited to, permits for facilities and activities related to air and water quality by the U.S. Environmental Protection Agency and the Alaska Department of Environmental Conservation and actions relating to migratory species of wildlife by the U.S. Fish and Wildlife Service, Department of Commerce, and Alaska Department of Fish and Game.

Local Governmental Actions

The North Slope Borough and the Village of Kaktovik may be involved with the proposed AAGPC pipeline system. Action, if any, required from local government is unknown.

Under the provisions of the Alaska Native Claims Settlement Act, Native corporations were established to select, own, and manage lands and resources. The proposed AAGPC pipeline project may require permits from these and other Alaskan Native Corporations. The extent, if any, is not known at this time since land selections by Alaskan Natives have not been completed. It is possible, however, that the Kemik gas field may pass into Native ownership.

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2 DESCRIPTION OF THE EXISTING ENVIRONMENT

2.1 ARCTIC GAS PIPELINE PROJECT

2.1.1 Alaska Arctic Pipeline

2.1.1.1 Climate

Temperature

The Arctic Slope of Alaska has long, cold winters and short, cool summers, with winter temperatures ranging between -20°F and -60°F, (-28.9°C and -51.1°C) and summer temperatures between 40°F and 75°F (4.4°C and 23.8°C). In summer, a semi-permanent weather front oscillates irregularly between the Brooks Range and the Beaufort Sea. When the front lies north of the coast, it may warm all areas.

The Brooks Range acts as a physical barrier to the mixing of arctic and continental air masses in both summer and winter.

Weather data records are scarce along the Arctic Coast of Alaska. Data have been recorded at Barter Island, which is just off the coast north of the project area, for a period of 22 years. The records show that ambient air temperatures range from 78°F to -59°F (23.8°C to -50.5°C). Weather data for Barter Island are presented in Table 2.1.1.1-1.

Ten-year records at Barter Island show that minimum ambient air temperatures during December, January, and February will be -25°F (-31.6°C) or lower for 52 days. Temperatures at or below -25°F (-316°C) may be expected for 15 days in December, 14 days in January, and 23 days in February (Hastings, 1971 from Namtvedt et al., 1974).

Fragmentary weather data from scattered coastal and inland sites along Alaska's Arctic Coast show that the Arctic Ocean moderates ambient air temperature. Southward and inland toward the Brooks Range, winters are colder and summers somewhat warmer. Figure 2.1.1.1-1 shows average sea surface temperatures in the Arctic Ocean in August.

Information developed by the Applicant shows that the average winter temperature along the proposed pipeline route ranges from -9°F to -12°F (-22.7°C to -24.4°C) and that the average summer temperature is 32°F (0°C) (Table 2.1.1.1-2).

Precipitation

The Arctic Slope area is semi-arid, with annual precipitation ranging between 4 and 10 inches (10.2 and 25.4 cm). Storm paths are present only during summer months. Precipitation is highest in July and August when it generally falls as rain. Snow, however, appears in every month and usually predominates beginning in September. The highest recorded 24-hour snowfall of 17 inches (43.2cm) fell in September 1954 (Table 2.1.1.1-1). Precipitation in the Brooks Range to the south may exceed 40 inches (101.6 cm) per year (Feulner, 1973).

At Barter Island, 22 years of precipitation records show the average annual precipitation is 6.28 inches (16 cm). The average annual snowfall is 46 inches (116.8 cm).

Annual precipitation in the vicinity of the proposed pipeline route generally would not be expected to exceed 20 inches (50.8 cm) and then only

Table 2.1.1.1-1 Barter Island weather data - normals, means, and extremes

Month	Temperatures °F							Normal Degree days Base 65 °F		Precipitation in inches										
	Normal			Extremes						Water equivalent							Snow, ice pellets			
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Heating	Cooling	Normal	Maximum monthly	Year	Minimum Monthly	Year	Maximum in 24 hr	Year	Maximum monthly	Year	Maximum in 24 hr	Year
(a)				25		27					26		26		26		26		26	
J	-8.5	-21.9	-15.2	39	1974	-51	1962	2486	0	0.55	4.08	1962	0.01	1959	2.25	1962	35.0	1962	14.8	1962
F	-13.1	-25.8	-19.5	34	1962	-59	1950	2366	0	0.33	2.53	1955	T	1965	1.22	1955	15.3	1955	3.8	1970
M	-7.5	-21.9	-14.7	36	1967	-51	1973	2471	0	0.26	1.44	1967	T	1974	0.55	1967	15.0	1967	5.5	1967
A	8.2	-8.1	.1	43	1958	-38	1971	1947	0	0.23	1.22	1963	T	1968	0.44	1963	12.2	1963	4.4	1963
M	26.5	15.7	21.1	52	1964	-16	1964	1361	0	0.31	1.51	1967	T	1948	0.76	1954	11.1	1954	7.6	1954
J	38.2	29.9	34.1	67	1961	13	1974	927	0	0.53	2.09	1956	0.06	1969	1.15	1956	9.4	1974	6.7	1974
J	45.5	34.5	40.0	78	1974	24	1973	775	0	1.12	3.01	1971	0.15	1958	1.64	1971	3.0	1974	2.8	1974
A	43.5	34.3	38.9	72	1957	24	1971	809	0	1.28	3.40	1955	0.16	1958	1.11	1955	7.4	1969	3.4	1956
S	35.0	28.1	31.6	64	1950	4	1970	1002	0	0.89	4.91	1954	0.07	1969	2.23	1954	35.8	1954	17.0	1954
O	21.5	11.2	16.4	46	1969	-23	1970	1507	0	0.81	3.62	1954	0.12	1969	1.98	1954	32.1	1954	16.0	1954
N	6.3	-5.9	.2	37	1950	-51	1948	1944	0	0.45	1.50	1950	0.04	1960	0.43	1954	14.9	1950	5.0	1967
D	-6.4	-18.3	-12.4	37	1973	-51	1961	2399	0	0.29	1.17	1949	T	1960	0.55	1949	12.9	1965	5.2	1949
YR	15.8	4.3	10.1	78	Jul 1974	-59	Feb 1950	19994 19994	0 0	7.05	4.91	SEP 1954	T	MAR 1974	2.25	JAN 1962	35.8	SEP 1954	17.0	SEP 1954

#Sun below horizon continuously November 24 to January 17.
Yearly totals of data entered in columns headed "Clear, Partly Cloudy and Cloudy" in both tables are for period sun above horizon.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b (b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

Table 2.1.1.1-1 Continued

Month	Relative humidity pct. Hour 02 (Local time)	Hour 08	Hour 14	Hour 20	Wind: Mean speed m.p.h.	Prevailing direction	Fastest mile: Speed m.p.h.	Direction	Year	Pct. of poss sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days: Sunrise to Sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 in. or more	Snow, ice pellets, 1.0 in. or more	Thunderstorms	Heavy fog, visibility 1/4 mi or less	Temperatures °F Max.: 90° and above	32° and below	Min.: 32° and below	0° and below	Average station pressure mb. Elev 50 feet m.s.l.
(a)	27	27	27	27	25	15	18	18			26	26	26	26	25	26	25	26	27	27	27	27	2
J	69	69	68	68	14.7	W	81	27	1974		#	4	2	8	6	1	0	1	0	31	31	29	1016.8
F	67	68	67	68	14.0	W	62	27	1962		5.3	10	6	12	5	1	0	1	0	28	28	28	1019.3
M	67	67	68	68	13.5	W	77	28	1969		5.5	11	8	12	5	1	0	1	0	31	31	30	1019.2
A	74	74	75	75	12.0	W	52	27	1963		6.0	8	8	14	6	1	0	3	0	29	30	23	1020.2
M	87	87	85	87	12.2	E	55	26	1968		8.2	3	6	22	7	1	*	8	0	24	31	3	1014.4
J	92	90	88	90	11.4	ENE	38	27	1970		7.8	3	7	20	6	1	*	12	0	4	23	0	1011.4
J	93	89	86	89	10.5	ENE	40	25	1963		7.8	3	9	19	9	*	*	15	*	*	9	0	1010.5
A	95	92	88	92	11.6	E	44	27	1969		8.5	1	7	23	11	1	0	16	*	1	11	0	1012.2
S	92	91	88	91	13.2	E	78	27	1957		8.5	2	5	23	10	2	0	10	0	11	25	0	1012.7
O	84	84	84	84	14.5	E	58	27	1963		8.3	2	5	24	13	3	0	4	0	29	31	7	1012.0
N	75	75	75	74	15.0	E	81	26	1970		#	4	4	15	8	2	0	3	0	30	30	20	1013.9
D	69	69	69	69	13.9	E	72	27	1961	#	#	0	0	0	6	1	0	1	0	31	31	29	1012.4
YR	80	79	78	80	13.0	E	81	27	JAN 1974			51	67	192	91	13	*	75	*	249	312	168	1014.6

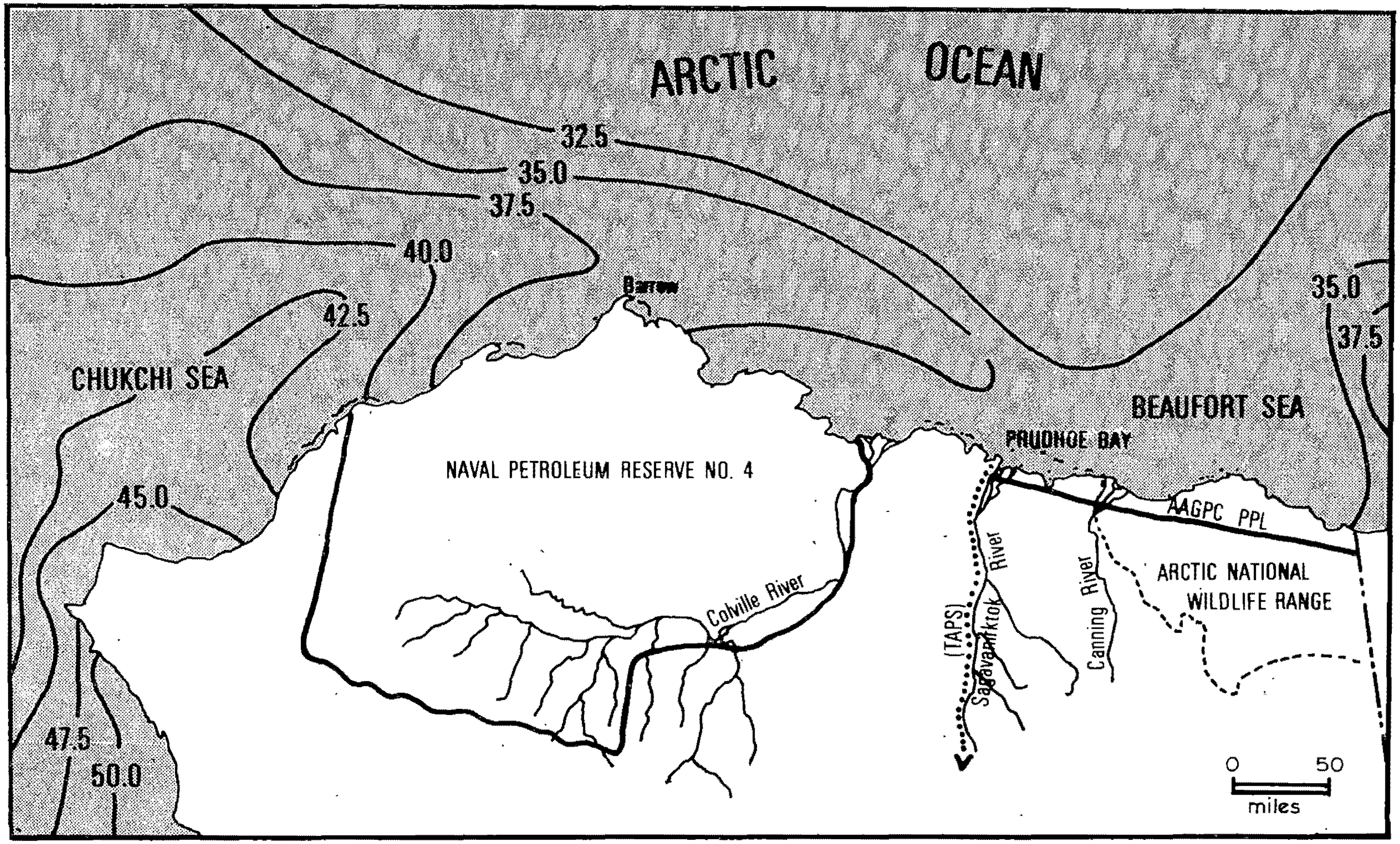


Figure 2.1.1.1-1 Average sea surface temperature for August

to the south on the higher continuous mountain peak areas. (Battelle, 1973a, p. 4)

Approximately half of the total precipitation during the year is received as snow. Figure 2.1.1.1-2 presents the mean annual pattern of snowfall in northeastern Alaska. Although the generalized values presented are believed to be accurate, they do not indicate how much snow is actually on the ground at any one time or location during the winter.

Battelle (1973a) surveyed snow depths along the 62-mile (99.8 km) length of the proposed AAGPC pipeline route between Prudhoe Bay and the Canning River. April 17 and 23, 1973, were selected as survey dates since those were the dates when the snow pack was believed to be at maximum.

Snow pack characteristics of the 62-mile segment were found to depend upon microrelief features such as polygonal structures (see permafrost). Snow depths seldom exceeded 3 feet and were usually much less. Winds are important in the distribution and depth of snow at any specific site; irregular low spots are filled with snow and high spots thinly covered. In many places, vegetation is uncovered.

Average snow depth recorded in the April 1973 survey was 15.1 inches (38.3 cm). Data collected by Battelle at the Prudhoe Bay area between May 8, 1971, and April 3, 1973 show that average snow depths during the winter of those years ranged from 10.3 inches to 13.5 inches. Collected data indicate approximately 2 inches less snow in January. The average snow depth along the proposed AAGPC pipeline route is expected to be less than 13 inches when construction of the snow/ice roads is started.

Battelle (1973a) points out important aspects of the regional snow pack. Extensive areas have vegetation protruding through the snow; drifts into streambanks are affected by the orientation of the drainage to the wind direction. Larger drainages such as the Canning often lack snow cover next to the mountain. Stream side vegetation, especially shrubby willows, encourages increased snow depths; such depths may be more than 3 feet.

The Applicant has not provided data on snow depths on the segment of the proposed AAGPC pipeline in the Arctic National Wildlife Range (which contains more than 70 percent of the system).

Winds

Surface winds along the Arctic Coast are persistent in direction and velocity. Along the Alaskan arctic coastal zone, winds average between 15 and 59 mph. The highest winds occur in the period from November through March. Wind velocities reached 81 mph at Barter Island in November 1970. Prevailing winds are from the northeast but most high winds (in excess of 40 mph) are from the west (Figure 2.1.1.1-3).

Surface wind, especially on exposed knobs and in river valleys where winds are funneled through mountain passes, picks up fine materials which can abrade succulent plants and obscure visibility.

Onshore winds along the Arctic Coast occasionally push the icepack to shore when the coast would otherwise be ice free. Table 2.1.1.1-3 shows that winds 25 mph or greater may be expected at Barrow on 72 days annually.

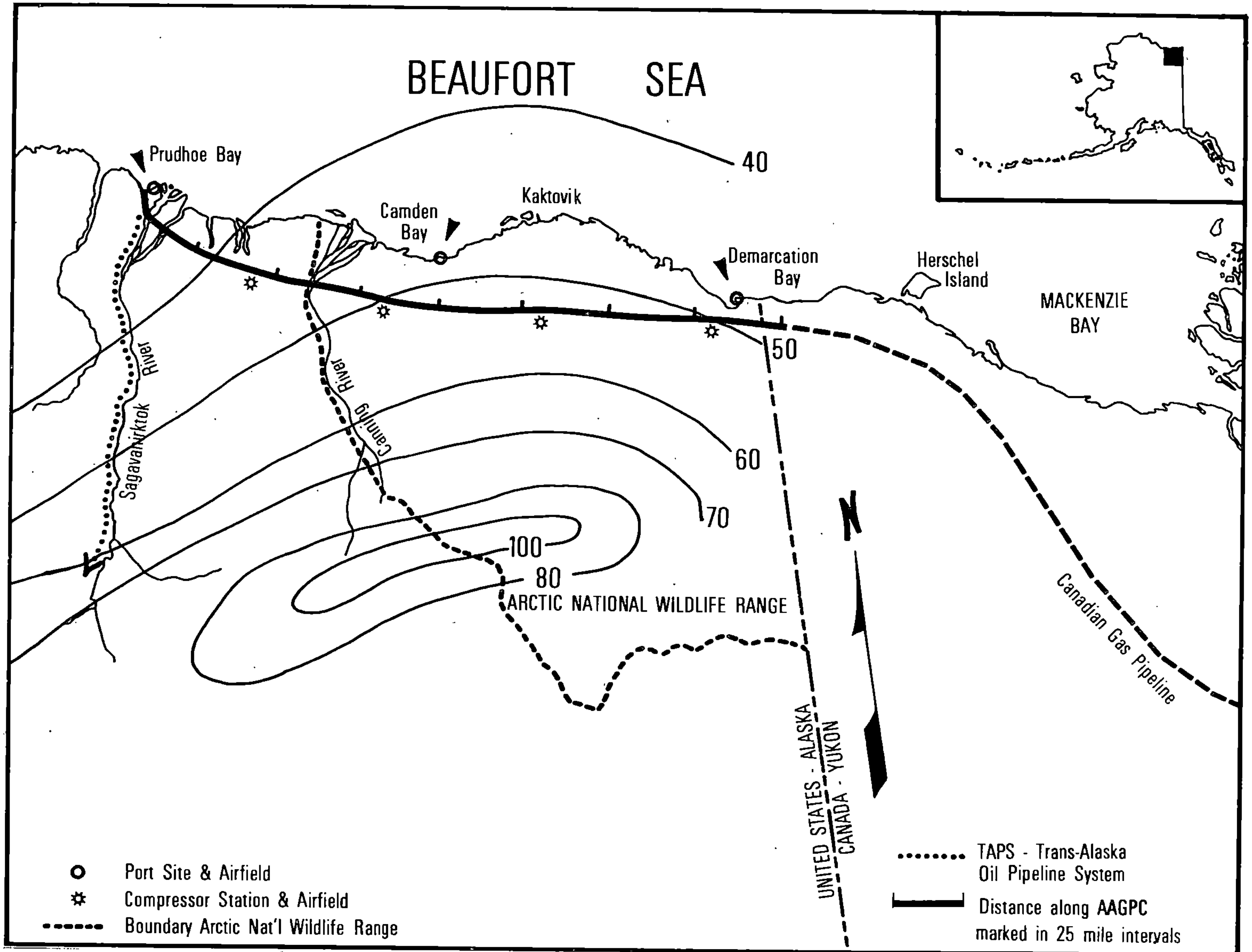


Figure 2.1.1.1-2 Mean annual snowfall in the vicinity of the proposed AAGPC pipeline

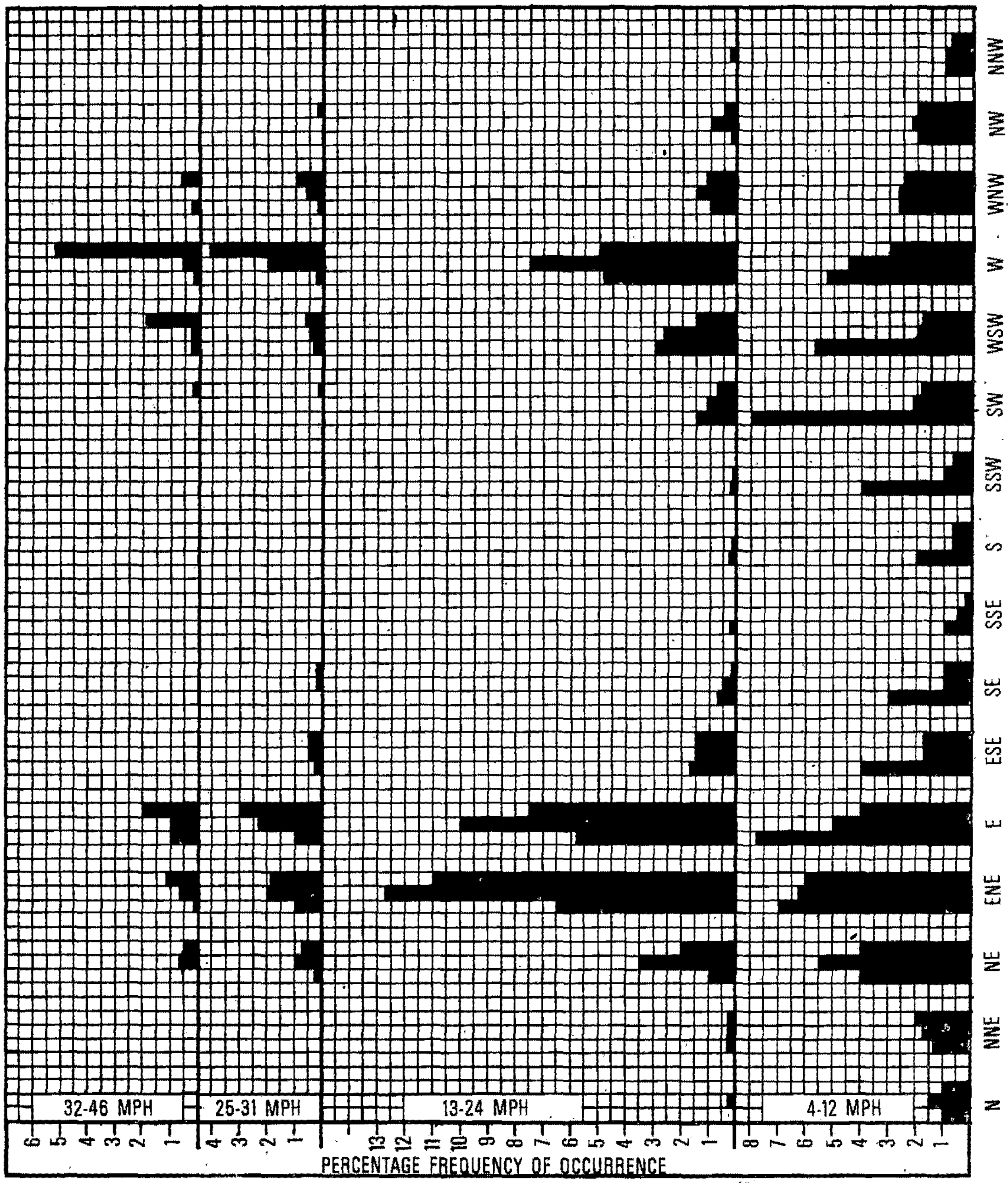


Figure 2.1.1.1-3 Surface wind speed, frequency, and direction, Easter Island

Micrometeorological Conditions

Ice fog is peculiar to arctic and subarctic regions. The water in an ice fog is frozen. Ice fog is not considered to be harmful to the natural environment, but may restrict human activities because of limited visibility. For ice fog to form, large quantities of water vapour, along with temperatures below -22°F are required. Between temperatures of -22°F and -40°F, an abundance of nuclei are also required for the ice particles to form around. Below -40°F, the formation of ice particles is spontaneous and does not require the aid of nuclei.

The quantity of water vapor in the station exhaust gases will probably be enough to form ice fog provided atmospheric conditions are right. In areas where ice fog is a problem, such as Fairbanks, Alaska, there is an abundance of unburned hydrocarbons and particulate matter in the atmosphere which originate from automobile exhausts and several coal burning plants in the area. With natural gas as the turbine fuel, if no other contaminants are present in the atmosphere, it is possible that not enough nuclei will be present to form ice fog at temperatures above -40°F. This appears to be the case with existing compressor stations in western Canada where ice fogs are not common during these temperatures.

At temperatures below -40°F, the density and thickness of the ice fog will be dependent on the terrain and the degree of stability of the atmosphere. It is possible that even during temperatures below -40°F, the density of the ice fog will not be high enough to seriously limit visibility.

Ice fog is not restricted to urban areas. Hot springs, cooling ponds, and construction equipment all are adequate sources of vapor. The latter also emit particulate matter. Without dissipating winds, ice fog often is confined to narrow stretches, or patches, along highways and around industrial plants. It remains in situ until the inversion lifts.

During warm months, fog frequently reduces visibility. At Barter Island, fog may be expected at least 74 days each year.

Low visibility conditions are frequent along the Arctic Coast. At Barter Island for an average of 118 days a year, visibility is reduced to one mile or less by natural causes other than darkness. The distribution of these days by month is shown in Table 2.1.1.1-4.

During a 4- to 5-week period in December and January, low visibility on the Arctic Slope makes flying more hazardous than usual. High winds, blowing snow, and darkness combine to create hazardous conditions. Despite these conditions several daily flights from Anchorage and Fairbanks usually make their schedule to Deadhorse airport.

Sunlight

There is a total lack of direct sunlight in the winter months (55 days at Barter Island) during which diurnal temperatures range from 12°F to 15°F (-11.1°C to -9.4°C). It is during this winter period that the Applicant proposes to initiate and complete major construction elements of the pipeline system.

Table 2.1.1.1-2 Temperature ranges at compressor station locations, Alaska

Mile Post	Elevation	Winter	Summer	Jan.	April	July	Oct.
43.4	150 ft. (45.7m)	-12°F (-24.4°C)	+32°F (0°C)	-19°F (-28.3°C)	0°F (-17.7°C)	+45°F (7.2°C)	+15°F (-9.4°C)
83.0	690 ft. (210.3m)	-10°F (-23.3°C)	+32°F (0°C)	-17°F (27.2°C)	+1°F (-17.2°C)	-43°F (6.1°C)	+15°F (-9.4°C)
129.2	510 ft. (155.4m)	-9°F (-22.7°F)	+32°F (0°C)	-16°F (-26.6°C)	+3°F (-16.1°C)	+42°F (5.5°C)	+17°F (-8.3°C)
176.0	290 ft. (88.4m)	-9°F (-22.7°F)	+32°F (0°F)	-15°F (-26.1°F)	+1°F (-17.2°F)	+43°F (6.1°C)	+17°F (-8.3°C)

Table 2.1.1.1-3 Average number of days when wind speed equals or exceeds 25 mph at Barrow, Alaska

Barrow -	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
No. Days	6	5	4	6	3	4	5	7	5	7	13	7

(Hastings 1971, from Namtvedt et al. 1974, p. 137)

Table 2.1.1.1-4 Average number of days at Barter Island, Alaska, when horizontal visibility is restricted to 1 mile or less by natural causes other than darkness

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Average Number of Days	10	13	9	7	7	9	12	15	12	7	9	8

(Hastings 1971, from Namtvedt et. al. 1974, p. 137)

Sea Ice

Sea ice is a dominant feature in the Beaufort Sea for 7 to 9 months of the year. During the open-water (summer) season, fast ice, which is relatively immobile ice attached to the coast, breaks up, and the polar pack ice moves offshore to the north. The polar pack ice may remain quite close to the Beaufort Sea shoreline or even against it during periods of high northerly winds.

In the years of maximum sea ice retreat, the polar pack lies only 30 to 40 miles (48.3 to 64.4 km) north of the Beaufort Sea coast. The distance the polar ice pack moves offshore varies greatly and severely impedes shipping in the Beaufort Sea (Figure 2.1.1.1-4). Dates of ice breakup and freezeup in the Beaufort Sea are quite variable at Barter Island. The earliest recorded freezeup was September 20 and the latest, October 25 (average October 5). The earliest breakup was on July 22, the latest, August 4 (average July 7 to 28) at Barter Island (Table 2.1.1.1-5). Generally, the shoreline is icefree for fewer than 3 months (Namtvedt et al., 1974).

The seasonal freeze-thaw cycle controls the development and dissipation of sea ice in northern Alaska. The normal cycle begins with the formation of river and sea ice during late September when mean air temperatures fall below freezing. By the end of December, when mean temperatures are well below -4°F (-20°C), ice is commonly more than 3.3 feet (1 m) thick. Ice continues to thicken, reaching a maximum of about 6.6 feet (2 m) in May, when melting starts.

Twenty-four hours of sunshine aid rapid thawing during late May and early June. Melting is accelerated when river water begins to flow over the river and sea ice. The flood of fresh water may exceed 3 feet (1m) in depth on the sea ice and ultimately drains through cracks and holes in the sea ice called strudel (Reimnitz and others, 1974). See 2.1.1.3 for additional discussion on strudel. The sea ice along the coast continues to melt during June and much of July, usually resulting in a lead of open water 33 to 164 feet (10 to 50 m) wide off the coastal and insular beaches (Short 1973). Most of the lagoonal ice and ice inside the 33 foot (10 m) contour melts with little or no lateral movement. Off rivers, this melt lead can be 16 to 24 miles (10 to 15 km) in width with the influx of warm river water. Sometime late in July the remaining sea ice breaks up and moves offshore. The cycle is completed during the rest of the summer season--August and early September--when temperatures are above freezing and remaining ice continues to melt.

Sea ice in the Beaufort Sea may be divided into three broad categories: (1) the seasonal fast ice along the coast; (2) a brecciated shear line and associated shear zone that marks the seaward boundary of the fast ice; and (3) the multiyear polar pack ice seaward of the shear zone.

The fast ice zone is composed mostly of seasonal ice which can be thought of as an extension of the land (Kovacs and Mellor, 1974). Typically, fast ice reaches a thickness of about 6 1/2 feet (2 m) by May and, depending on the coastal configuration, extends out to the 33 to 66 foot (10 to 20 m) depth contour. This zone is essentially immobile during the winter, with few topographic irregularities that can be ascribed to deformation or to the inclusion of larger blocks of older ice from the previous summer. By the end of winter the ice inside the 6.6 foot (2 m) depth contour rests on the bottom. As the seas oscillate vertically with astronomical and meteorologic tides while downward adfreezing continues, the fast ice is elevated inshore of the 6.6 foot (2 m) contour and often contains layers of sediment (Barnes and Reimnitz, 1974).

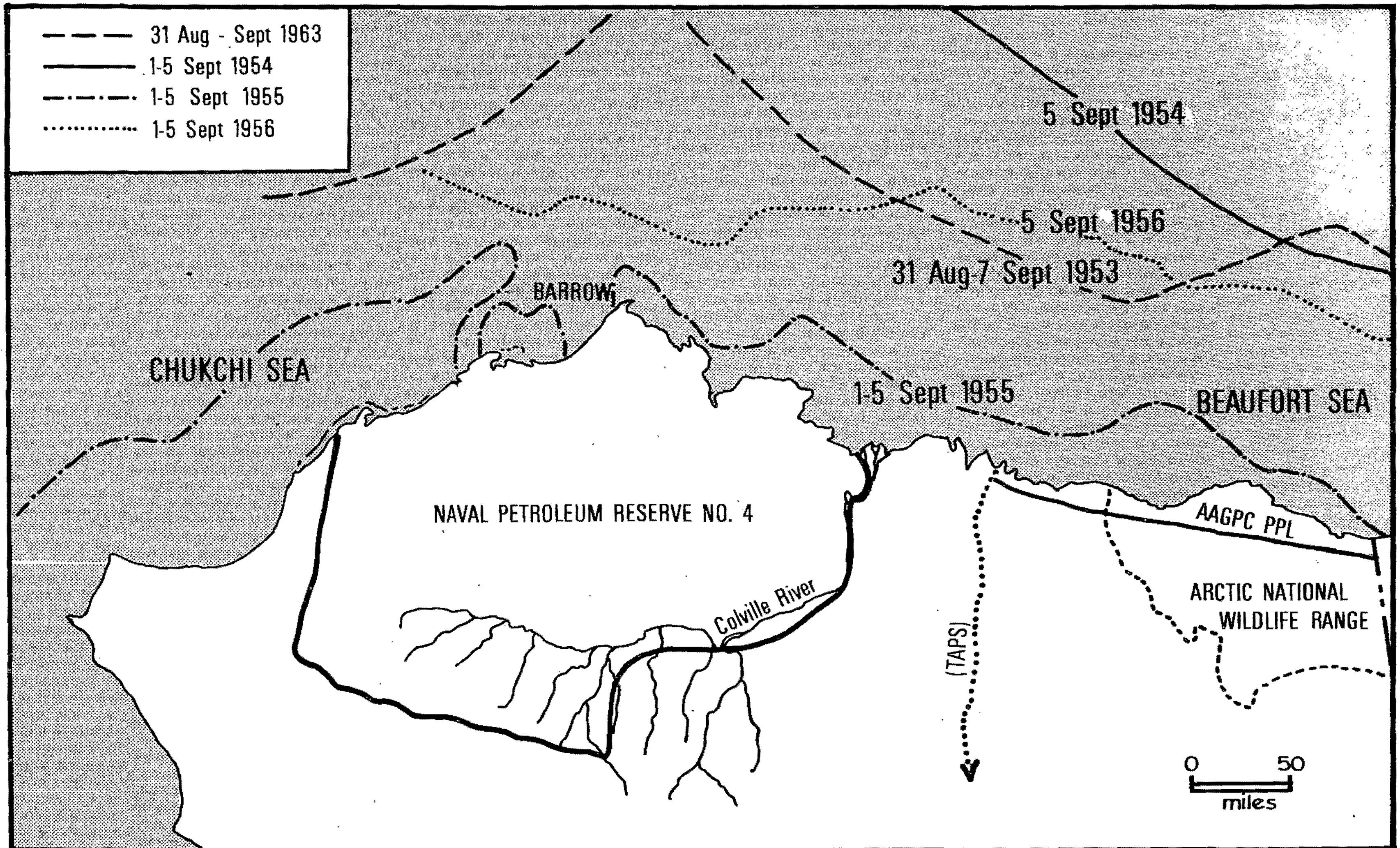


Figure 2.1.1.1-4 Comparison of polar ice pack boundaries for selected years

Table 2.1.1.1-5 Freezeup and breakup dates for the Chukchi and Beaufort Seas at selected coastal stations

FREEZEUP ON CHUKCHI AND BEAUFORT SEAS

Station	Earliest	Latest	Average	Yrs. Data
Point Hope	Oct. 6	Dec. 1	Oct. 25-29	6
Point Lay	Oct. 15	Nov. 27	Nov. 7-11	4
Wainwright	Sept. 16	Oct. 25	Oct. 3-7	8
Point Barrow	Sept. 3	Dec. 19	Oct. 1-5	26
Barter Island	Sept. 20	Oct. 25	Oct. 5	6

BREAKUP ON CHUKCHI AND BEAUFORT SEAS

Station	Earliest	Latest	Average	Yrs. Data
Point Hope	May 30	Jul. 2	Jun. 10-16	5
Point Lay	May 20	Jul. 9	Jun. 11-17	3
Wainwright	Jun. 7	Jul. 26	Jun. 23-29	3
Point Barrow	Jun. 15	Aug. 22	Jul. 17-23	24
Barter Island	Jul. 22	Aug. 4	Jul. 7-28	4

The boundary between the stationary fast ice and the mobile pack ice is marked by the shear line oriented parallel to the coast along the 33 to 65 foot (10 to 20 m) depth contour. Seaward of this boundary, shear ridges and pressure ridges develop in response to the impingement of moving ice against the fast ice, forming a shear zone up to 12.5 miles (20 km) wide (Kovacs and Mellor, 1974).

The polar pack ice consists of multiyear ice floes 6.6 to 13.2 feet (2 to 4 m) thick and pressure ridges with keels to 154 feet (47 m) (Weeks et al., 1971). As a result of wind stresses, the general drift of the ice is westward in the southern part of the clockwise Pacific Gyre (Campbell, 1965).

During the summer, ice conditions are controlled by local winds. The polar pack edge is usually 12.4 to 37.2 miles (20 to 60 km) from the coast, although still inshore of the shelf break (U.S. Navy Hydrographic Office, 1958). Under the influence of westerly winds, the Eckman drift forces the ice and water onshore. When these conditions are severe, sea level is raised as much as 10 feet (3 m), submerging the offshore islands and stranding ice on both the beaches and barrier islands (Reimnitz et al., 1972). Conversely, easterly winds move water and ice offshore, resulting in lowering of sea level by as much as 3.3 feet (1 m). In the absence of an influencing wind, scattered drifting and grounded ice are a common sight inshore of the pack ice boundary. The presence of the pack ice reduces the wind fetch and limits the development of waves during the summer so that seas higher than 3.3 feet (1 m) are rare (Wiseman et al., 1973).

2.1.1.2 Topography

The proposed AAGPC pipeline is to be entirely on the North Slope of Alaska. On the basis of major topographic and geologic features, Wahrhaftig (1965) divided the North Slope into the Arctic Coastal Plain and Arctic Foothills. The Arctic Coastal Plain grades imperceptibly into the Arctic Foothills as elevation and distance from the coast increases. Elevations range from sea level at Prudhoe, Camden, and Demarcation Bays to an estimated 825 feet at M.P. 85 and M.P. 92 within the Arctic National Wildlife Range. The general line used to separate these two physiographic provinces is the 600 foot contour interval. Although the bulk of the proposed AAGPC pipeline system is at or below the 600-foot elevation, most of the topography on the proposed route across the Arctic National Wildlife Range is more typical of the Arctic Foothills province than the Coastal Plain. Figure 2.1.1.2-1 shows the general demarcation of the two provinces and the proposed pipeline.

Information submitted by the Applicant indicates approximately 90 percent of the slopes traversed by the proposed pipeline route are less than 3°. The proposed routing involves at least 56 places in Alaska where the slopes range from 3° to 9° +. Most of the steeper slopes are near stream crossings and locally may approach 20°.

<u>Arctic Coastal Plain</u>

The first 62 miles of the proposed AAGPC route cross terrain that is typical of the Arctic Coastal Plain, which is flat and treeless; its topography rises imperceptibly from the Beaufort Sea to a maximum elevation of 600 feet (182.9 m) at its southern margin. The coastline makes a very small break in the profile of the coastal plain and shelf, and the shore is generally only 1 to 10 feet (0.3-3 m) above the ocean; the highest coastal cliffs generally rise no more than 50 feet (15.2 m) above the sea. Locally,

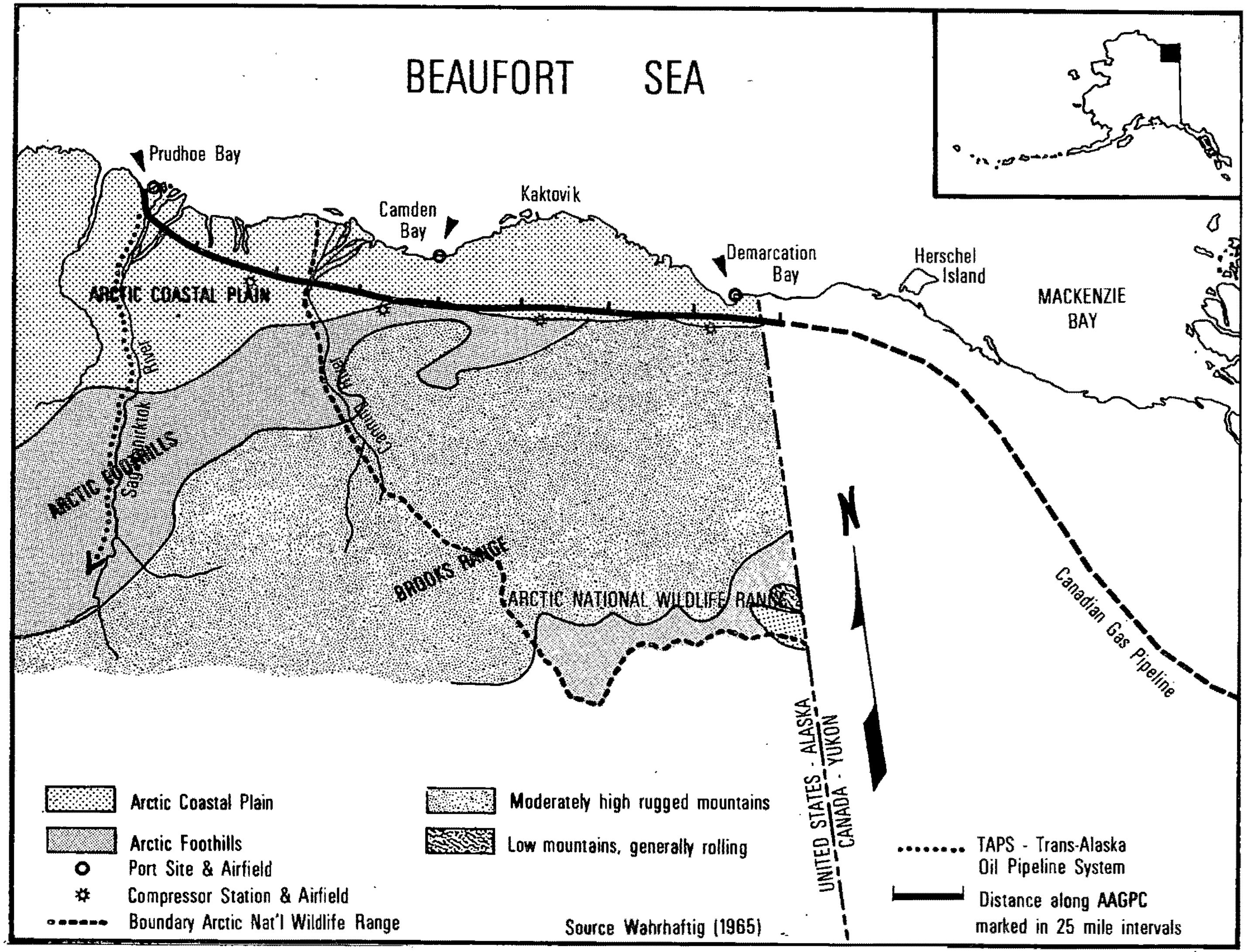


Figure 2.1.1.2-1 Physiographic divisions associated with the AAGPC pipeline system, Alaska

an abrupt scarp 50 to 200 feet (15.2-61 m) high separates the coastal plain from the Arctic Foothills. In some places, pingos (ice-cored hills) are sufficiently numerous to form an undulatory skyline. The coastal plain just west of the delta of the Sagavanirktok River has scattered longitudinal sand dunes.

The Arctic Coastal Plain is poorly drained, and consequently, is marshy in summer. It is crossed by northward-flowing rivers whose headwaters are in highlands to the south. A large portion of the plain is covered by elongated thaw lakes oriented approximately N. 15°W.; the lakes range from a few hundred feet to 9 miles long, are from 2 to 20 feet deep, and generally are oval or rectangular in shape. They often expand about 3 feet (1m) per year on the windward shore in places. Several generations of drained lake basins are present.

The entire Arctic Coastal Plain is underlain by continuous permafrost. A honeycomb of ice-wedge polygons covers most of the coastal plain and produces local microrelief of up to 2 feet. Because these ice wedges extend local topography above standing water, distinctive plant communities tend to be associated with the raised portions of the polygons.

Arctic Foothills

The 55-mile-long intermediate segment (M.P. 62 to M.P. 117) of the proposed AAGPC route crosses the northern edge of the Arctic Foothills. The province is characterized by rolling plateaus and linear mountains with intervening flat to gently undulating plains. The foothills are crossed by rivers flowing north from sources in the Brooks Range. Most streams have swift, braided courses across broad gravel flats that are locally covered in winter with extensive sheets of aufeis that freeze to the streambeds; this filling of the channels causes the streams to flood their gravel flats. A few thaw lakes are present in the river valleys and on some divides. The upper valleys of major rivers from the Brooks Range contain many morainal lakes; however, there are no glaciers. The entire province is underlain by continuous permafrost. Ice wedges, stone stripes, polygonal ground, pingos, and other features of a frost climate are common.

The last 80 miles of the proposed route technically fall within the Arctic Coastal Plain, according to Wahrhaftig (1965). The terrain and vegetation are not typical of the coastal plain except that they lie at elevations below 600 feet. This segment is more closely related to the drier Arctic Foothills than the Arctic Coastal Plain.

2.1.1.3 Geology

Lithology

Bedrock along the portion of the pipeline route through the Arctic Coastal Plain is overlain by 10 or more feet of unconsolidated Quaternary marine, and locally terrestrial, sediments consisting of pebbly sandy silt, silty sand, and sandy gravel. Fine-grained sediments generally mantle the surface. The underlying bedrock is nearly flat-lying to gently folded Tertiary and Cretaceous sedimentary rocks, ranging from mudstones to conglomerates (generally poorly indurated).

The bedrock units mentioned above extend into the Arctic Foothills, but have been folded into east-west trending anticlines and synclines. Where the proposed AAGPC pipeline would cross the Foothills, the bedrock is generally covered by more than 10 feet of surficial deposits which, in most part, are fine grained and range from organic-rich silt in depressions to gravelly silt on some of the upland surfaces. The larger stream valleys are underlain by sandy gravel. Preliminary soil test holes by the Applicant indicate bedrock is found at a depth of 7.5 to 14.5 feet in the vicinity of M.P. 87 and at 7 feet near M.P. 94. The Applicant estimates that approximately 5.1 percent of the pipeline route (10 miles) is located in areas where bedrock is no deeper than 10 feet. The U.S. Geological Survey (1974) indicated that bedrock is exposed in the vicinity of the proposed crossing of the Katakturuk River (M.P. 87). This outcrop is poorly indurated clayey silt with a few sandy and pebble-gravel beds capped by a conglomerate, which has weathered to a lag gravel at the surface. Locally, these deposits are very unstable, and mud-flows form at the bases of the valley walls. Similar bedrock probably is present locally at shallow depths along the proposed pipeline route elsewhere through the foothills.

Bedrock is not exposed along the easternmost segment of the proposed pipeline route between M.P. 117 and 197. The western half of this segment is generally underlain by gravelly silt (glacial till), with local depressions filled with organic-rich silt. The larger stream valleys are underlain by sandy gravel. The eastern half of this segment is generally underlain by medium- to coarse-grained sandy gravel forming broad coalescent alluvial fans. A few areas between fans are underlain by fine-grained deposits.

Mineral Resources

Petroleum

The entire Alaskan North Slope has large petroleum deposits. They are being explored and exploited in an intensive program of development.

Known Reserves

Prudhoe Bay Field (Sadlerochit Formation) (Figure 2.1.1.3-1)--Oil was discovered at the Prudhoe Bay field in July 1968. It is the first commercial oil discovery in Alaska since the southern Alaska Cook Inlet (in 1958) and Gulf Coast (at Katalla in 1901) regions. Estimated pool reserves are approximately 10 billion barrels of oil and 22.5 trillion cubic feet of natural gas. Prudhoe Bay is the largest oil pool ever discovered on the North American continent.

About 80 wells have been completed in the Prudhoe Field. Actual crude oil production awaits completion of the Alyeska oil pipeline in mid-1977.

The natural gas produced along with the crude oil will be separated, compressed, and injected back into the producing reservoir. If a gas transmission system is available, the gas will be transported to consumer markets.

Construction of the Prudhoe to Valdez oil pipeline has generated drilling activity in the Prudhoe Bay area, both developmental and exploratory. By the end of March, 1975, two significant well completions have probably added to the known reserves of the Prudhoe Bay Field. One well, drilled within the areal limits of the Prudhoe Bay Field, was directionally drilled from land to an offshore bottom-hole location under the Beaufort Sea. This well tested 1,350 BOPD (barrels oil per day) and 7,000 MCF of gas per day from the Lisburne formation. The Lisburne limestone underlies the main producing formation in the Prudhoe Bay Field (the Sadlerochit sandstone reservoir). Although reserves of oil and gas contained in the Lisburne limestone cannot be calculated on the basis of information from one well, the operator of the well believes that the Lisburne "contains significant quantities of hydrocarbons." If the additional exploratory wells planned during the spring of 1975 to develop the Lisburne are successful, a new dimension will be added to the proven reserves of oil and gas in the Prudhoe Bay area.

Another well, also within the areal limits of the Prudhoe Bay Field, but about 6 miles north of the nearest development well, successfully extended the productive capability of the Sadlerochit sandstone reservoir. In March, 1975, the well was cased off as it passed through the Sadlerochit sandstone reservoir and was drilled to an increased depth to test the Lisburne formation.

These wells are significant in that both the trans-Alaska oil pipeline system and the proposed AAGPC pipeline system for natural gas are basically designed to transport the previously "proven" reserves of oil and gas from the Prudhoe Bay Field.

Kemik Field--This field is identified by the petroleum industry as a gas field. One well was completed in 1969 as a gas well and is shut-in. A confirmation well was drilled in March 1975. A third well is planned. Information on estimated reserves is unavailable. The location of this gas field is close to the Applicant's proposed gas pipeline.

Kavik Field--This field also is identified as a gas field, with two wells drilled and completed as gas wells. Both wells are shut-in and, as with the Kemik field, no information is available on gas reserve estimates. The location of this gas field also is close to the Applicant's proposed gas pipeline.

Potential Reserves

Marsh Creek Anticline--A potential oil and gas field of very large accumulation is believed to be located beneath the coastal plain just south of Camden Bay and near the mouths of Carter and Marsh Creeks.

This geologic structure, known as the Marsh Creek anticline, has a visible 40-square-mile (103.6 sq. km) uplift. The potential oil-bearing structure is 46 miles (74 km) long and covers a surface area of approximately 150,000 acres (234.4 sq. mi). At least four geologic formations are projected as capable of holding petroleum reserves, including the Sadlerochit and Lisburne formations, and are comparable to zones with proven oil and gas reserves in the Prudhoe Bay Field.

No exploratory wells have been drilled because drilling activities have not been permitted within the boundaries of the Arctic National Wildlife Range. Geologic information collected outside the Range, however, suggests there is high oil and gas potential in the Marsh Creek anticline. The Marsh Creek anticline is close to the Applicant's proposed gas pipeline.

Beaufort Sea Province--Petroleum exploration activities along the Alaskan North Slope have not yet advanced to the stage of drilling offshore structures in the Beaufort Sea. The basic geologic elements necessary for petroleum accumulation and entrapment exist in the offshore Beaufort Sea area. The onshore oil and gas fields provide a basis for optimism regarding the petroleum potential based upon the total volume of sedimentary rock underlying the Beaufort Sea which often is associated with oil and gas deposits; the Alaska State Geological and Geophysical Survey (Open File Report #50) made estimates of 2.7 billion barrels of oil and 13.5 trillion cubic feet of gas as possible petroleum reserves within the Beaufort Province.

Coal

The potential for discovery of additional coal deposits is thought to be good although this area has been largely unexplored (Figure 2.1.1.3-2).

Geothermal

The only known geothermal resource potential along the Applicant's proposed gas pipeline route lies within the Arctic National Wildlife Range. Two areas constituting approximately 46,000 acres (71.9 sq. mi) within the Range have been identified by the Geological Survey as having potential for geothermal resources. These are located at the Shublik and Sadlerochit warm springs in the Sadlerochit Mountains. Knowledge is inadequate to evaluate the area's potential commercial value, but the Geothermal Steam Act of 1970 (84 Stat. 1566) prohibits issuance of geothermal leases within wildlife refuges or ranges.

For additional discussion of these springs, see fisheries and unique areas (2.1.1.7 and 2.1.1.12, respectively).

Metals

No mineral deposits are known to occur along the low coastal plain area crossed by the Applicant's proposed gas pipeline route (Bottge, 1974). There is high to good potential that metallic mineral deposits occur within the foothills and mountainous areas just south of the route.

Copper mineralization is associated with a lower Paleozoic volcanic and carbonate sequence in the Shublik Mountains. Similar volcanic rocks with reported associated copper mineralization occurs in the Sadlerochit Mountains. Volcanics that are probably equivalent in age are extensively exposed to the east in the Demarcation Point quadrangle. U.S.G.S. studies within the Arctic National Wildlife Range found that mineralization is evident in granitic plutons at and near Mt. Michelson.

Various amounts of lead, tin, beryllium, and locally, zinc, occur at Mt. Michelson, and persist around the west edge of the main granitic pluton and in a 10-mile transverse across its center. Indications are that the granite is average in lead content but higher than average in tin.

Known mineral occurrences of beryl, galena-sphalerite veins, and pyritized schist at the granite contact and a pyritized shear zone occur within the granite at Mt. Michelson. Abundant red-weathering pyritized zones within the granite have been mapped. The known data suggest that there are many small mineralized zones, and that placer tin is a potential economic mineral prospect.

Gravel

Gravel is locally being extracted along the Applicant's proposed gas pipeline route.

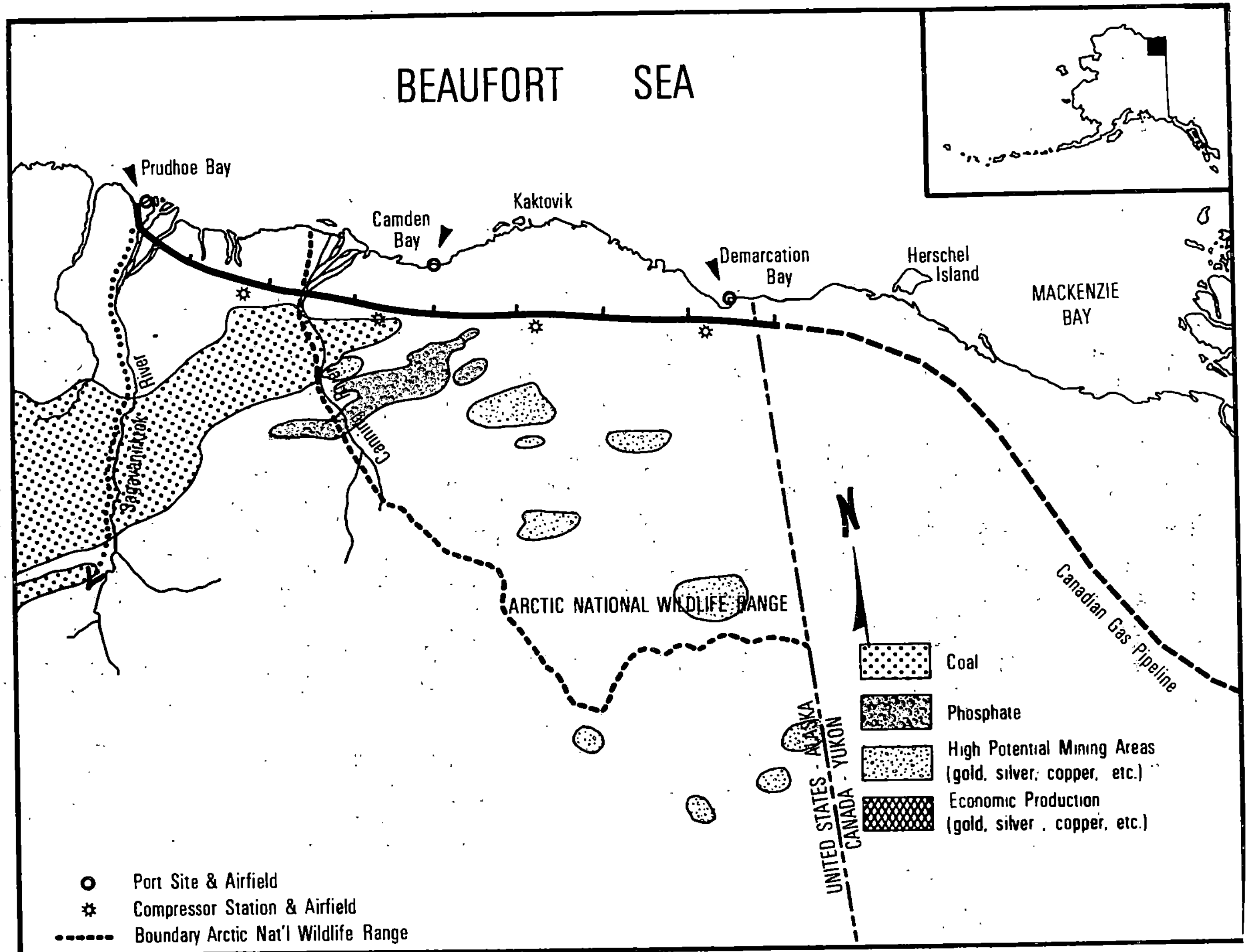


Figure 2.1.1.3-2 Mineral deposits near AAGPC proposed pipeline, Alaska

The Alyeska Pipeline Company and the petroleum development companies of the Prudhoe Bay Field are extracting sand and gravel from the bed and outwash plains of the Sagavanirktok River. Volume data for gravel removed from the Sagavanirktok River drainage are not available, because the State of Alaska does not keep cumulative records of free use permits or materials sales in the area.

There is no overall estimate for the amount, quality, and location of gravel along the proposed AAGPC pipeline system. Bedrock is exposed close to the route. Accordingly, it is unlikely that a rock quarrying and crushing method could be used to produce the 3.1 million cubic yards of gravel which the Applicant estimates will be required to construct the pipeline system.

Geologic Hazards

Permafrost

Permafrost is a critical geological-climatological phenomenon that is important to this environmental impact statement.

The entire proposed AAGPC pipeline system is located in an area of continuous permafrost. Permafrost is defined as soil, rock, or any other earth material, the temperature of which remains at or below 32°F (0°C) continuously for two or more years (Muller, 1945). It is important to note that it is not necessary to have ice in order to have permafrost. Permafrost is defined exclusively on the basis of temperature, without regard to other conditions of the material, such as lithology, texture, degree of induration, or water (ice) content. Although ice is not a necessary prerequisite of permafrost, its presence and amount in relative proportion to soil, gravel, bedrock, or other earth material is of extreme importance to construction in the Arctic.

The term permafrost is a misnomer. "Perma-" is derived from the word permanent, and permafrost is anything but permanent when its thermal environment is altered. When altered there can be significant changes in the surface configuration in direct proportion to the amount of ice present. When thawed, excess water trapped as ice is freed, resulting in subsidence or sinking of the ground surface. Conversely, exposing a new supply of water to permafrost can cause the water to turn to ice and the ground surface to be raised or to heave.

Permafrost distribution is not uniform and depends on many variables. Although mean annual air temperature is basic in determining the distribution, mean annual ground temperature is the key that determines presence or absence of the phenomenon. Several other variables relate to these two values, including glacial and climatic history of an area; thermal properties of the earth material; insulating properties of any overlying material such as vegetation, snow, or water bodies; topographic conditions such as orientation of a slope with respect to the sun; and other shade factors caused by topography or vegetation.

In the lowland area north of the Brooks Range, the temperature of permafrost at depths just below the zone of seasonal variation generally ranges from 12° to 23°F (-11° to -5°C).

Data presented by the Applicant indicate soil temperatures along the proposed pipeline route in Alaska range between 16°F and 33°F (-8.9°C and .6°C) at half the depth of the buried pipeline centerline (approximately 54 inches or 1.4m.). These are shown in Table 2.1.1.3-1. Most of the

Table 2.1.1.3-1 Average ground temperatures along proposed pipeline route, Alaska, at a depth of the centerline of the buried pipeline

Pipeline segment (M.P.)	Average winter temp. (°F)	Average summer temp. (°F)	Maximum value (°F)	Average temp. (°F)			
				Jan.	April	July	Oct.
00 - 43.4	19(-7.2°C)	28(-2.2°C)	33(0.6°C)	17(-8.4°C)	16(-0°C)	30(-1.1°C)	31(-0.6°C)
43.4 - 83.0	19	28(-2.2°C)	33(0.6°C)	17	16	29(-1.7°C)	31(-0.6°C)
83.0 - 129.2	20-6.7°	28(-2.2°C)	32(0°C)	18(-7.8°C)	17(-8.4°C)	29(-1.7°C)	30(-1.1°C)
129.2 - 176.0	20	28(2.2°C)	32(0°C)	18	17	29(-1.7°C)	30(-1.1°C)
176.0 - 225 */	20	28(0.6°C)	33(0.6°C)	18	17	30(-1.1°C)	31(-0.6°C)

*/ U.S. - Canada Border at M.P. 194.80

(AAGPC, 1974b, Exhibit G, pp. 42, 43)

permafrost in Alaska has been in a similar condition for many thousands of years; some is a slowly shrinking product of ancient colder climates, but some is growing thicker. In northern Alaska where the climate is colder, permafrost forms a virtually continuous layer to depths of several hundred feet beneath the surface. It reaches a maximum thickness of about 2,000 feet (609.6 m) near the origin station of the proposed AAGPC pipeline system in the Prudhoe Bay area (Howitt and Clegg, 1970).

Even in the coldest parts of Alaska, a thin layer of ground, the active layer, thaws every summer, and separates the permafrost from the ground surface. The thickness of the active layer depends upon the capacity of the surface material to protect the underlying permafrost from summer heat. The thickness can vary locally from 1/2 foot to 5 or more feet (.2 to 1.5 m) and can change dramatically when the surface is disturbed. See the Soils and Erosion Sections for more detailed discussion of the "active layer."

The amount of ice present in the surficial deposits or bedrock in which the permafrost is developed can vary from none to nearly 100 percent. The proportion of ice to surficial material depends initially on the water present in the material before freezing, but during the process of formation of the permafrost (and during the freeze-thaw cycles in the supra-permafrost zone) the ice becomes segregated, particularly when the percentage is relatively high. The segregated ice may take the form of irregular blobs or lenses, more or less horizontal layers that may range in thickness from less than 1 inch (2.5 cm) to many feet, or vertically oriented wedges which thin downward and which may be tens of feet deep and several feet wide at the top in northern continuous zones (to the south they have smaller dimensions).

Wedges occur in cracks formed when the ground contracts as it freezes. Cracks develop over long periods of time and commonly form in a polygonal pattern resembling mud cracks, but generally much larger. Ice-wedge systems are sometimes visible on the surface of the ground (ice-wedge polygons), but more commonly may have no surface indication. (Figure 2.1.1.3-3).

The engineering problems associated with permafrost are not the same in every type of rock or sediment. For example, bedrock or well-drained, coarse sediments such as glacial outwash gravel present few, if any, construction or maintenance problems because there is little ice.

Major engineering problems arise where permafrost occurs in poorly drained, fine-grained sediments. Such sediments generally contain large amounts of ice, and when the natural thermal regime is disrupted, the ice begins to melt. The thawing produces instability as excessive wetting and plasticity of the fine-grained sediments occurs. This instability can result in the subsidence of the ground surface or in downslope movement of the entire thawed mass.

It is the change or modification, chiefly degradation (thawing), of permafrost that is of primary concern to construction projects in the Arctic.

Degradation can happen in two basically different ways: (1) changes in the thermal balance at the ground surface can cause the active layer to thicken from summer heating. Major factors affecting the natural thermal balance when construction damages the organic surface layer are through destruction, or compaction and disruption of surface drainage, and (2) heated buildings, or other new and steady sources of heat, can change the equilibrium thawing configuration of the permafrost. Both degradations may drastically affect the behavior of the material underlying the surface, but the change may be incomplete for decades, or even centuries (Lachenbruch,

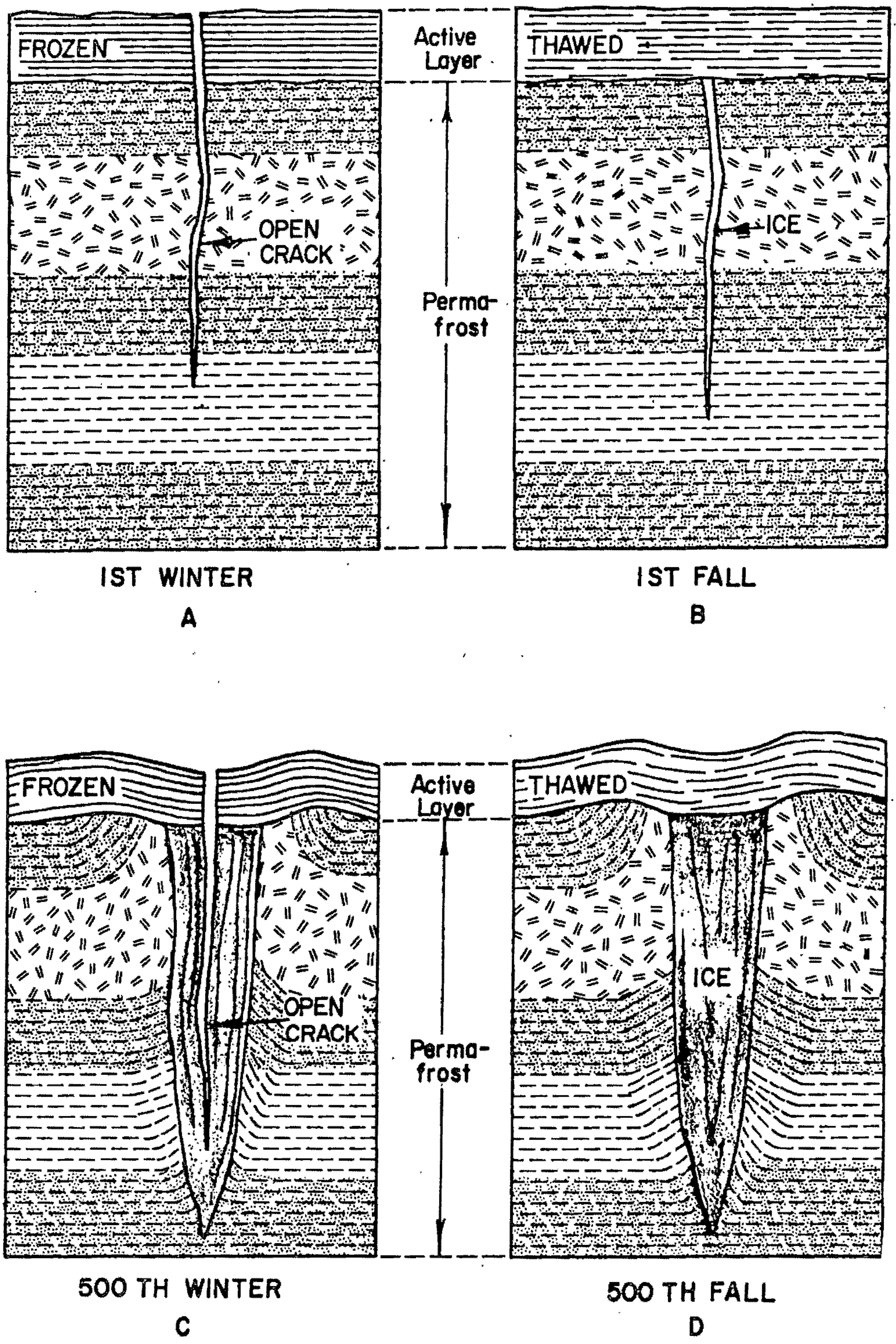


Figure 2.1.1.3-3 Schematic representation of the evolution of an ice-wedge according to the contraction-crack theory

1970). Thus, a new thermal balance may not be reached until well after the pipeline has gone out of use.

The primary engineering problems resulting from thawing of permafrost relate to the potential loss of strength and volume of the material (Ferrians et al., 1969). In ice-rich material, thawing can cause severe differential settlement or loss of bearing strength in foundations. Such effects may be self-perpetuating and difficult to predict.

The nature of the ice in the active layer, as well as its thickness has an important effect on the amount of frost heaving. In relatively coarse-grained sediment with a low water content, the ice acts as a binder and does not produce appreciable amounts of heaving. If coarse sand is inter-bedded with silt and the water content is not high, ice forms as layers in the silt and as a binder in the coarse sand. In this case, thin ice lenses are formed and moderate heaving results. If the sediments are mixed silts and fine sands along with high water content, large masses of segregated ice are formed and maximum frost heaving occurs.

Preliminary data submitted by the Applicant indicate that more than 50 percent of the first 45 miles (72.4 km) crosses areas where an "80 percent ice content" would be expected. Major portions of this same 45-mile (72.4 km) segment are identified as crossing areas where "much ground ice" is anticipated. Between M.P. 45 and 125 approximately 85 to 90 percent of the pipeline route crosses terrain where "thermal erosion is prevalent where overlying vegetation mat is disturbed or destroyed." Between M.P. 115 and the United States-Canada border, approximately one third of the route crosses terrain where "high ice content makes material subject to extreme settlement and flowage even on gentle slopes if ice melts" (AAGPC, 1975).

The Applicant has conducted a reconnaissance soils investigation along the proposed AAGPC pipeline route in Alaska. A total of 55 test holes have been drilled, but they are too few for more than generalized conclusions, because of the wide range in subsurface conditions from site to site. Data are lacking between M.P. 130 and M.P. 175 (approximately 23 percent of the total proposed pipeline alignment).

Summary data prepared by the Applicant indicate glacial deposits comprise 37.9 percent of the proposed pipeline route; alluvial deposits, 29.0 percent; marine deposits, 20.1 percent; diverse deposits, 10.2 percent; and lacustrine deposits, 2.7 percent. Although these percentages could change when engineering studies are completed, the relationships are considered typical.

Erosion, Landslides, Slumping, and Subsidence

Most erosion in the Arctic Coastal Plain is concentrated in stream valleys, gullies, rills, and steeper slopes or exposures which lack cohesive vegetative covers. Major factors that influence erosive processes at specific locations include: (1) vegetation; (2) local topography; (3) microclimatic conditions, including rainfall, snow accumulation, and diurnal temperature fluctuation; (4) nature of surface runoff; (5) composition and texture of the surface soil and rock; (6) frost heave; and (7) permafrost conditions. These factors are discussed in other sections of this report.

The type and scale of soil erosion and/or mass-movement processes which can affect a specific location generally are determined by: (1) permafrost conditions, (2) bedrock type, (3) slope characteristics, and (4) surficial materials.

No glaciers are associated with the proposed route.

Reconnaissance level information on the geology along the proposed route indicates that except for the vicinity of the Katakturuk River (M.P. 87), bedrock generally is covered by more than 10 feet (3 m) of materials for all but 10 miles (16 km) (5 percent). The 10-mile (16-km) section of the proposed route that involves bedrock at a depth of 10 feet (3 m) or less primarily is located on the Arctic National Wildlife Range between the Tamayariak and Sadlerochit Rivers (M.P. 81 to M.P. 111).

In permafrost regions, slope stability is very sensitive to the amount of water in the soil, and therefore, instability is not uncommon when slopes are as small as 3° and may occur on slopes of less than 3°.

Wind erosion is also a natural process that moves sand and silts along the coastal areas and river bars. Much of the erosion along the coastal bluffs occurs during major storms when the coastal waters are not covered with ice.

All of the mass movement processes described here are directly related to slope angle because gravity provides the driving force to make them operate. The tendency for slope failure to occur increases proportionately with the degree of slope. Because of permafrost conditions, some slopes of less than 3° are subject to mass movements.

In winter, erosion and slope instability in the project areas are essentially nonexistent because the ground is completely frozen.

Mass movement processes are generally thought to be the major processes responsible for lowering the landscape in Arctic regions. Important processes along the proposed AAGPC pipeline route include: (1) thaw consolidation, (2) solifluction, (3) skin flows, and (4) deepseated creep or mass movement. These processes are usually closely interrelated and frequently compounded once a process has started.

Thaw Consolidation

Thaw consolidation results when frozen fine-grained ground thaws. As interstitial ice melts, the volume of the thawing soil profile is reduced. If water is generated faster than soil materials are discharged, the total soil mass may flow as a liquid.

Typically, the active layer (soil or rock material that thaws annually) is close to or at saturation because percolation is limited in depth by the top of the permafrost layer.

The collection of moisture at the base of the active layer provides a lubricated surface which enhances slope instability. Brown and others (1969) report that 50 percent of the total annual thaws occurs within three weeks of the onset of the thaw season, and that in some summers, 100 percent of the annual thaw depth has been attained by the first two weeks in August. Therefore, thaw consolidation must be considered a rapidly occurring annual event.

Thermal erosion, a closely related process, commonly takes place when permafrost is in contact with flowing water. Thermal heating and melting result when water or permafrost ice is exposed to solar radiation. Surface drainage tends to collect in thaw depressions or ponds, concentrating runoff, causing additional melting, and usually accelerating the erosion.

Solifluction

Solifluction, the downslope movement of water-saturated unfrozen sediments over a surface of frozen material, is probably the most evident indication of slope instability on the Arctic Coastal Plain and Arctic Foothills. Solifluction differs from other forms of slope instability, such as creep and rockslides, in that entire sheets or lobes of unconsolidated sediment move. Solifluction is effected by the impermeability of permafrost and low evaporation rate. It is limited to periods of thaw. Downslope movements may be so rapid that a structure resting upon the area of movement either will be subjected to large earth pressures or will move passively downslope.

Fine-grained, ice-rich materials are extremely sensitive to solifluction and, according to Walker (1973), slopes of less than 3° can have active solifluction. Movement is generally slow and limited to the period of thaw; however, it is an effective instrument in the transport of large volumes of material.

Skin Flows

Skin flows involve the detachment of thin veneers of vegetation and soil and subsequent downslope movement over a planar incline surface. These generally are long ribbonlike tears in the surface vegetation which sometimes coalesce into broad sheets. This type of slope instability is shallow in comparison to its length. As with solifluction, skin flows can occur on both steep and low angle slopes. They are local and are considered a minor form of slope instability, as they are generally of shallow depth.

Deep Seated Creep

Deep creep involves the displacement of a mass of soil along a sheer surface in a more-or-less rigid body motion and is influenced by the ice or water content of surficial material and the thickness of the active layer.

Large-scale, deep-seated, rapidly moving mass-movement features can develop where there is a combination of high moisture content, a thick active layer, and steep slopes. Preliminary evidence collected by the Applicant and the Department of the Interior indicates naturally occurring deep-seated creep or land-slide areas are not associated with the location of the proposed AAGPC pipeline system. However, construction of the pipeline ditch may provide local conditions favorable to deep-seated creep.

Coastal and Marine-related Erosion and Deposition

Coastline erosion, through the processes of wave and thermokarst activity, is common along the Beaufort Sea. Leffingwell (1919) reported possible shoreline recession rates of 30 feet (9 m) per year between Flaxman Island and the Brownlow Point. In a review of coastline erosion rates elsewhere on the Arctic Coast, Lewellen (1970) documented erosion rates up to more than 98 feet (30 m) per year. On the east end of Pingok Island, Wiseman et al. (1973) report that the low tundra bluffs retreated as much as 164 feet (50 m) during a three-week period in 1972. The retreat was associated with the growth of an inlet spit, during a time of high wave activity. Similar erosion and deposition activity could occur in the area of coastal facilities such as port areas planned as part of the proposed AAGPC pipeline system.

The nearshore bars and barrier islands are known to alter position in response to winds and currents (Wiseman et al., 1973). Bar migration was noted to average 230 feet (70 m) per year, with migration apparently influenced by occasional storms. Barrier islands apparently are migrating to the west at 19.8 to 627 feet per year (6 to 190 m). Similar rapid changes in nearshore morphology are known to occur around the inlets between the barrier islands (Wiseman et al., 1973).

Early maps and explorers' reports, when compared with present-day geography, suggest that some islands have disappeared in historic times. Whalers wintered in Camden Bay between Konganevik Point and Collinson Point behind islands that no longer are present. Similarly, an island shown on early maps of the Cape Halkett area is no longer to be found.

In the nearshore area off deltas, river overflow drainage through strudel in the sea ice canopy during breakup in May and June creates scour depressions at least 67 feet (20 m) in diameter and 15 feet (4.5 m) deep (Reimnitz et al., 1972) (Figure 2.1.1.3-4).

Little deltaic deposition has been noted at deltas associated with the proposed AAGPC pipeline system.

Ice-sediment interaction is the main cause of sediment reworking from about a depth of 13 feet (4 m) seaward. Ice gouges, scrapes, and resuspends bottom sediments in this zone. Maximum ice gouge depths inshore of the barrier islands are generally less than 20 inches deep (50 cm) while immediately seaward of the barriers gouges up to 39 inches (100 cm) deep are common (Reimnitz and Barnes, 1974). The density of gouges is generally less than 41 per mile (25 per km) of track line inside of the barrier islands and upwards of 41 to 81 per mile (25-50 per km) of track line immediately seaward of the barriers.

The distribution and density of these features can change significantly from year to year, perhaps in response to storm-related erosion and deposition (Remnitz and Barnes, in press).

In an attempt to assess the relative importance of ice and water as process agents on the bottom sediments of the Beaufort shelf, Barnes and Reimnitz (1974) have developed a conceptual model (Figure 2.1.1.3-5).

It is important to keep in mind that the summer period is much shorter than the winter and, therefore, must display a greater intensity of activity to equal the impacts of winter agents on the bottom sediments.

Earthquakes

No active faults along the proposed AAGPC pipeline system are known from reconnaissance geology mapping, but detailed geologic field investigations might reveal evidence of geologically recent movements. Earthquake activity along the proposed AAGPC pipeline is low (Figure 2.1.1.3-6). The proposed route lies entirely within zone 1 of the seismic risk map for Alaska, published in the 1973 edition of the Uniform Building Code (International Conference of Building Officials, 1973). Seismic risk increases from zone 0 to zone 3. In zone 1 minor earthquake damage may be expected in correspondence with Modified Mercalli intensities of V and VI (International Conference of Building Officials, 1973). It is difficult to equate intensity with magnitude. However, for general purposes the V, VI Mercalli intensity is somewhat less than a 5.5 Richter magnitude. The risk map (Figure 2.1.1.3-7) is based primarily on historic seismicity and is a

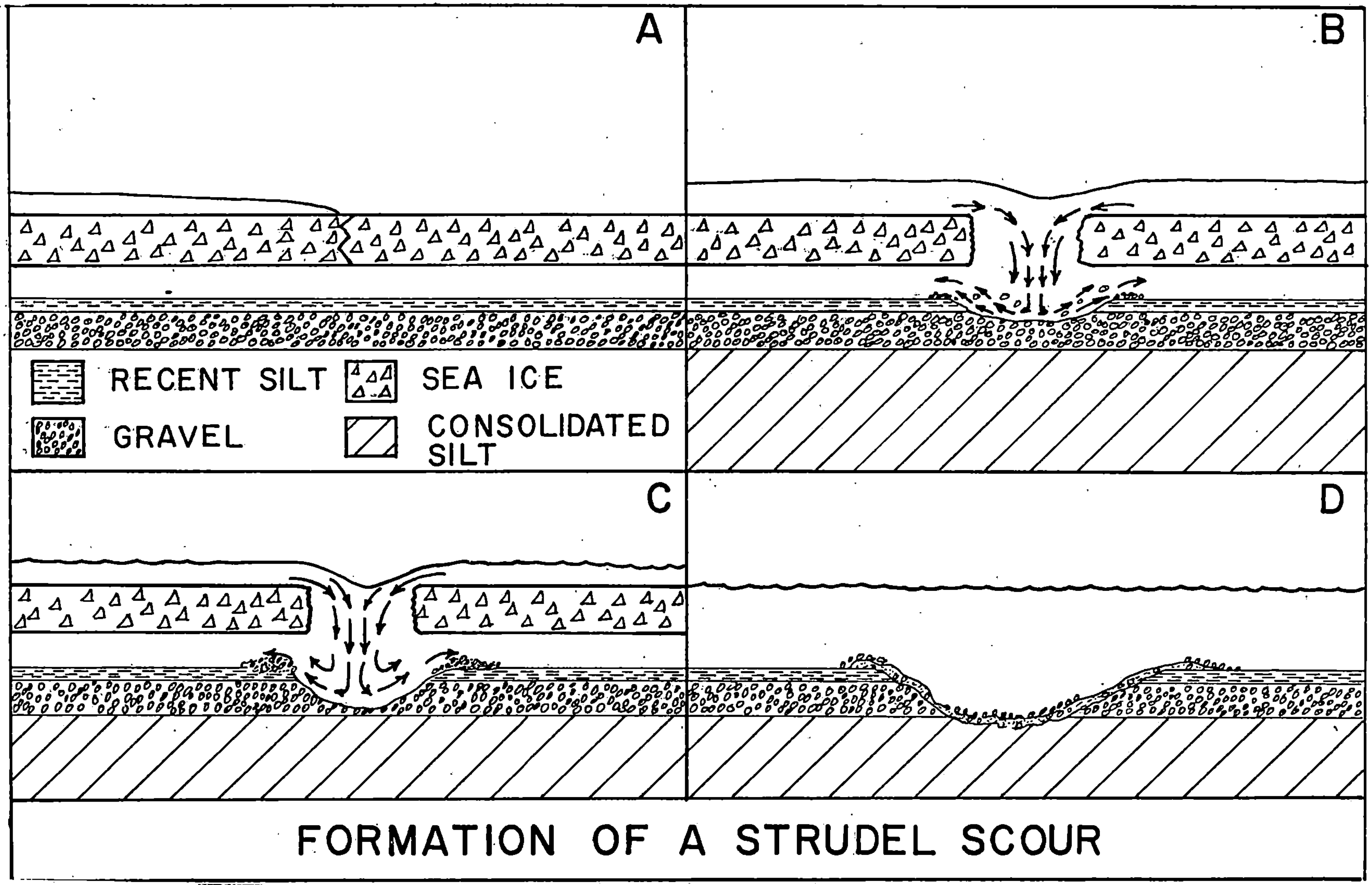
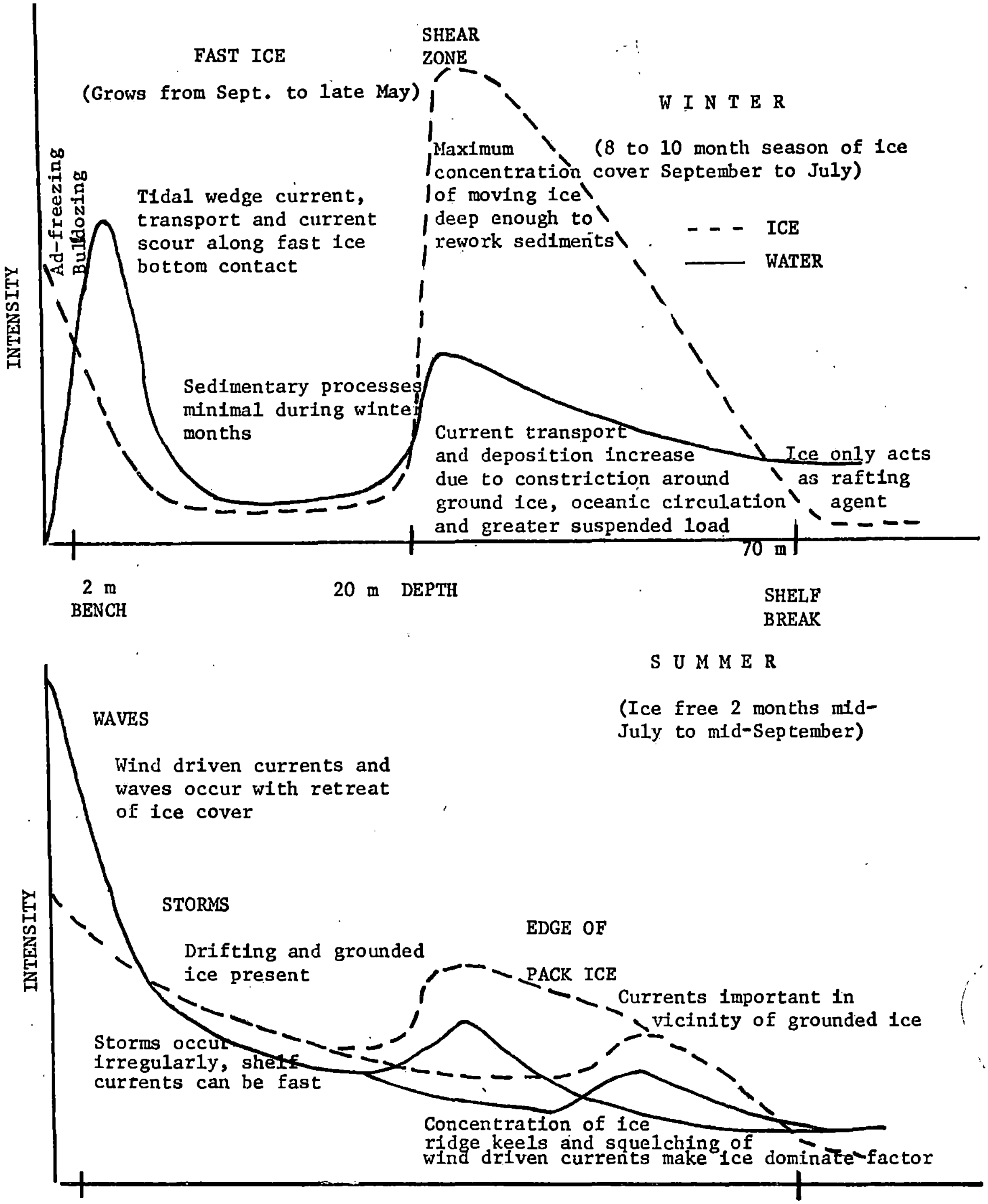


Figure 2.1.1.3-4 Sequential process of strudel scour formation during river flooding of the sea ice



Source: Barnes and Reimnitz, 1974.

Figure 2.1.1.3-5 Comparison of the intensity of ice and water effects on bottom sediments in the Beaufort Sea

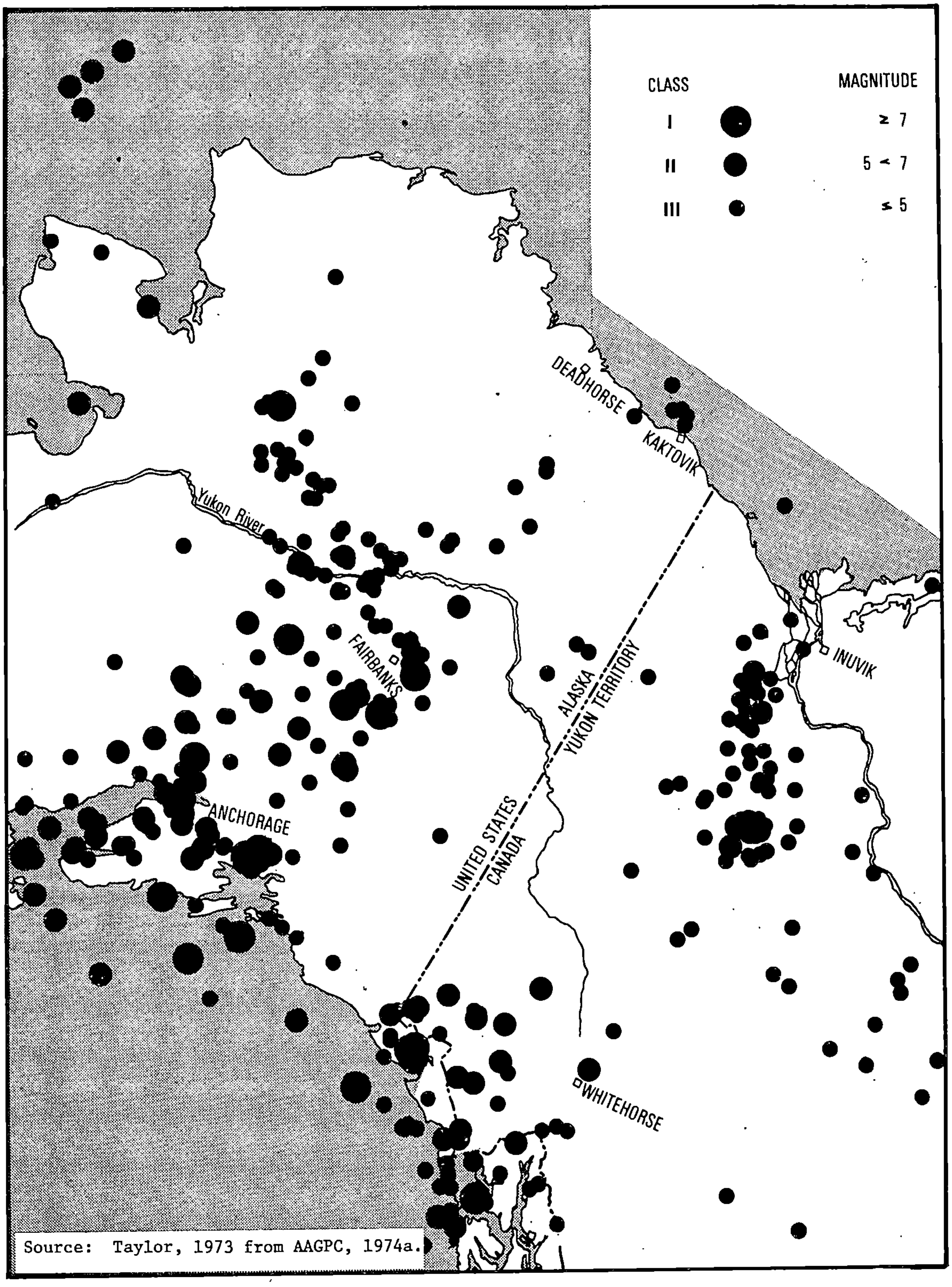


Figure 2.1.1.3-6 Earthquake epicenter locations, 1899-1971

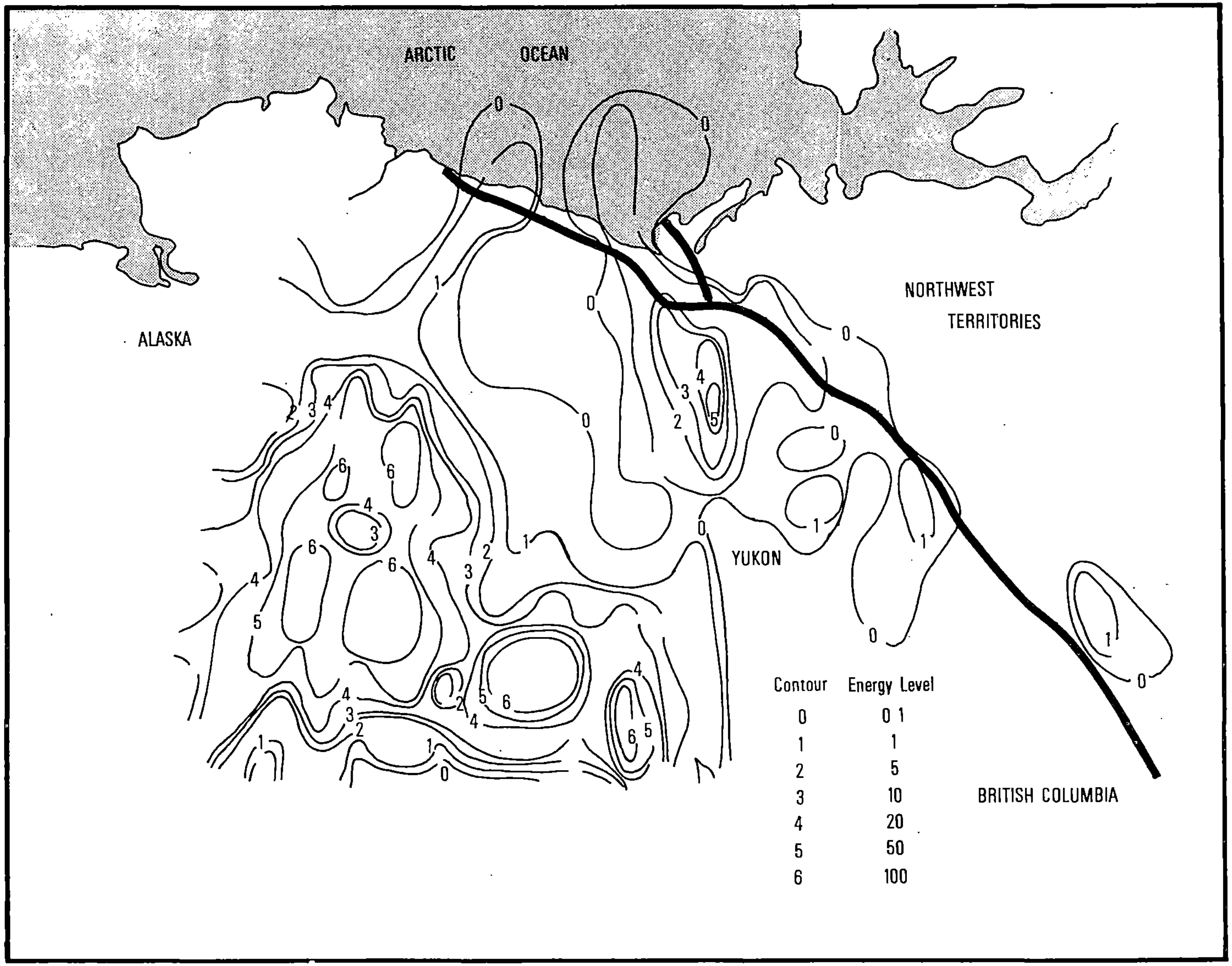


Figure 2.1.1.3-7 Strain release map

gross regionalization of seismic risk for the purpose of a standardized national building code.

The seismic history along the route is short relative to the time over which strains accumulate to create an earthquake; hence, the historic record of seismicity is a limited guide to future seismic risk.

Earthquakes of magnitude 6 and larger on the Richter scale of intensity are potentially destructive, and earthquakes of magnitude 5 may cause damage locally. The seismic history for mainland Alaska is probably complete for earthquakes of magnitude 6.0 since the installation of the seismograph station at College, Alaska, in 1935 and as small as magnitude 5.0 since the mid-1960's when regional seismograph networks were established in central and southern Alaska.

Since the mid-1960's epicenters of at least six shocks with magnitudes larger than 4.0 have been located within about 40 miles of the route between longitudes 143° and 146° W. The uncertainties in the epicentral determinations are estimated to be on the order of 25 miles.

The maximum expectable earthquake is the largest earthquake that, on the basis of existing knowledge, may reasonably be expected to occur; it exceeds the largest known historic earthquake. Accordingly, the earthquake potential along the proposed AAGPC pipeline system may be specified in terms of a maximum expectable earthquake of magnitude 5.5. This is consistent with the use of a magnitude 5.5 design earthquake for the northernmost segment of the trans-Alaska oil pipeline (SITF, 1972; Page et al., 1972).

Focal depths of earthquakes, though not precisely determined, are consistent with the earthquakes occurring at shallow depths in the crust. Accordingly, there is no *a priori* reason to expect that larger earthquakes will not rupture the surface. Without detailed geologic knowledge that there are no seismically active faults associated with the proposed pipeline system, it must be assumed that the maximum expectable earthquake could occur anywhere along the system.

2.1.1.4 Soils

The information in this section is from exploratory surveys of the USDA Soil Conservation Service and from the Alaskan Arctic Gas Pipeline Co. The Company drilled test holes along the proposed pipeline route to produce its data. The data of the Soil Conservation Service are based on exploratory surveys that report broader soil classifications than the soil series. Soil series and associations of them are unidentified in the basic soil mapping units that are on 1:1,000,000 scale. Thus, the associations are in broader categories than the soil series level.

The soil mapping units in Figure 2.1.1.4-1 were developed as equivalents of associations of series by utilizing the broad categories of the SCS exploratory surveys and the specific profile data from the test holes drilled by the Company.

Table 2.1.1.4-1 contains interpretive information for each series equivalent occurring within the associations shown in Figure 2.1.1.4-1.

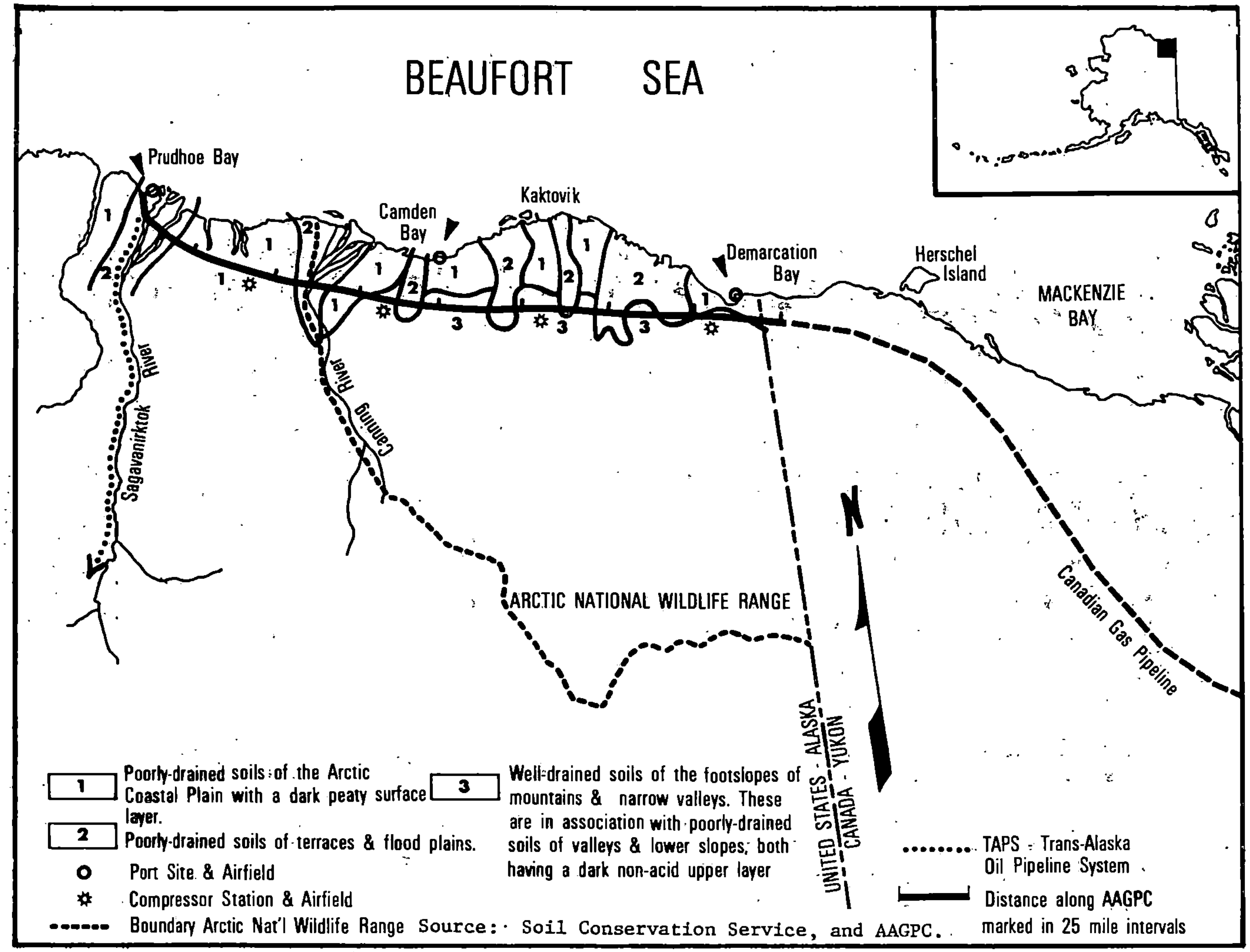


Figure 2.1.1.4-1 Soil associations along proposed AAGPC pipeline system, Alaska

Table 2.1.1.4-1 GENERALIZED SOILS INFORMATION

Soil	Units Miles	Land Position	Thickness Organic Mat	Depth to Permafrost	Dominant Texture USDA	Unified	Underlying Material
1A	18	Coastal Plain	<8"	<12"	0"-60"sil	ML	ML
1B	15	Coastal Plain Low Terraces	8"-16"	<12"	0"-60"sil	ML	ML
1C	11	Low Broad Kones Convex Slopes	8"-16"	10"-24"	0"-60"sil	ML	ML
1D	6	Low Terraces & Ridges	<8"	Deep	0"-60"vgs	GP, GM	GP
1E	4	Shallow Basins & Lake Borders	>16"	<12"	0"-24" pt	PT	PT
1F	3	Floodplains	<8"	<10"	0"-60"vgs	GP	GP
1G	2	Low Dunes	<4"	18"-30"	s	SP	SP
2A	42	Floodplains Low Terraces	<4"	15"-30"	0"-60"vgl	GP	GP
2B	9	Low Terraces	<4"	Deep	0"-60" vg	GP	GP
2C	8	Floodplains Low Terraces	<4"	<20"	0"-40" 1 40"vgs	ML GP	 GP
2D	7	Floodplains & Swales	<4"	10"-30"	0"-60" s	SP	SP
3A	18	Low Ridges Broad Valleys	<8"	10"-20"	0"-60"sil cl	ML-CL	CL
3B	17	Broad Hilltops	8"-16"	6"-20"	0"-60"sil	ML-CL	CL
3C	11	Broad Valley Long Footslopes	8"-16"	<6"	0"-60"sil	ML	ML
3D	10	Valley Bottoms Swales	<8"	<10"	0"-60"sil	ML	ML
3E	7	Hilltops	8"-16"	6"-16"	0"-60" sc	CL	CL
3F	7	Narrow Ridges	<4"	Deep	0"-60"gsil	GM	GP

USDA Texture

- cl - clay loam
- 1 - loam
- pt - peat
- s - sand
- sil - silt loam
- vgl - very gravelly loam
- vgs - very gravelly sand
- vg - very gravelly
- sc - sandy clay
- gsil - gravelly silt loam

Unified Group Symbols

- CL - Lean clays - gravelly, sandy, or silty
- GM - Mixed gravels, sands or silts
- GP - Gravels - gravel and sand mixture
- GW - Graded gravels - gravel and sand mixtures
- ML - Silts and very fine sands - silty, clayey fine sands or clayey silts
- PT - Peat
- SM - Silty sands - sand-silt mixtures
- SP - Poorly graded sandy, gravelly sands, little or no fines

ALONG THE PROPOSED PIPELINE ROUTE

Drainage Class	Flooding	Frost Action	Reaction Class	Permeability	Slope
Poorly drained	None	High	non-acid to calcareous	Moderate	0-3
Poorly drained	None	High	non-acid to calcareous	Moderate	0-3
Poorly drained	None	High	calcareous	Moderate	0-7
Well drained	Moderate	Low	non-acid to calcareous	Rapid	0-7
Poorly drained	Moderate	High	strongly acid	Moderate	0-3
Poorly drained	High	Moderate	calcareous	Rapid	0-3
Well drained	Low	Moderate	non-acid to calcareous	Rapid	0-7
Poorly drained	High	Moderate	non-acid to calcareous	Rapid	0-3
Well drained	Moderate	Low	non-acid to calcareous	Rapid	0-3
Poorly drained	High	High	non-acid to calcareous	Rapid	0-3
Poorly drained	Moderate	Moderate	non-acid to calcareous	Moderate	0-3
Poorly drained	None	High	calcareous	Moderate	0-10
Poorly drained	None	High	calcareous	Slow	0-7
Poorly drained	None	High	calcareous	Moderate	0-10
Poorly drained	None to Low	High	non-acid	Moderate	0-10
Poorly drained	None	High	calcareous	Slow	0-7
Well drained	None	Low	non-acid calcareous	Rapid	10-20

Soil Association No. 1

This association occupies extensive areas of the Arctic Coastal Plain. Low-lying plains, stream terraces, alluvial fans, many small floodplains, and the lower footslopes of hills characterize the areas.

Thick permafrost underlies the soil, and nearly all areas are prominently patterned by the frost features that are common in the arctic tundra. The dominant soils are poorly drained and consist of loamy non-acid and calcareous sediments. Gravelly and sandy soils are scattered among the terraces and floodplains that border the numerous streams which flow northward from the Brooks Mountain Range to the Beaufort Sea. Poorly drained fibrous peat soils occupy lake borders, shallow depressions on terraces, and small drainageways.

The soils of Association No. 1 are too cold for cultivation (as are the soils in other associations along the proposed pipeline). Except for a few well-drained, gravelly soils scattered on the terraces, the soils offer severe construction problems. The proposed pipeline route encounters approximately 59 miles of soil association number 1.

Principal Component Soils (series) of Association No. 1

Soils 1A, which underlie a nearly level to a moderately sloping ground surface, are loamy; such soils comprise about 30 percent of the association. These are poorly drained soils that occur on nearly level low-lying coastal plains, terraces, and long footslopes. They are usually formed in non-acid and calcareous silty materials. Typically they have a surface mat of roots and organic materials less than 8 inches thick. A black, mucky silt loam upper layer is underlain by mottled dark gray loamy materials that contain frost-churned streaks of buried organic matter. Ice-rich permafrost is usually less than 12 inches below the organic mat.

Soils 1B, which also lie beneath a nearly level to moderately sloping ground surface, are loamy, poorly drained in their occurrence on low-lying plains, terraces, and long footslopes. Soils 1B comprise about 25 percent of the association. They, too, are formed in non-acid and calcareous silty sediments. Polygons, frost scars, and pingos are common surface features. Typically, they have a surface layer of organic material ranging from 8 to 16 inches in thickness. The soils consist of dark gray, mottled silt loam or silty clay loam that contains dark frost churned streaks of organic matter. A thin darkened layer of mixed mineral and organic materials is common at the permafrost table which is usually less than 12 inches below the mineral surface.

Soils 1C are nearly level to gently sloping, loamy, poorly-drained soils occurring on the crests of very low broad knolls that are only a few feet above the surrounding plains. They also occur on convex footslopes and in small scattered areas on terraces. The surface of these areas is patterned with closely spaced, circular, sparsely vegetated frost boils. In areas between the frost scars, the soil surface is covered with a thick vegetative mat. Both the soil in the frost scars and the soil under the vegetative mat consist of mottled dark gray, non-acid to calcareous loamy materials that contain black streaks of churned organic materials. Depth to ice-rich permafrost is usually less than 10 inches in the soil under the thick vegetative mat, but is up to 24 inches in the sparsely vegetated frost boils which occupy about 40 to 50 percent of the surface area.

Soils 1D are nearly level to gently sloping very gravelly soils that make up about 10 percent of the association. These are well-drained soils that occur on portions of low terraces bordering major streams and on a few low knolls and ridges. Frost features that include polygons and roughly circular frost scars are weakly developed. On these soils, the vegetative mat is normally only an inch or two thick and on windswept knolls, the surface is nearly bare. The soils consist of dark grayish brown non-acid or calcareous sandy loam. They have a mean annual temperature lower than 32° F. but they do not retain enough moisture for ice-rich permafrost to form.

Soils 1E are very poorly drained peat soils with a shallow permafrost table. They occur in shallow basins on terraces and in areas bordering thaw lakes. In summer these soils are always wet and low-lying areas are commonly ponded. The peat materials consist of very dark brown coarse sedge and moss fibers that are usually very strongly acid. Below a depth of about 12 inches, the materials are perennially frozen and interbedded with thick layers of clear ice.

Soils 1F are nearly level, very gravelly and sandy, poorly drained soil that generally occur on floodplains. They have shallow permafrost tables and are subject to periodic flooding. This soil makes up less than 5 percent of the association.

Soils 1G are nearly level to rolling sandy soils that occur on low stabilized dunes bordering floodplains. They are well-drained and have moderately deep permafrost tables. This soil makes up less than 5 percent of the association.

Soil Association No. 2

This association occupies low terraces, braided flood plains, and broad alluvial fans bordering major streams in northern Alaska. Elevations range from sea level on plains bordering the coast to 2,000 feet in the Brooks Range. The dominant soils consist of very gravelly stream deposits that are underlain by permafrost. Low-lying portions of the association are commonly flooded by runoff from spring snowmelt and heavy summer rainstorms in the mountainous watershed areas.

Most of the soils have severe limitations for construction, but well-drained very gravelly soils of minor extent that occur near escarpment edges on low terraces, slightly above the level of floodplains, are among the most suitable soils for building sites, roads, and other intensive uses in the arctic. The proposed pipeline route encounters approximately 66 miles of this soil association.

Soils 2A are nearly level, very gravelly, poorly-drained soils with permafrost that occur on low terraces, floodplains, and alluvial fans braided with small secondary stream channels. This soil comprises about 65 percent of the associations. Shallow floods of short duration are common in the spring and summer on soils in low-lying areas along streams. Most of the soils on terraces escape flooding. Typically, the soils have a thin surface mat of organic material over a thin layer of gray stratified silt loam and fine sand that is usually less than 15 inches thick over very gravelly and sandy stream deposits. Depth to permafrost ranges from about 15 to 30 inches.

Soils 2B are nearly level, very gravelly well-drained soils that occur above escarpment edges on low terraces. They make up about 10 percent of this association. These soils consist of very gravelly alluvial deposits. Soil temperatures at moderate depth are continually lower than 32 degrees, but the coarse textured materials seldom retain enough moisture to form large ice lenses. Beneath a thin surface mat of organic material the soils consist of grayish brown or dark grayish brown very gravelly sand that commonly contains many cobblestones.

Soils 2C are nearly level, loamy, poorly-drained soils with shallow permafrost that occur on portions of low terraces and floodplains. Beneath a thin peaty surface mat, the soils consist of mottled gray stratified silt loam and fine sand that contains dark streaks of buried organic matter. Depth to ice-rich permafrost is generally less than 20 inches. This makes up about 10 percent of the association.

Soils 2D are nearly level, sandy, poorly-drained soils with permafrost that occur on floodplains and swales between low undulating dunes. The soils have a thin peaty surface layer over gray or mottled dark grayish brown fine sand that commonly contains streaks or thin layers of buried organic matter. Depth tc permafrost ranges from about 10 to 30 inches. These soils comprise about 10 percent of the association.

Soil Association No. 3

This association occupies low rounded hills bordered by coastal plains and low-lying portions of the arctic foothills. The hilltops are broad with smooth, gentle, convex slopes and are strongly patterned with barren or sparsely vegetated circular frost scars. The entire association is underlain with thick permafrost and the vegetation is typical arctic tundra. Elevations range up to about 500 feet along the coast. The dominant soils are poorly drained and formed in thick deposits of loamy ice-rich materials derived chiefly from weathered nonacid and calcareous shales. A few very gravelly well-drained soils occur on narrow ridgetops. The area has only a few thaw lakes and they are drained mainly by small streams and waterways.

Soils of the association are toc cold for cultivation and have severe limitations for construction. The proposed pipeline route encounters approximately 70 miles of this soil association.

Soils 3A are nearly level to moderately sloping, loamy, poorly drained soils which occur on low ridges, long smooth slopes, and broad valleys. In many places the vegetation on these soils is interrupted with unvegetated frost scars. Typically, the soils have mottled dark gray and dark grayish brown silt loam or silty clay loam cambic horizons that are strongly frost churned and streaked with black organic materials. Beneath the vegetation the soil thaws to a depth of about 10 inches but in frost scars the depth of thaw is about 20 inches. The unconsolidated perennially frozen materials generally contain thick lenses and wedges of clear ice. These soils make up about 25 percent of the association.

Soils 3B are nearly level to gently sloping, poorly drained soils that commonly occur on broad hilltops. They are strongly patterned with closely spaced circular frost boils that support little or no vegetation and occupy about 50 percent of the surface area. The soil between the frost scars supports a dense thick mat of vegetation. Both the soil beneath the thick vegetative mat and the soil in the frost scars have mottled dark gray to dark grayish brown silt loam or silty clay loam cambic horizons that contain many frost churned streaks of black organic materials. The permafrost table is usually less than 6 inches below the vegetative mat but ranges up to 20 inches in the frost boils. The soils are nonacid to calcareous in reaction and generally contain thick lenses and wedges of ice in the perennially frozen materials. These soils make up about 25 percent of the association.

Soils 3C are nearly level to gently sloping, loamy, poorly drained soils that commonly occur in broad valleys and on long footslopes. Typically the organic mat ranges from 8 to 16 inches thick. The soils consist of mottled, dark gray, nonacid silt loam that is frost-churned and streaked with black organic material. The depth of thaw is usually less than 6 inches below the vegetative mat and the perennially frozen materials contain thick lenses and wedges of clear ice. These soils make up about 15 percent of the association.

Soils 3D are nearly level to gently sloping, loamy, poorly drained soils that occur in scattered swales and broad bottoms. Typically, beneath the organic mat, the soils have a black, nonacid mucky silt loam upper layer over mottled, dark gray, frost-churned loamy materials derived from calcareous rock. Depth to ice-rich permafrost is usually less than 10 inches below the organic mat. These soils make up about 15 percent of the association.

Soils 3E are nearly level, gently sloping, loamy, poorly drained soils that occur in scattered areas on hilltops and are formed in clayey materials. They are strongly patterned with closely spaced, circular unvegetated frost boils that occupy 40 to 50 percent of the total surface area. Between the frost scars the soils support a thick cover of organic materials. Both the soil in the frost scars and the soil beneath the vegetative mat consist of mottled, gray, nonacid silty clay or clay loam. The soil above the permafrost is frost-churned and commonly contains a few black patches of organic matter. Depth to ice-rich perennially frozen material ranges from about 6 inches under the vegetative mat to about 20 inches in the frost boils. These soils make up about 10 percent of the association.

Soils 3F are strongly sloping to steep very gravelly, well-drained soils that occur on a few sharp narrow ridge tops. Typically, beneath a thin mat of organic matter, the soils consist of grayish brown very gravelly silt loam or silty clay loam. Gravel content generally increases with depth; the fragments are usually sharp and angular. Though the mean annual soil temperature is less than 32 degrees the soils do not retain enough moisture to form lenses of ice.

2.1.1.5 Water Resources

Water quality data for the proposed AAGPC project area are inadequate for long-term assumption. Because of the present wilderness condition and light level of human use in the area of the proposed route within the Arctic National Wildlife Range, water quality is assumed to be good. There are no industrial chemicals, pesticides, human sewage, or similar contaminants in the water. This is not to say, however, that the water is "pure." Large concentrations of waterfowl adversely affect water quality at lakes during molting and staging periods. Streams carry heavy sediment loads during periods of high runoff.

Because of the increasing level of human activity through oil and gas field development in the Prudhoe Bay area, water quality in that area is assumed to be not as good as that within the Arctic National Wildlife Range. It is believed, however, that water quality in the Prudhoe Bay area is within established State and Federal water quality standards.

Nutrients are low in lakes, ponds, and streams; nitrate concentrations are low in lakes and high in ponds and streams. Dissolved oxygen levels tend to remain high during the summer because of relatively low water temperatures and low biological activity. Turbidity generally is less than

70 Jackson Turbidity Units, but it ranges from a condition where the water is extremely clear at low flow stages to one where the water is extremely turbid at high flow during spring runoff and frontal storm flooding. Approximately 75 percent of the annual sediment load is transported in the first 3 weeks in June.

The Arctic Coastal Plain contains thousands of shallow lakes and ponds; wide, braided rivers; and many small streams. The Arctic Foothills contain swift, braided rivers and a few thaw lakes. Rock-basin lakes are scattered through the mountains. The major rivers and streams of the Arctic Slope drainage originate in the Brooks Range and flow generally north (Figures 1.1.1.2-1 and 1.1.1.2-2).

Permafrost generally blocks the downward movement of water, causing it to go either through the thaw "active layer" or slowly over the tundra soil. Ferrians et al. (1969) state that all water derived from rain, snow, and thawed subsoil accumulates above the permafrost, often in such quantities that a liquid layer is formed underneath the vegetative mat.

Most runoff is from snowmelt. Major spring flooding occurs in late May or early June. In subsequent months, flow generally declines. The recession of flow is punctuated by periodic frontal storm runoff, with peak flows occasionally being larger than that generated by snowmelt. During winter months, flow declines to a very low level, and in most streams, ceases by late November and December.

During the spring flood, the accumulated precipitation of about seven months becomes available for runoff within only a few weeks. Flooding may be severe. The rate of snowmelt is controlled by spring weather, and is slowed by refreezing and the capacity of the snowpack to hold melt water. Ice jams can accumulate runoff and amplify flood peaks when the jams break.

Summer runoff from frontal storms is likely to be more important than spring flood for construction planning and design considerations on all but the largest rivers. Summer floods are sometimes as severe as spring floods and can be far more destructive since they occur when the riverbanks and beds are partially thawed.

Snowdrifts formed across small streams in winter can form weak dams when spring runoff begins. When the dams break, the impounded water is suddenly released downstream along with slush and snow. Such floods dissipate quickly in the steep, rough channels at source points, but within a mile or two of their source, they are likely to be more destructive than any other flow event. Such flows sometimes reach alluvial fans in the Canning River region. Similar impoundments may be formed by aufeis.

There are no glacier-dammed lakes in any basin along the proposed route that might cause major catastrophic flooding.

Surface Runoff--Rivers and Streams

The proposed AAGPC pipeline route crosses 120 identified Alaskan streams between Prudhoe Bay and the Canadian border. Streams identified and crossed by the route are listed in Table 2.1.1.5-1. Although much descriptive material has been written on the water resources, little quantitative information exists.

A shift of final alignment of the pipeline route upstream or downstream could increase or decrease the number of streams crossed.

Table 2.1.1.5-1 Streams crossed by the proposed route

Name	Location (milepost at crossing)	Category 1/	Name	Location (milepost at crossing)	Category 1/
Putuligayuk R.	2	T	Unnamed stream	78	T
Unnamed stream	3	T	Unnamed stream	80	T
Sagavanirktok R.*	8	MG	Unnamed stream	82	T
Unnamed stream	9	T	Tamayariak R.	82	T
Unnamed stream	10	T	Unnamed stream	81	T
Unnamed stream	11	T	Katakuruk R.*	87	M
Unnamed stream	12	T	Unnamed stream	89	T
Sagavanirktok R.*	16	M	Unnamed stream	94	T
Unnamed stream	17	T	Unnamed stream	97	T
Unnamed stream	19	T	Unnamed stream	98	T
Unnamed stream	27	T	Unnamed stream	98	T
Kadleroshilik R.	29	T	Unnamed stream	99	T
Unnamed stream	29	T	Marsh Creek	100	T
Unnamed stream	31	T	Unnamed stream	102	T
Shaviovik R.	37	M	Unnamed stream	103	T
Kavik R.	37	MG			
Unnamed stream	37	T	Unnamed Stream	103	T
Unnamed stream	38	T	Carter Creek	104	T
Unnamed stream	42	T	Carter Creek	105	T
Unnamed stream	50	T	Carter Creek	106	T
Unnamed stream	54	T	Carter Creek	107	T
Unnamed stream	57	T	Carter Creek	108	T
Unnamed stream	59	T	Itkilyaiak Creek	109	T
Unnamed stream	61	T	Unnamed stream	110	T
Staines R.	61	M	Unnamed stream	111	T
Staines R.	62	M	Sadlerochit Spring**	111.5	S
			Sadlerochit R.*	112	M
Canning R.*	62	MG	Unnamed stream	113	T
Unnamed stream	64	T	Unnamed stream	115	T
Unnamed stream	65	T	Hulahula R.	116	M
Unnamed stream	66	T	Unnamed stream	117	T
Unnamed stream	68	T	Akutoktak R.	122	T
Unnamed stream	69	T	Unnamed stream	123	T
Unnamed stream	71	T	Unnamed stream	124	T
Unnamed stream	72	T	Okpilak R.*	125	M
Unnamed stream	74	T	Okpirourak Creek	128	M
Unnamed stream	76	T	Unnamed stream	129	T
Jago R.	131	MG	Unnamed stream	171	T
Unnamed stream	135	T	Unnamed stream	172	T
Unnamed stream	135	T	Kongakut R.	173	MG
Okerokorik R.	139	M	Unnamed stream	174	T
Unnamed stream	140	T	Unnamed stream	175	T
Niguaruk R.	142	T	Unnamed stream	178	T
Angun R.	146	T	Unnamed stream	181	T
Angun R.	147	T	Turner River	183	T
Angun R.	148	T	Turner River	184	T
Kogolpak	151	T	Unnamed stream	186	T
Aichilik R.*	151	M	Putugook Creek	188	T
Unnamed stream	152	T	Unnamed stream	189	T
Unnamed stream	154	T	Unnamed stream	190	T
Unnamed stream	155	T	Unnamed stream	192	T
Unnamed stream	156	T	Unnamed stream	192	T
Unnamed stream	157	T	Unnamed stream	192	T
Unnamed stream	159	T	Unnamed stream	193	T
Unnamed stream	160	T	Unnamed stream	193	T
Unnamed stream	161	T	Unnamed stream	194	T
Egakarak R.*	162	M	Unnamed stream	194	T
Unnamed stream	163	T	Clarence R.	194	M
Unnamed stream	163	T			
Unnamed stream	164	M			
Ekatuakat R.	166	M			
Siksikpalak R.	168	M			
Unnamed stream	169	T			
Kalokut Creek	170	T			

1/ Legend:
- M: Mountain streams
- MG: Mountain streams with glacial influence.
- T: Tundra streams
- S: Spring streams
- *: Numerous channels in braided floodplain
- **: The alignment does not "cross" Sadlerochit Spring; however, it is so close (about 1 mile downstream) that it is considered in this category.

In Table 2.1.1.5-1 streams are categorized as follows: Spring streams are those flowing from springs. Tundra streams drain boggy areas and are brownish in color because of organic leachates. Mountain streams carry relatively large suspended sediment loads during summer, but normally become clearwater streams during the fall. Some mountain streams are influenced by small glaciers high in the Brooks Range.

One hundred identified streams are categorized as tundra, nineteen as mountain or mountain-glacier, and one as spring fed.

Available data for the Arctic Slope Drainage indicate the mean annual daily maximum discharge rates range from about 30 cubic feet per second (cfsm) in the coastal plain to about 10 cfsm in the mountains. Mean annual peak runoff rates reported are as large as 50 cfsm in the region. The mean annual low flow for the entire region is reported at less than 0.1 cfsm (Feulner et al., 1971).

Normally, river breakup first occurs in the Arctic Foothills in early to mid-May, then progresses downstream, reaching the coastal plain by late May or early June. During initial stages of breakup, the permafrost's active layer is generally frozen up to the ground surface; consequently, most water reaching the river channels from snowmelt must move over the ground surface.

During early spring breakup, bottom-fast ice protects the river channel from scour. As flow increases, this ice is lifted and carried downstream.

After the spring flood, ice may become stranded, increasing the likelihood of ice jamming, localized flooding, and erosion.

Hydrologic hazards include icings (aufeis), ice-jam flooding, and scour associated with these events. There are no glaciers along the proposed gas pipeline route. Small glaciers in the headwaters of streams to the south have only slight affects on water quantity and quality. The term "icing" or aufeis describes a phenomenon of arctic or subarctic regions. In this report, it is defined as a mass of surface ice formed by successive freezing of sheets of water that seep from the ground, from a river, or from a spring (Carey, 1973). River icings are formed from waters of the river itself. River ice may extend beyond the limits of the river channel into the flood plain. Ground icings are formed when an obstruction blocks normal groundwater flow.

Ice jams and flooding may also occur in major rivers in Alaska in the spring, since river ice (usually several feet thick) does not always break up uniformly and may accumulate in unfrozen reaches in areas of construction or in the shallows. During the brief summer open-water period, there are floods of two basic kinds. The first of these is the spring breakup flood which is predictable in severity and time. Breakup of most arctic rivers is not caused by increased river flow beneath the ice cover whereby the ice is floated off, as is true for larger, more southerly rivers. Rather, the process is one of flow over the icing, with cutting of erosion channels through the ice. Sometimes, accumulated pieces of ice cause minor jams and local flooding. The large spectacular ice jams of deep rivers such as the Yukon and Kuskokwim do not occur.

The second kind of flood is the result of late summer or early fall rainfall. These are convective rainstorms; they are most frequent in the Brooks Range and Foothills provinces. Because of the impervious permafrost, lack of retarding vegetative cover, and steep slopes, the rise in water level on the smaller tributary streams is characteristically extremely rapid. Little advance flood warning may be possible. The summer floods are much less dramatic in the major rivers of the Arctic Coastal Plain.

Stream response to summer storms range widely because of tundra relief. In a study of a small watershed in the coastal plain (Brown et al., 1968), runoff was found to range from 1 to 70 percent of the total precipitation for individual summer storms.

Rivers and streams in Alaska along the proposed AAGPC pipeline project are usually frozen over by early November. The ice continues to thicken until heat losses by the stream through the insulating snow and ice cover equal the heat produced by frictional dissipation of the flowing water (in larger streams). This is the equilibrium thickness. In smaller streams, flows cease entirely or may exist only in the deeper reaches of the stream. In shallower areas there may be only subsurface flows in the gravels underlying the streams.

Studies of a small glacially influenced stream in the eastern Brooks Range indicate mean annual runoff rates of 0.8 cfsm (Wendler et al., 1972). Stream-flow records for the Putuligayuk, Kuparuk, and Sagavanirktok Rivers indicate mean annual flow rates of 0.2, 0.5, and 0.8 cfsm, respectively (USGS, 1972, 1974a, 1974b). Approximately 50 percent of the total annual precipitation becomes surface runoff (Brown et al., 1968).

Stream-flow data collected since 1971 are available for three major basins on the western section of the route. These are the only gaged stations with data summarized in Table 2.1.1.5-2.

Table 2.1.1.5-3 shows the winter characteristics of streams along the proposed route, and includes ice depth, water depth, flow, and dissolved oxygen.

Water Quality

Water quality characteristics of closest gaging stations on streams on the Arctic Slope associated with the proposed AAGPC pipeline system are presented in Table 2.1.1.5-4. The Sagavanirktok River represents a mountain stream with minor glacial influence; Happy Valley Creek is an example of a tundra stream; and Chamberlin Creek is a mountain stream.

These streams exhibit good water quality. The pH of the Sagavanirktok River is generally between 7.5 and 8.0; Happy Valley Creek is usually close to neutral; Chamberlin Creek had a pH of 6.5 to 6.6 in the summer of 1958 (Rainwater and Guy 1961). Their temperature ranges from 0°F to 17°C annually. The maximum temperatures are 33°F (1°C) in Chamberlin Creek (Rainwater and Guy, 1961), 37°F (8°C) in Happy Valley Creek, (EPA, 1973), and 41°F (17°C) in the Sagavanirktok River (USGS, 1972). Dissolved oxygen is usually high in the Sagavanirktok River and in Happy Valley Creek because of relatively low temperatures and biological activity.

The nutrient content of arctic streams is generally low. According to Hobbie (1973), phosphorous concentrations are always low, but nitrate may be high.

Nitrate concentrations are usually lower than 0.20mg/1 in the Sagavanirktok River. Nitrate was absent from Chamberlin Creek during the study by Rainwater and Guy (1961).

The erosion and deposition of sediments in the Arctic Slope drainage have not been studied extensively. These processes probably occur during

Table 2.1.1.5-2 Summary of surface water data on three selected Arctic streams, Alaska

Stream	Drainage area (sq mi)	Period of record (years)	Average Discharge (cfs)	Maximum Flow*		Minimum Flow	
				Date	Discharge (cfs)	Date	Discharge (cfs)
Putuligayuk River near Prudhoe Bay	176	2(1971-72)	43	Jun 6, 1971	4,980	No flow during some winter months	
Kuparuk River near Deadhorse	3130	2(1972-73)	1630	Jun 8, 1973	77,200	Jan 1/May 3-72 Dec 26/May 31-73	10
Sagavanirktok River near Sagwon	2208	2(1971-72)	1760	Jun 8, 1971	22,000	Mar 21/May 14-71	1.6

* Maximum peak flow

Source: USGS, 1972, 1974a, and 1974b

Table 2.1.1.5-3 Winter characteristics of streams along the proposed AAGPC pipeline route

M.P. (approx.)	Stream	Location	Date	Ice depth (m)	Water depth (m)	Flow m^3/sec	D.O. (mg/1)
15.5	Sagavanirktok River	1N	11/06/73	0.45	0.35	--	--
29.0	Kadleroshilik River	RC	04/18/73	0.6-1.0	0	0	0
36.0	Shaviovik River	RC	04/18/73	0.3-0.6	0	0	--
41.0	Kavik River	RC	04/18/73	1.0	0	0	--
		RC	11/03/73	0.44-0.46	0	0	--
58.5	Unnamed Stream	RC	11/07/73	--	0	0	--
61.5	Canning River	RC	04/18/73	2.3	0	0	--
		6N	11/05/73	0.3-0.35	0	0	--
81.5	Tamayariak River	RC	11/07/73	0	0	0	--
		1N	11/07/73	0	0.13-0.35	0.45	12.6
87.0	Katakturuk River	RC	11/07/73	0	0	0	--
upstream .5	Sadlerochit Spring	4S	04/12/73	0	0.2	1.30	10.4
		RC	11/07/73	0	0.09/0.21	0.76	12.2
111.5	Sadlerochit River	RC	11/07/73	0-0.01	0	0	--
115.5	Hulahula River	19S	04/06/73	0.9-1.2	--	--	11.2
		RC	04/18/73	0	0	0	--
		2.5N	11/05/73	0	0.00-0.25	1.35	--
130.0	Jago River	RC	04/18/73	0	0	0	--
		RC	11/07/73	0.26-.26	0	0	--
139.0	Okerokovik River	RC	11/07/73	0	0.1-0.2	0.1	10.0
151.0	Aichilik River	RC	11/07/73	0.66	0	0	--
	Unnamed Stream (MP 155.5)	RC	11/05/73	0	0	0	--
161.0	Egaksrak River	RC	11/05/73	0	0.05	0.01	12.6
165.5	Ekaluakat River	RC	11/05/73	0.34-0.42	0.0-0.01	0	--
172.5	Kongakut River	1N	04/04/72	0	0.3-0.9	--	12.2
		RC	11/05/72	0	0	0	--

*RC = River Crossings, S,N = Directions (south and north) and mileage from river crossing.

Table 2.1.1.5-4 Water quality of three streams in the Arctic slope drainage

Sample Date	Temp. °C	pH	Dissolved Oxygen mg/l	Dissolved Oxygen %Sat.	Conductivity μmhos at 25° C	Nitrate, NO_3-N mg/l	Color Pt Units	Suspend. Solids, mg/l	Turbidity JTU	Source
Sagavanirktok River Near Prudhoe Bay (LAT 70°11'40" LONG 148°06'40")										
05/07/69	0.2	--	--	--	1604	1.24	5	--	--	USGS, 1971c
Sagavanirktok River at Sagwon (LAT 69°22'00", LONG 148°06'40")										
05/02/69	0.2	8.0	--	--	905	0.00	5	--	--	USGS, 1971c
08/14/70	13.0	8.1	--	--	170	0.09	0	--	--	USGS, 1971d
09/03/70	5.0	8.0	--	--	188	0.05	0	4	--	USGS, 1971d
09/06/70	--	8.0	--	--	219	0.05	5	--	--	USGS, 1971d
Sagavanirktok River at Sagwon (LAT 69°05'20", LONG 148°45'10")										
11/15/70	0.0	7.3	9.0	63	190	--	--	--	--	N&K, 1973 1/
11/15/70	--	8.1	--	--	230	0.16	0	--	--	USGS, 1972
03/17/71	--	8.3	--	--	291	0.07	10	--	--	USGS, 1972
04/17/71	0.5	7.9	--	--	298	0.20	--	--	--	USGS, 1972
06/05/71	8.0	7.6	--	--	122	0.05	0	76	--	USGS, 1972
06/05/71	8.0	7.8	11.8	103	120	--	--	--	--	N&K, 1973
08/12/71	--	8.3	--	--	217	0.00	10	--	--	USGS, 1972
08/12/71	5.6	8.1	11.2	92	50	--	--	--	--	N&K, 1973
09/09/71	2.0	8.1	--	--	213	0.05	0	3	--	USGS, 1972
10/16/71	0.0	8.3	13.8	97	270	--	--	--	--	N&K, 1973
03/17/72	0.5	8.0	8.4	--	270	--	--	--	--	N&K, 1973
06/22/72	9.0	8.4	11.0	97	140	--	--	--	--	N&K, 1973
Happy Valley Creek (LAT 69°09'05", LONG 148°51'00")										
08/13/71	6.1	7.2	11.2	93	<50	--	--	--	--	N&K, 1973
10/15/71	0.0	7.3	13.3	94	60	--	--	--	--	N&K, 1973
06/21/72	10.7	7.0	10.2	94	21	--	--	--	--	N&K, 1973
08/13/72	9.3	6.8	10.6	94	21	--	--	--	--	N&K, 1973
09/08/72	5.3	6.9	11.7	87	38	--	--	--	--	N&K, 1973
Chamberlin Creek (800 feet downstream from Chamberlin Glacier)										
07/07/58	--	--	--	--	12	--	--	265	--	R&G, 1961 2/
07/14/58	--	--	--	--	11	--	--	616	--	R&G, 1961
07/28/58	--	--	--	--	12	--	--	758	--	R&G, 1961
08/03/58	--	--	--	--	15	--	--	84	--	R&G, 1961
08/10/58	1	--	--	--	14	--	--	85	80	R&G, 1961
08/17/58	1	--	--	--	20	--	--	131	150	R&G, 1961
08/26/58	1	--	--	--	24	--	--	60	70	R&G, 1961
08/28/58	--	--	--	--	60	--	--	2	20	R&G, 1961

Source: EPAC, 1974, Vol. 4, 2A.4-14

1/ Nauman and Kernodle

2/ Rainwater and Guy

periods of peak flow, primarily during spring breakup. During a 3-week period in June in 1962 approximately 75 percent of the annual sediment load of the Colville River was transported (Walker, 1973).

Lakes and Ponds

The coastal plain contains numerous lakes; in some areas 80 percent of the total surface area is lakes (Brown et al., 1968). The lakes are from 2 to 20 feet in depth; they are rectangular or oval in shape. During spring breakup, the lakes impound meltwater and often flood beyond their normal shorelines. Lake levels decrease after breakup, often to levels below their outlet elevation, and may become stagnant.

Water Quality

Topographic and climatologic conditions greatly affect the physical and chemical water quality of tundra lakes and ponds. Lakes and ponds usually freeze over by mid- to late-September; they remain frozen until late June or July (Brewer, 1958; Sater, 1969); and shallow-water bodies freeze to the bottom each winter.

Ice isolates the lakes from outside influences for 9 or 10 months of the year. Ice in the lakes generally reaches a maximum thickness in either March or April. This thickness in the eastern arctic area is between 6.0 and 7.5 feet.

Dissolved oxygen is normally at maximum during the open-water season and in the fall (Howard and Prescott, 1971). This is due to the low level of biological activity (Sater, 1969). From midwinter to breakup, dissolved oxygen decreases, often to levels less than 5 mg/1 (Howard and Prescott, 1971); severe deoxygenation may take place under ice so that some waters become anaerobic (Hobbie, 1973).

In general, the fresh waters of the North Slope that are uninfluenced by the ocean are dilute calcium bicarbonate waters (Kalff, 1968). During summer, the salt concentration in lakes and ponds near the coast increases as salt spray is carried inland by storms (Howard and Prescott, 1971). Salt concentrations also fluctuate seasonally. Low dissolved solids concentrations in tundra ponds and lakes occur during breakup (Sater, 1969). Salts in ponds and small lakes concentrate during summer because of evaporation (Hobbie, 1973); salts concentrate during winter because of solids rejection during freezing (Sater, 1969; Hobbie, 1973). The concentrations of inorganic ions (except nutrients) in North Slope fresh waters are similar to those in temperate waters (Hobbie, 1973).

In ponds and lakes, pH generally ranges from slightly below neutral to about 8.0 (Howard and Prescott, 1971). Nutrients in arctic waters are present in small quantities (Sater, 1969; Hobbie, 1973). Phosphate concentrations are low in lakes and ponds (Barsdate, 1971; Hobbie, 1973). In a study of six lakes and two ponds during the summer of 1964, Kalff (1968) reported phosphate (PO_4) as ranging from 0.002 to 0.018 mg/1 in lakes and from 0.002 to 0.010 mg/1 in ponds. In the same study, nitrate (NO_3) ranged from less than 0.01 to 0.02 mg/1 in lakes and from 0.05 to 0.17 mg/1 in ponds.

Tundra pondwater color is a result of the leaching of organic material, which is increased by poor drainage on the Coastal Plain. The bottom sediments of tundra ponds are also highly organic (Hobbie, 1971).

Groundwater

Groundwater conditions along the route of the proposed pipeline are affected by permafrost.

Groundwater is usually found beneath permafrost, sometimes at great depths where the permafrost is continuous. The water may or may not be brackish, depending upon availability of freshwater recharge, groundwater flow rates, and other factors. Where permafrost extends to great depths, groundwater is usually saline or high in mineral content, since permafrost tends to be impermeable and prevents fresh water from percolating downward. In many cases, water from wells drilled in permafrost flows under artesian pressure because permafrost confines the aquifer.

Where drainage is impeded by slope and soil conditions during the summer months, a perched water table at or near the ground surface may be created if the permafrost is close to the ground surface, thereby creating marshy or swampy conditions such as those found on the Arctic Slope. (See 2.1.1.3-Permafrost.)

Groundwater in permafrost regions may also be located under rivers so deep that they do not freeze solidly each winter. Groundwater resources have not been developed or explored to any significant extent in the Arctic Slope drainage or in the vicinity of the pipeline route. Underneath the rivers, shallow aquifers may exist. The principal recharge source then would be the river itself, and the direction of groundwater flow would be in the general direction of the regional slope.

Water Quality

The quality of groundwater in the Arctic Slope drainage is probably best in alluvium beneath rivers. Shallow groundwater in these areas is of the calcium bicarbonate type, usually with less than 250 mg/l of dissolved solids. Dissolved solids probably become more concentrated with depth. Formation tests of a well between Umiat Lake and the Colville River showed an increase in dissolved solids and chloride concentrations with depth. Saline groundwater, mainly of the sodium chloride type, is common below permafrost on the Coastal Plain; brackish or saline water occurs at great depth in the Foothills (Williams, 1970). Groundwater beneath lakes in the Coastal Plain may contain dissolved organic material (Williams, 1970). The temperature of groundwater in the Arctic Slope drainage rarely exceeds 33 to 33.5°F (1° to 1.5°C).

Springs

The eastern portion of the Brooks Range, where sandstone and shale overlie the limestone, contains numerous springs. Most springs within the drainage basins of rivers in the Brooks Range foothills and river valleys originate from fracture zones in the Lisburne Limestone Formation which is associated with the northern front of the Brooks Range (Williams, 1970). Other springs originate from younger rocks. All of these springs flow throughout the year. However, much of the water flow is immediately frozen as aufeis and augments the flow of recipient streams. Among the largest of the springs in the Brooks Range foothills are Shublik Spring (1.5 cu.m/sec), Echooka Spring (1.2 cu.m/sec) and Sadlerochit Spring (immediately upstream from the proposed route) (0.6 cu.m/sec) (Craig and McCart, 1974a).

Many springs are found in the eastern Brooks Range, but most of the larger springs are found along the northern edge of the mountains. In 1972 the Geological Survey (Childers et al., 1973) conducted a reconnaissance survey of selected springs in the upper Sagavanirktok River basin and Shublik Spring on the Canning River.

Discharge, temperature, and specific conductance of the springs were measured and water samples collected for laboratory analysis. Spring discharge ranged from 4.2 to 36.5 cfs, and spring temperatures ranged from 2.8° to 9.2°C. In August, Shublik Spring discharged 37.3 cfs at 3.6°C compared to 36.2 cfs and 5.3°C in July 1972. These small differences were attributed to the accuracy of the field measuring equipment.

Calcium bicarbonate was the principal mineral in the springs; total dissolved solids ranged from 162 to 156 milligrams per liter. Water temperature and chemical analysis indicate the springs were recharged during the melt season when water percolates into permeable limestone bedrock and associated talus and alluvial deposits.

Most springs discharge from limestone of the Lisburne Group or its associated alluvial deposits.

Large areas of aufeis (icing) are associated with springs in the area and provide an excellent indicator of spring activity. In some instances, aufeis deposits are 20 or more feet thick and several miles in length.

The U.S. Geological Survey planned a reconnaissance level survey of springs associated with the proposed AAGPC pipeline system during April 1975. The purpose of this survey was to obtain better information on low flow and water quality.

Table 2.1.1.5-5 summarizes water data collected at selected springs in 1972.

The locations of known springs are shown in Figure 2.1.1.5-1. Almost all of the springs are located south of the general route. A few perennial groundwater sources are also located on the Arctic Coastal Plain itself; these probably originate from tertiary formations rather than the Lisburne limestone (U.S. Geological Survey, 1971).

Present Water Use: Streams, Lakes, and Groundwater

A small amount of water may be taken from streams by hunting or fishing parties, or other small groups during the summer months.

Ice thickness and reduced flow cause water supply problems, except in deeper zones of the stream, after about the end of December.

Many of the shallow lakes freeze solid, however, the ice can provide a water source. Flowing groundwater (springs) usually has some unfrozen areas during the winter.

Beaufort Sea

The overall movement of surface water in the Pacific Gyre off the northern coast of Alaska is westward, paralleling the ice drift (Campbell, 1965; Wiseman et al., 1974) (Figure 2.1.1.5-2). On the inner shelf, there are significant shifts in this pattern during the summer and an intermittent influx of Bering Sea water has been noted (Hufford, 1974; Mountain, 1974). The oceanographic regime reflects strongly an influence of winds and the

Table 2.1.1.5-5 Physical and chemical characteristics of selected springs

Name	Location		Date sampled	Discharge (cfs)	Temperature (°C)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)
	Latitude	Longitude								
Lupine	68°51'45"	148°12'20"	7/ 9/72	5.8	9.2	3.3	48	8.2	0.5	0.1
Saviukviayak W.	68°54'10"	148°05'10"	7/10/72	12.9	2.8	3.1	42	7.4	.5	0
Saviukviayak Trib.	68°56'20"	147°58'45"	7/10/72	10.7	5.3	4.2	37	8	.2	0.1
Flood Creek	68°58'40"	147°51'30"	7/11/72	36	8.5	5.1	35	8.5	.4	.2
Ivishak Hillside	69°01'50"	147°43'00"	7/11/72	4.2	8.0	4.8	35	9	.3	.1
Echooka West	69°15'35"	147°22'50"	7/12/72	36.5	6.6	4.9	36	9.8	1.2	.2
Echooka East	69°16'00"	147°20'25"	7/12/72	34.9	5.0	3.9	34	8.6	0.5	.1
Shublik	69°28'20"	146°11'50"	7/12/72	36.2	5.3	4.3	39	11	1.5	.3

Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as $CaCO_3$		Total alkalinity as $CaCO_3$	Dissolved solids calculated	Specific conductance (microchos at 25°C)	pH
					Calcium, magnesium	Noncarbonate				
160	10	1.0	0.5	0	153	12	85	156	271	8.6
154	7	1.0	.4	0	135	9	76	137	243	8.5
130	11	2.0	.5	0.2	125	18	64	127	226	8.4
131	11	2.0	.6	.3	122	15	64	127	224	8.4
134	11	0.8	.5	0	125	15	66	128	225	8.4
132	22	1.5	.3	0	131	23	65	141	245	8.4
126	16	1.0	.2	0.1	120	17	62	126	222	8.4
128	35	1.8	.4	0	142	37	63	156	265	8.4

Source: Childers et al., 1973.

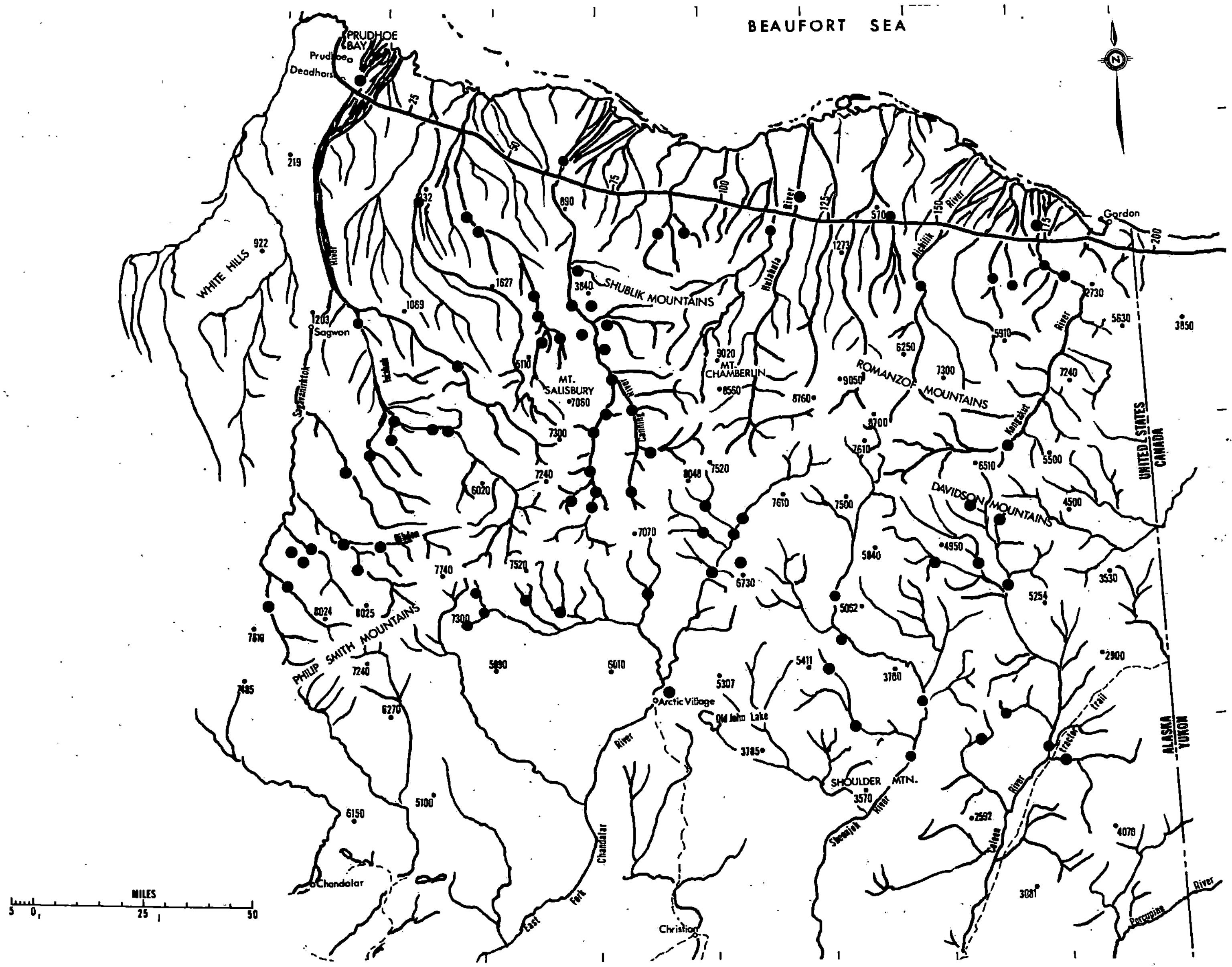
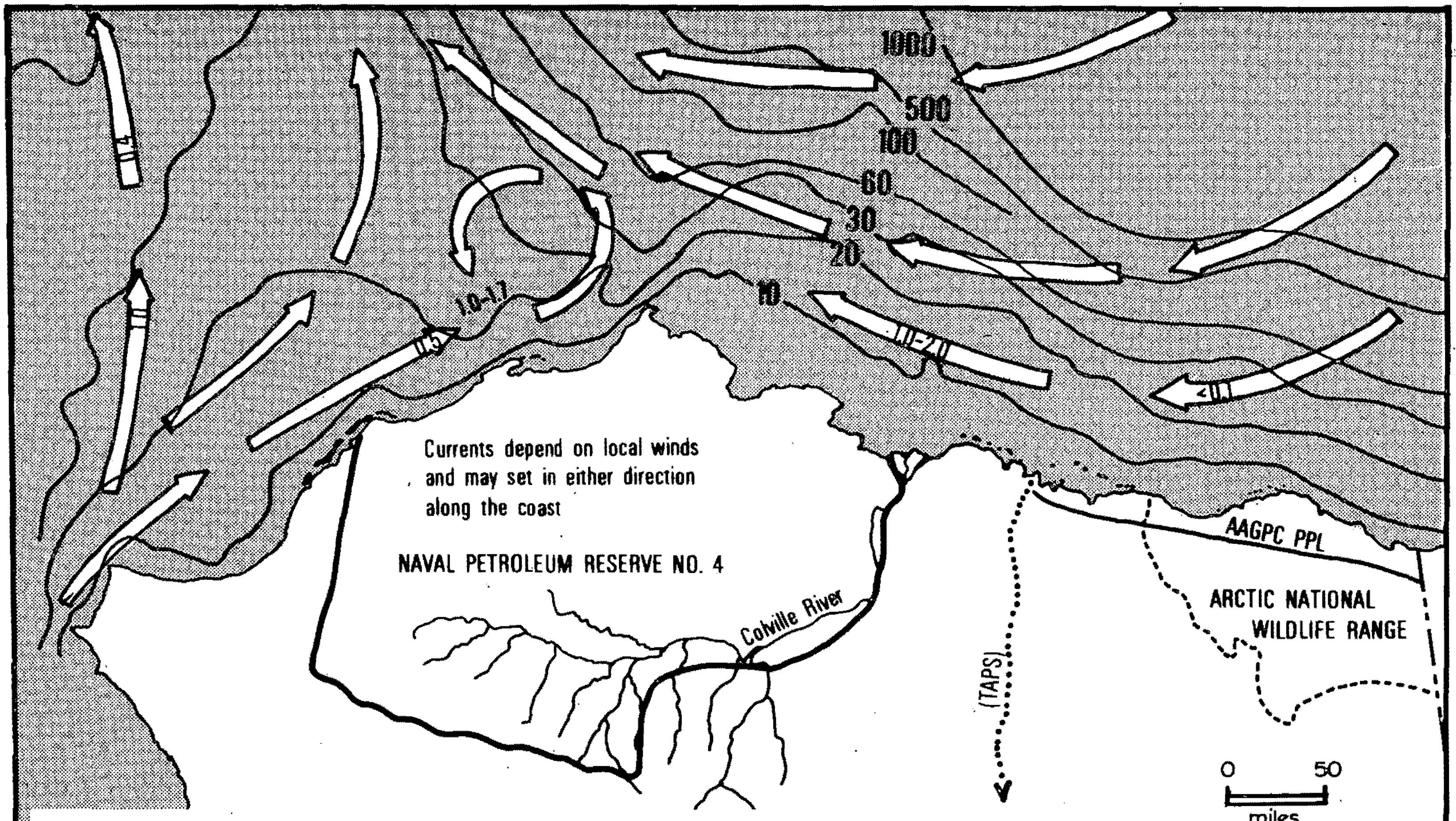


Figure 2.1.1.5-1 Location of perennial springs in N.E. Alaska



Source: Searby & Hunter, 1971 from Namtvedt et al., 1974

Figure 2.1.1.5-2 General surface circulation seasonal presence or absence of ice. Current velocity measurements made during the season of ice cover show an cverall westward movement of near-bottom waters on the inner shelf at 2 cm/sec parallel to the coastline (Barnes and Reimnitz, 1972, and unpublished data). The flow rates are low because the ice cover eliminates wind stress on the water. During the winter, tidal currents of up to 25 cm/sec in shallow water have been measured under the ice in places where the tidal prism has been constricted by the growth of ice (Barnes and Reimnitz, 1974).

During the summer, seasonal currents and ice movement are controlled by the wind regime and both easterly and westerly currents are observed, although easterly winds and westerly currents are most prevalent (Kinney et al., 1972; Short, 1973; Wiseman et al., 1974). Analysis of ERTS-1 imagery of the summers of 1972 and 1973 indicates that the dominant direction of movement for the river-supplied sediment plumes is westerly. During this season current-meter records show an overall westward current up to 25 cm/sec (USGS, unpublished data) inside the 33 foot contour.

The normal tidal range along the coast is 5.9 to 11.8 inches (15 to 30 cm) but storm conditions (wind and pressure) commonly create sea-level fluctuations of more than 3.3 feet (1 m) (Wiseman et al., 1974).

Westerly storms, like the one of September 13, 1970, may cause sea level setup of over 10 feet (3 m) (Reimnitz et al., 1972).

Waves are generated during the summer months only, and generally are small because of the restricted fetch related to the presence of sea ice not far from the coast. When the fetch is large, swells with the height of 6.6 to 8.2 feet (2 to 2.5 m) and periods of 8 to 10 seconds have been observed along the coast. The first comprehensive long-term study on wave regime and related coastal processes along this coast was made during the 1972 open season (Short, 1973; Wiseman et al., 1974).

The Beaufort Sea overlies a narrow continental shelf and interacts with the deep Arctic Ocean to the north and the shallow Chukchi Sea to the west.

The circulation on the Beaufort shelf in summer is complex and not completely understood. Mountain (1974) reports eastward flow of water along the inner shelf which appears to be a regular and dominant feature of shelf circulation. The eastward flow does not result from a local driving force but, rather, appears to develop from intrusion of Bering Sea water into the Chukchi and finally onto the Beaufort Shelf. The Bering Sea water enters the shelf through Barrow Canyon and has considerable momentum. Current measurements from depths of 361 to 459 feet (110 and 140 m) showed maximum velocities of over 100 cm/sec, with averages of about 40 cm/sec.

In addition, clockwise westward flow associated with the Pacific Gyre has been identified along the outer shelf (Dunbar and Harding, 1968). The gyral center is near 78°N and 150°W in the Arctic Ocean. The clockwise motion is associated with periods of upwelling. The upwelling regime is driven by the local easterly winds. This westward flow has been observed less frequently than the eastward circulation and is believed to be intermittent (Mountain, 1974). The conditions generating upwelling are not yet understood.

The nearshore currents along the Beaufort Sea are strongly influenced by local winds. Southwesterly winds, produced by low pressure system and infrequent westerly storms encountered mainly in late summer and fall, can cause easterly flow and higher sea level.

The mean lunar tidal range for the Alaska Arctic Coast along the Beaufort Sea is of very low amplitude, about 5.9 to 11.8 inches (15 to 30 cm) (Kinney et al., 1972; Reimnitz and Barnes, 1974; Beal, 1968). The associated tidal currents are weak. Because lunar tides are not important, nontidal factors affecting sea heights are unusually significant. Winds and atmospheric pressure are particularly important. Storm surges can cause changes in sea level as great as 4.9 feet (1.5 m) over a period of a few days (Kinney et al., 1972). All available data indicate a strong correlation between high tides and westerly winds.

The generation of surface waves is restricted to the summer open-water months. Even during this time, waves are small because of the restricted fetch resulting from sea ice near shore (Reimnitz and Barnes, 1974). Swells with heights of 5.9 to 6.9 feet (1.8 to 2.1 m) and periods of 8 to 10 seconds have been observed along the coast when the ice pack was far out to sea (Wiseman, 1974).

2.1.1.6 Vegetation

Vegetation is generally classified by units in order of their magnitude as: plant formations, plant associations, and component plant communities.

Major Plant Formations, Associations, and Communities

Tundra Plant Formation

The proposed pipeline route involves only the Tundra plant formation. This is a treeless formation that is substantially influenced by topography, substrate origin and composition, surface hydrology, and ice features at all locations on the Arctic Slope.

Permafrost restricts the roots of plants to a very shallow layer of soil that annually thaws. From early November to early May, the entire soil column is frozen. New plant growth is held in check until either the soil is adequately thawed or until soil around the permeating crown has warmed. Longitudinal growth of the roots of most arctic plants follows the retreating frost at a high rate with the root tip no more than about 1 inch from the frozen zone.

Permafrost not only controls the rate of plant growth, but also vitally affects the abundance and variety of plant life. Since the average annual precipitation is approximately 10 inches, the Arctic Slope would be a desert, but the permafrost keeps water at or near the surface and thereby maintains a reservoir within reach of the plant roots.

Frost-boils (semiliquid mud forced to the surface during the fall-winter freeze cycle) result in a thin layer of subsurface soil materials being spread on top of the original soil-vegetation cover. In frost-boil areas, plants usually are established very slowly.

Several arctic waterfowl and animals affect vegetation. Molting waterfowl, because of their great numbers, consume large quantities of vegetation along lakes and estuaries, pack the denuded soil, and enrich the soil with fecal matter in concentrated areas. The brown lemming exerts a much wider effect. The food-gathering activities of these small animals at the peak of their population cycle can be significant. Migration routes of the caribou where extensive trails are cut can cause severe, local erosion; their trampling can destroy plant cover.

Plant Associations and Component Plant Communities

Five broad associations of vegetation have been identified in the area of the proposed AAGPC pipeline. These associations are: Wet Tundra, Moist Tundra, High Brush, Riparian Shrub, and Beach-Sand Dune-Strand (Figure 2.1.1.6-1). The following discussion of these associations are accompanied by description of their component plant communities.

Wet Tundra

Wet Tundra occurs with areas of standing water with little topographic relief. Microrelief features caused by frost polygons and peat ridges are common. Dominant plants are sedges and cottongrass, which tend to form a uniform vegetative mat rather than tussocks. A few woody and herbaceous plants grow above the water table.

Rooted aquatic plants along fresh-water shorelines and shallow lakes are associated with lichens, mosses, low-growing willows, dwarf birch, Labrador tea, cinquefoil, and beach rye. Rooted aquatic plants are burr reed, pondweed, pendent grasses, and mare's tail.

Wet Sedge Meadow Community--The wet sedge meadow plant community is characterized by a broad, flat, poorly drained lowland closely intervalled by areas of polygonally patterned ground.

Sedge (Carex aquatilis) is the most characteristic species, though a number of other sedges may be important or dominant in some areas occupied by this species. Other sedges include Carex chordorrihiza, C. rariflora, C. rotundata, and C. membranacea. Cottongrasses (Eriophorum spp.) may be locally important, but usually are not tussock-forming species. Mosses consisting of sphagnum (Sphagnum spp.) constitute as much as 50 percent of the ground cover in some wetter areas.

Other plants associated with this community include horsetail (Equisetum palustre), cloudberry (Rubus chamaemorus), bistort (Polygonum viviparum), coltsfoot (Petasites frigidus), and nodding saxifrage (Saxifraga cernua).

Fresh-water Aquatic Vegetation Community--Plant in concentric bands, reflecting water depths. Most plants are limited to water less than 4 feet deep. Near the Arctic Coast, where climatic conditions are more severe, plants grow only at shallower depths. Each plant community reproduces by vegetative means and, once established, tends to exclude other species.

Submerged rooted aquatic plants can grow in water up to 4 feet deep. Pondweed (Potamogeton) and buttercups (Ranunculus) are most common. The rooted emergents are more important and generally grow in 1 to 3 feet of water. Most common are the grass (Arctophila fulva), horsetail (Equisetum limosum), mare's tail (Hippuris vulgaris), and cinquefoil (Potentilla palustris). The sedge (Carex aquatilis) cottongrass (Eriophorum angustifolium), and mountain foxtail (Alopecurus alpinus) grow in less than 1 foot of water and are considered transitionally emergent.

Rooted emergent plants are important in the filling of lakes through peat accumulation. With the accumulation of plant remains, the water is gradually displaced with organic debris, which forms a vegetative mat. A meadow sedge mat finally becomes established.

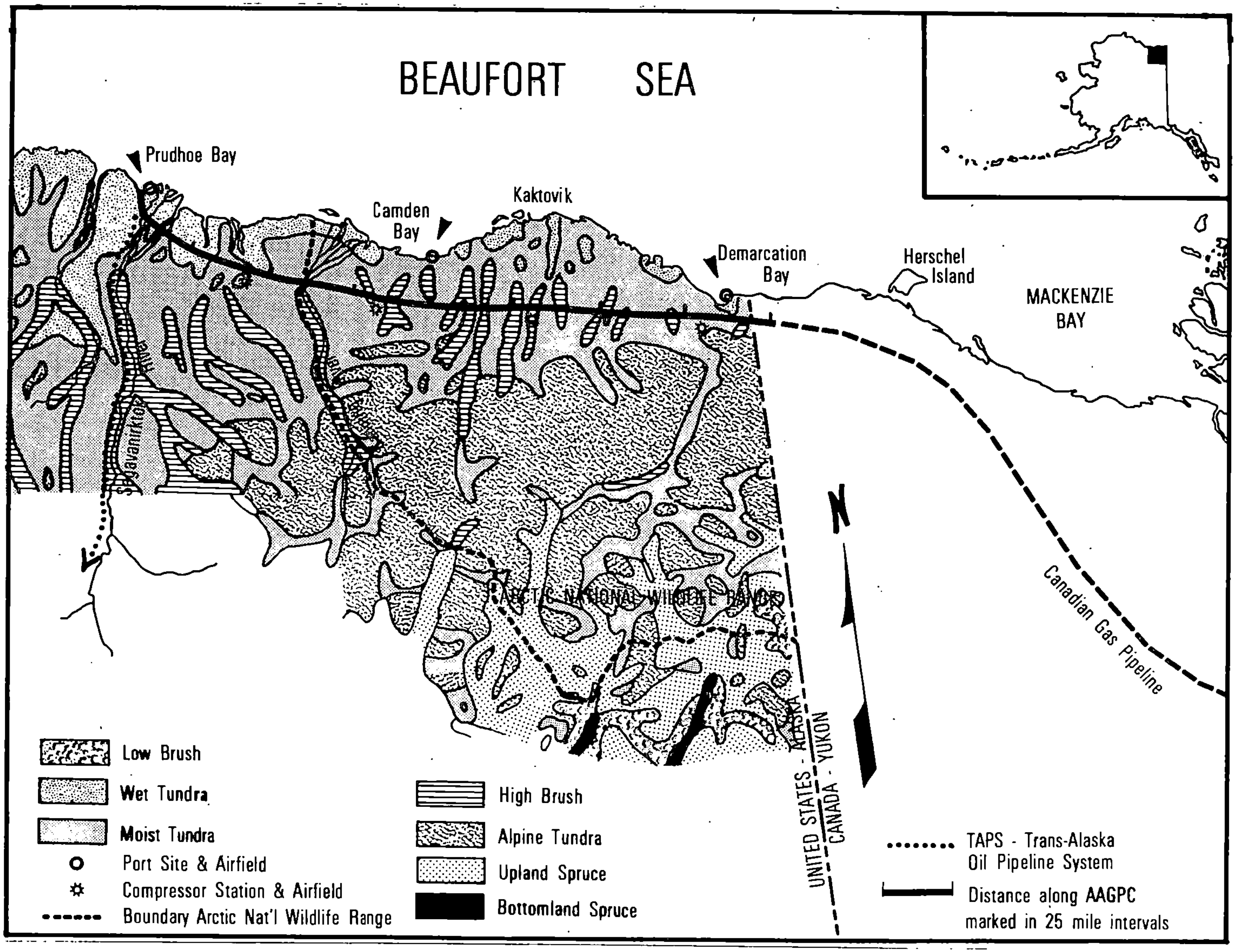


Figure 2.1.1.6-1 Plant associations along the proposed AAGPC pipeline, Alaska

Moist Tundra

Moist Tundra varies from continuous and uniformly developed cottongrass tussocks with sparse growth of other sedges and dwarf shrubs to areas where tussocks are scarce or lacking and dwarf shrubs are dominant. Associated species are arctagrostis, bluejoint, tufted hairgrass, mosses, alpine azalea, wood rush, mountain avens, bistort, low-growing willows, Labrador tea, green alder, Lapland rosebay, blueberry, and mountain cranberry. Cottongrass-tussock communities are most widespread, and in northern areas, often are associated with polygonal patterns created by underlying icewedges. This community occurs most commonly on south slopes and low moraines which have well-drained loamy soils.

Tussock-Dwarf Heath Tundra Community--The tussock-dwarf heath tundra plant community occurs extensively on poorly to moderately drained soils, typically covered by standing surface water for several weeks following spring snow melt. Sometimes wet soil surface or standing water remain during the entire growing season.

Cottongrasses (Eriophorum vaginatum, spp. spissum and E. angustifolium spp. subarticum) are the dominant. Some cottongrass species, particularly E. vaginatum spp. spissum, form tussocks from 6 to 10 inches high and of equal width. Mossy channels, several inches to 1 foot in width, may separate the individual tussocks. Tussock development, however, may not be pronounced where this vegetation type has not been long established. Mountain avens (Dryas integrifolia), crowberry (Empetrum nigrum), lingonberry (Vaccinium vitis-idaea), dwarf birch (Betula nana spp. exilis) are characteristic of drier areas of the tussock-dwarf heath community.

High Brush

High Brush is comprised of deciduous shrub plants. Interspersed among shrubs are barren rocks and rubble and low mats of both herbaceous and shrubby plants. White mountain-avens is often a major component of the low mat as are moss campion, black oxytrope, arctic sandwort and several lichens, grasses, and sedges.

Dwarf Shrub-heath Tundra Community--The dwarf shrub-heath tundra plant community occupies many of the drier (moderate- to well-drained) sites. These are formed either by elevation (i.e., where streambanks, pingos, or polygonal ridges provide sites above adjacent lower areas) or because of a well-drained substrate such as gravel.

The dwarf shrub-heath tundra association is characterized by dwarf willows, particularly the reticulate-leaved willow (Salix reticulata spp. reticulata), mountain avens (Dryas integrifolia), and mountain heather (Cassiope tetragona). Other common or locally abundant species include cottongrass (Eriophorum spp.), sedge (Carex spp.), polargrass (Arctagrostis latifolia), lingonberry (Vaccinium vitis-idaea), Labrador tea (Ledum palustre spp. decumbens), crowberry (Empetrum nigrum), and dwarf birch (Betula nana spp. exilis).

Plant communities on the drier locations are major components of the upland-tundra vegetation types of the Foothill and Mountain provinces.

Riparian Shrub

Within the riparian shrub association, shrub communities on gravel bars and well-drained lateral embankments of streams and rivers on the Arctic Coastal Plain are dominated by willow species, particularly the feltleaf willow (Salix alaxensis). Other willow species include Salix arbusculoides, S. niphoclada, S. Richrardsonii, and S. walpolei. Associated flowering herbaceous species include a firewood (Epilobium latifolium), milk vetches (Astragulus spp.), (Minuartia spp.), saxifrages (Saxifraga spp.), and louseworts (Pedicularis spp.).

Ground cover ranges from less than 10 percent on gravel bars of many rivers to almost total cover on older, established sites. Shrub communities at the latter sites often grade into the dwarf shrub-heath tundra type communities.

Beach--Sand Dune--Strand

The beach--sand dune--strand association is present along the shore of the Beaufort Sea between Prudhoe Bay and United States Canada border. This association is highly variable in its form, substrate makeup, microrelief, steepness, erosion, and associated plant communities. The tussock-dwarf heath tundra or wet sedge meadow communities of adjacent areas often are almost at shoreline or within a very short distance of it, depending upon the limit of ice and wave scouring. This plant association occurs in areas of wave and ice action or where a sand substrate creates an excessively drained substrate; therefore, little or no vegetation may be present. Gravel coasts and river and stream deltas are occupied by plant communities, similar to the riparian shrub communities, with willows less important on the immediate coast.

Figure 2.1.1.6-2 schematically shows the general relationship of the plant communities in the project area.

Tables 2.1.1.6-1 and 2.1.1.6-2 summarize the approximate abundance of vegetation and mileages of plant communities crossed by the proposed AAGPC pipeline.

Human Influences on Existing Vegetation

Residents of Kaktovik depend upon the native vegetation for food. Although data are unavailable on the amounts consumed, berries, greens, and roots are important elements of their diet. Human use of the native vegetation has had no significant influence on plant distribution.

Damage to vegetation is mostly from track impressions left on the tundra by all-terrain vehicles. There is no agriculture.

Unique, Sensitive, and/or Threatened Ecosystems or Communities

Arctic ecosystems traditionally are described as "sensitive." This sensitivity primarily reflects the severity of abiotic (nonliving) conditions and the tenuous adaptations evolved by tundra fauna and flora.

The low level of incoming solar radiation is the dominant factor influencing the biotic (living) community. The ability of vegetative communities to respond to natural or man-induced stresses is limited greatly

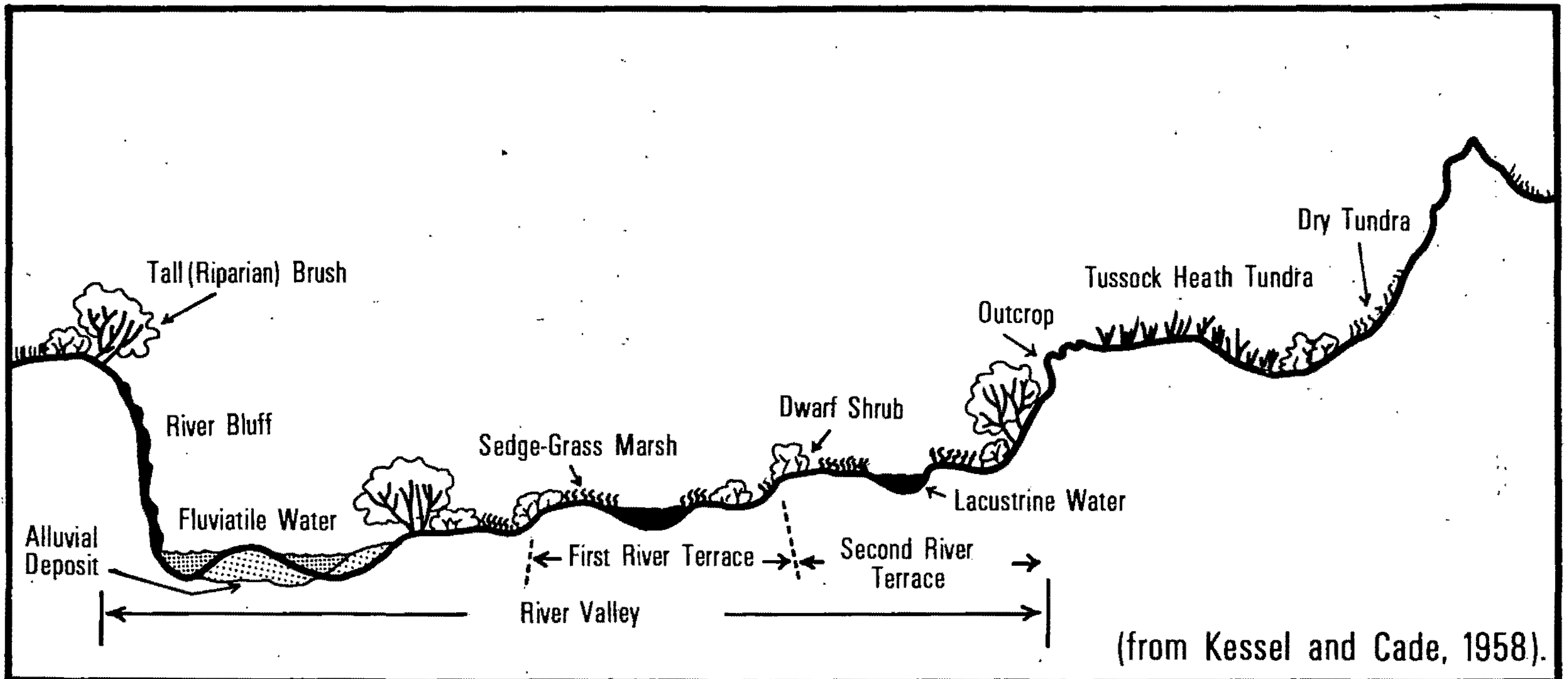


Figure 2.1.1.6-2 Alaskan vegetative communities in relation to topography

Table 2.1.1.6-1 The approximate abundance of vegetation along the proposed pipeline route

Plant Community	Total mileage	Percent total	Dominate areas (Mile Posts)
Wet Sedge Meadow	22	11.3	0 to 30
Tussock-Dwarf Heath Tundra	67	34.3	30 to 40
Dwarf-Shrub-Heath Tundra	84	43.1	40 to 195
Riparian shrub	21	10.8	120 streams
Beach-Sand Dune-Strand	-0-		
Freshwater aquatics		0.5	0 to 56
	195	100.0	

Filled in ponds where aquatic vegetation is converting to dryland vegetation: A total of 11 miles of old ponds is involved.

Table 2.1.1.6-2 The approximate mileage of the broad vegetation zones classified by the joint Federal-State land use commission

Vegetation type	Total mileage	Percent total
Wet tundra	22	11
Moist tundra	152	78
High brush	21	11
	195	100

by the abiotic conditions. As a result, activities which would cause minor dislocation in vegetative communities in more temperate climates may have major and long-lasting impacts in the Arctic.

The proposed AAGPC pipeline system intersects the only remaining largely undisturbed continuum of plant formations from the Arctic Ocean to the interior of Alaska. Several of these plant communities have been identified as having high prospective value for scientific study as ecological preserves. These are discussed in 2.1.1.12.

Threatened Species

The National Herbarium of the Smithsonian Institution in Washington, D. C., has compiled a list of endangered plant species for the United States. In this list are 35 species from Alaska. Only one of these, *Thlaspi arcticum*, a member of the mustard (*Cruciferae*) family, occurs in the vicinity of the proposed route.

During field studies connected with vegetation sampling along the proposed route, the Applicant collected samples of *Salix reptans*, a willow previously described only from Eurasia. This collection from the Kongakut River area represents the only known location of this willow in North America.

2.1.1.7 Wildlife

Principal mammalian species associated with the proposed AAGPC pipeline system include seven large land mammals of widespread public interest--polar bear, grizzly bear, musk oxen, moose, caribou, Dall sheep, and wolves. In addition, marine mammals including three species of seals and seven species of whales may be involved when arctic waters are used to ship supplies to construct and repair the proposed system. Small mammals include arctic and red foxes, wolverines, lemmings, voles, and ground squirrels.

Thirty-one species of waterfowl frequent the proposed AAGPC pipeline area. These include pintails, oldsquaw, Canada geese, snow geese, white-fronted geese, black brant, whistling swans, trumpeter swans, and arctic loons.

Thirty-five species of songbirds (passerines) are found in area associated with the proposed system, and 24 species of shorebirds. Lapland longspurs are the most abundant songbirds while pectoral sandpipers and semipalmated sandpipers are the most abundant of the shorebirds. Northern phalarope, golden plover, and ruddy turnstones are also abundant.

The dominant fish species found in waters along the proposed pipeline route are the arctic char, arctic grayling, and ninespine stickleback.

The dominant insects are the mosquitoes, horseflies, deerflies, and blackflies.

Land Mammals

Caribou

Caribou (*Rangifer tarandus*) are nomadic herd animals and must travel constantly to find adequate food. In summer, they feed on the leaves of the willow and dwarf birches, grasses, sedges, and succulent plants. After the autumn frost, they feed on lichens (reindeer moss) and dried sedges (Hemming, 1970). More than any other animal, the caribou symbolizes the windswept tundra. The annual 1300-1500 air mile movement of the more than 100,000 animals in the Porcupine Caribou Herd, treking along their ancestral paths, is one of the world's most impressive biological phenomena.

The Porcupine Caribou Herd, fourth largest on the North American Continent and second largest in Alaska (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 size of the Porcupine Herd fluctuates. In 1964 the population of the Porcupine Herd was estimated to be as large as 140,000 animals. Its current size is estimated to be between 115,000 and 120,000 animals (Roseneau, pers. comm., 1975).

A characteristic of caribou is that they constantly move from one area to another. They visit some areas annually; others infrequently. At the present time, most of the Porcupine Herd winters south of the Brooks Range in the boreal forests of Canada and Alaska. During April and May the herd moves to calving grounds north of the Brooks Range in Alaska and the British Mountains in the Yukon Territory, Canada. Which passes and valleys will be used as the herd moves north is unpredictable; however, old trails and caribou fences constructed by past generations of Native hunters suggest strongly that the herd's basic yearly movements may not have changed for centuries.

Major spring, post-calving and fall migration movements tend to be in an arc through Canada, around and through the British Mountains, across the Firth River drainage and along the foothills and arctic coastal plain north of the Brooks Range in Alaska. Figure 2.1.1.7-1 shows the spring migration routes of the Porcupine Herd in 1973 and 1974. As indicated above, all major river valleys and mountain passes through the Brooks Range are used at some time. The frequency and numbers of caribou using these migration routes appear to be associated with the number of caribou wintering south of the Brooks Range in Alaska. Within Alaska the Kongakut River on the Arctic Coast is a frequently used north-south migration route. The Canning, Hulahula, Aichilik and Kongakut River valleys are important routes through the Brooks Range for both spring and fall movements. Migration routes between seasonal ranges are important in the distribution of caribou.

During the spring migration moving groups of 1,000 to 5,000 or more caribou in single or multiple lines, nose to tail, are common. During post-calving movements the most impressive compact groups are encountered. Groups of 20,000 or even the entire herd characterizes this period.

The proposed AAGPC pipeline system crosses the traditional calving grounds of the Porcupine Herd. Recent studies have found that seasonal movements follow a relatively well defined pattern with the herd tending always to return to the traditional calving area (Figure 2.1.1.7-2). This area is windswept and generally snow free by mid-May or early June, with the foothills to about 500-feet in elevation generally becoming snow-free first. The Alaska Department of Fish and Game (1973) points out that the calving area is the focal point of a herd's range and is critical to the herd's existence. This critical area for the Porcupine Herd in Alaska is located within the Arctic National Wildlife Range.

It appears that the calving grounds of the Porcupine Herd vary considerably from year to year. Substantial calving may occur from the Canning River as far east as the Blow River in the Yukon Territory and from the Arctic Coast inland as far south as the northern slopes of the Brooks

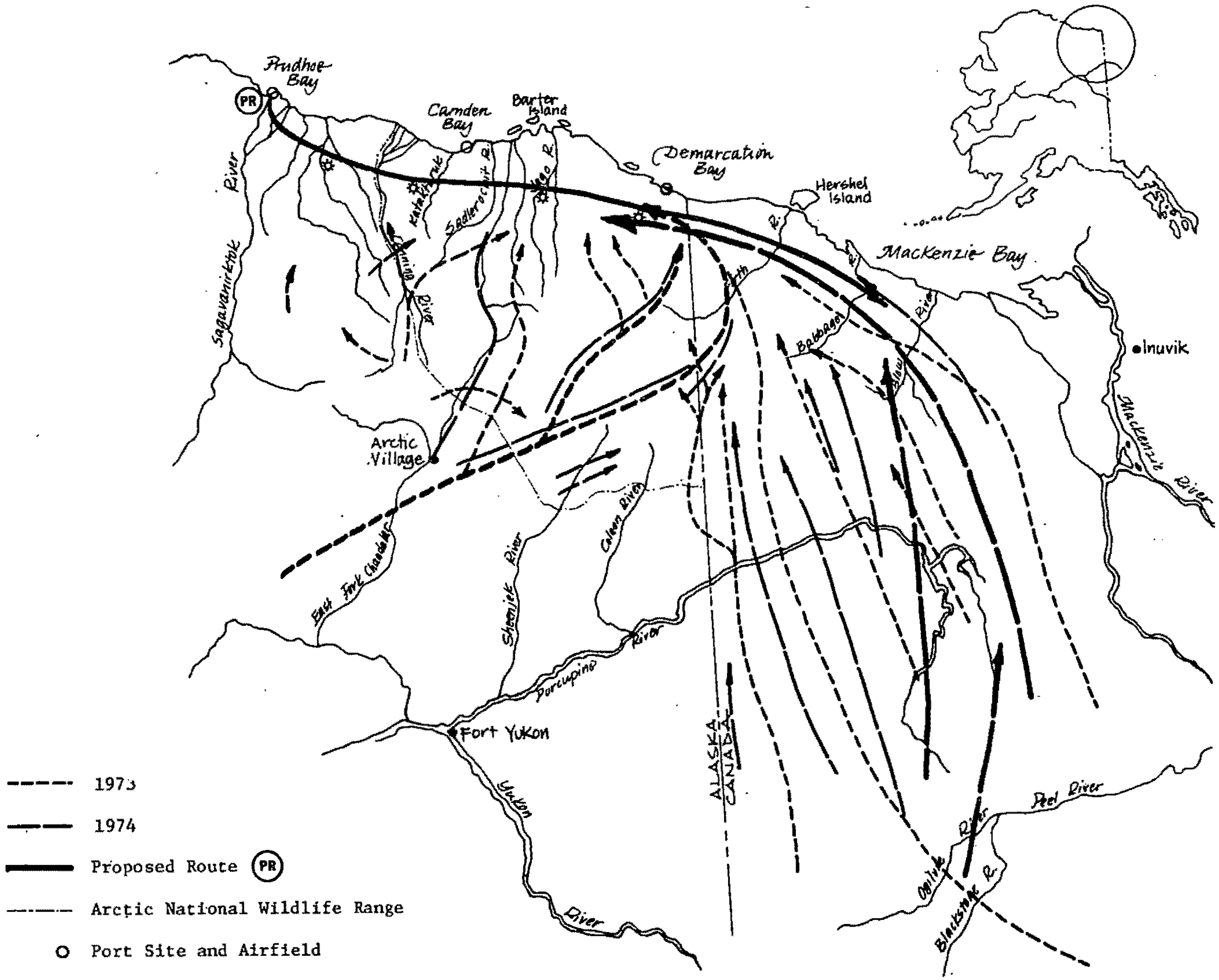
Table 2.1.1.7-1 Comparison of numbers in important caribou herds

Herd	Year	Number Estimated (including calves)	Method of Estimation	Total Area of Range mi^2	Population Density $/mi^2$	Reference to Pop. Estimate
Porcupine	1964	140,000	Aerial transect - Extrapolation (calving grounds)			Lentfer 1965
Porcupine	1972	90,000-110,000	Air photo count - extrapolation (post calving aggregations)	85,000*	1.06-1.29	Calef & Lortie 1973
Arctic	1962	175,000-200,000	Air photo count - extrapolation (post calving aggregations)			Lent 1966a
Arctic	1970	242,000		140,000†	1.73	Hemming 1971
Nelchina	1955	40,000	Aerial transect - winter	10,500*	3.81	Skoog 1968
Nelchina	1962	71,000	Range	17,500†	4.06	Skoog 1968
Nelchina	1967	61,000-66,000	Air photo - extrapolation (post calving aggregations)	12,000*	5.08-5.50	Hemming & Glenn 1968
Nelchina	1973	8,100	Air photo - extrapolation	8,300†	0.98	Bos (Pers. comm.)
Forty Mile	1921	568,000	Partial ground count - extrapolation (autumn migration)	100,000* 35,000†	5.68 1.51	Murie 1935
Forty Mile	1953	53,000	Aerial transect - winter	12,000†	0.50	Skoog 1956
Forty Mile	1973	6,000				Le Resche (Pers.comm.
Total Alaska (incl. Porcupine herd)	1970	400,000	Various	400,000†	1.0	Hemming 1971
Bluenose	1967	19,000	Air photo count & transect count spring migration	75,000*	0.25	Thomas 1969
Bathurst	1967	144,500	Air photo count & transect count spring migration	200,000*	0.72	Thomas 1969
Beverly	1967	159,000	Air photo count & transect count spring migration	150,000*	1.06	Thomas 1969
Kaminuriak		63,000	Air photo count - extrapolation (post calving aggregations)	109,000†	0.58	Parker 1972
Total Canadian Central Arctic	1967	387,000	Sum of above	500,000*	0.77	Parker 1971
Newfoundland	1966	7,500	Aerial transect counts-winter range	?		Bergerud 1971
Total in Canada (incl. Porcupine herd)		500,000	Sum of above	600,000*	0.83	
Taimyr (Siberia)	1959	110,000	Air photo counts - extrapolation (post calving aggregation)			
	1966	252,600				
	1967	276,900				
	1968	303,500				Pavlov et al.
	1969	332,900		468,000†	0.71	1971

Note: Metric conversion factor: 1 mi^2=2.59 km^2

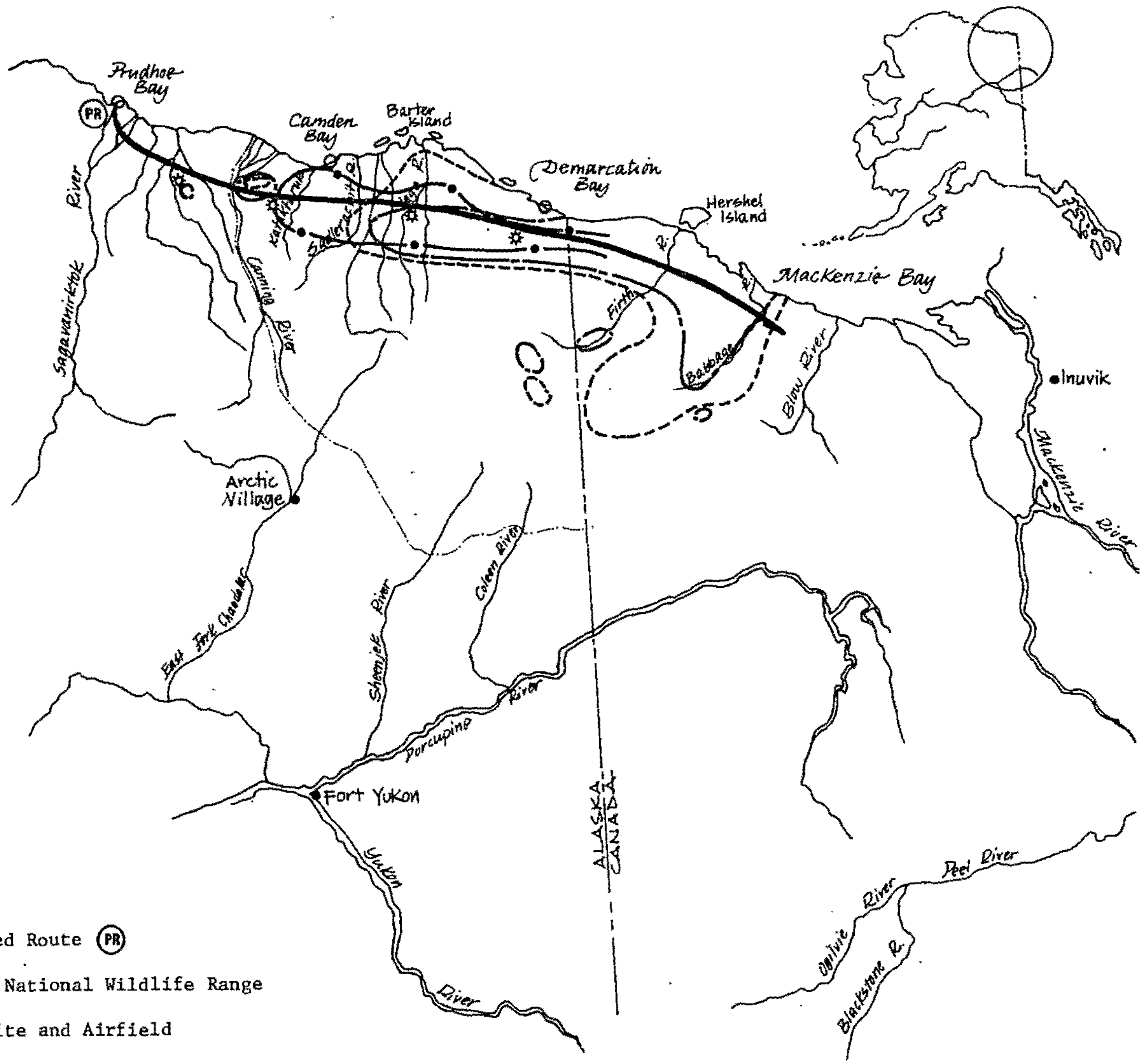
* Range calculated by G. Calef

† Range calculated by author cited



Source: Roseneau et al., 1975

Figure 2.1.1.7-1 Spring migration routes, 1973, and 1974 of the Porcupine caribou herd to its traditional calving area



—·— 1972

- - - - 1973

—•— 1974

—— Proposed Route (PR)

-·-·- Arctic National Wildlife Range

O Port Site and Airfield

✲ Compressor Station and Airfield

Source: Roseneau et al., 1975

Figure 2.1.1.7-2 Principal calving grounds utilized by the Porcupine caribou herd, 1972-1974

Range in Alaska and the northern edge of the Old Crow Flats and through the foothills of the northern Richardson Mountains in the Yukon Territory (Roseneau et. al., 1975). Within this large region the drier uplands generally appear to be the most important calving areas. At least half the herd calved in the Yukon in 1971, 1972 and 1973, while in 1974 most calving occurred in the Arctic National Wildlife Range (Roseneau et. al., 1975). If northward migration from wintering areas is delayed by severe weather or deep snow, calving may occur before cows reach the traditional calving area. In such event, however, cows and calves still proceed to the traditional calving area.

Calving begins in late May and is complete by mid-June. Following calving, caribou, primarily cows and calves, concentrate along the Arctic Coast north of the proposed AAGPC pipeline system in the Canning River - Barter Island vicinity. In 1972 and 1973 large concentrated aggregations were observed in the Camden Bay - Barter Island area. In 1974 a post-calving aggregation estimated to be between 70,000 and 90,000 animals were observed between the Canning River delta and Konganevik Point (Roseneau et. al., 1975).

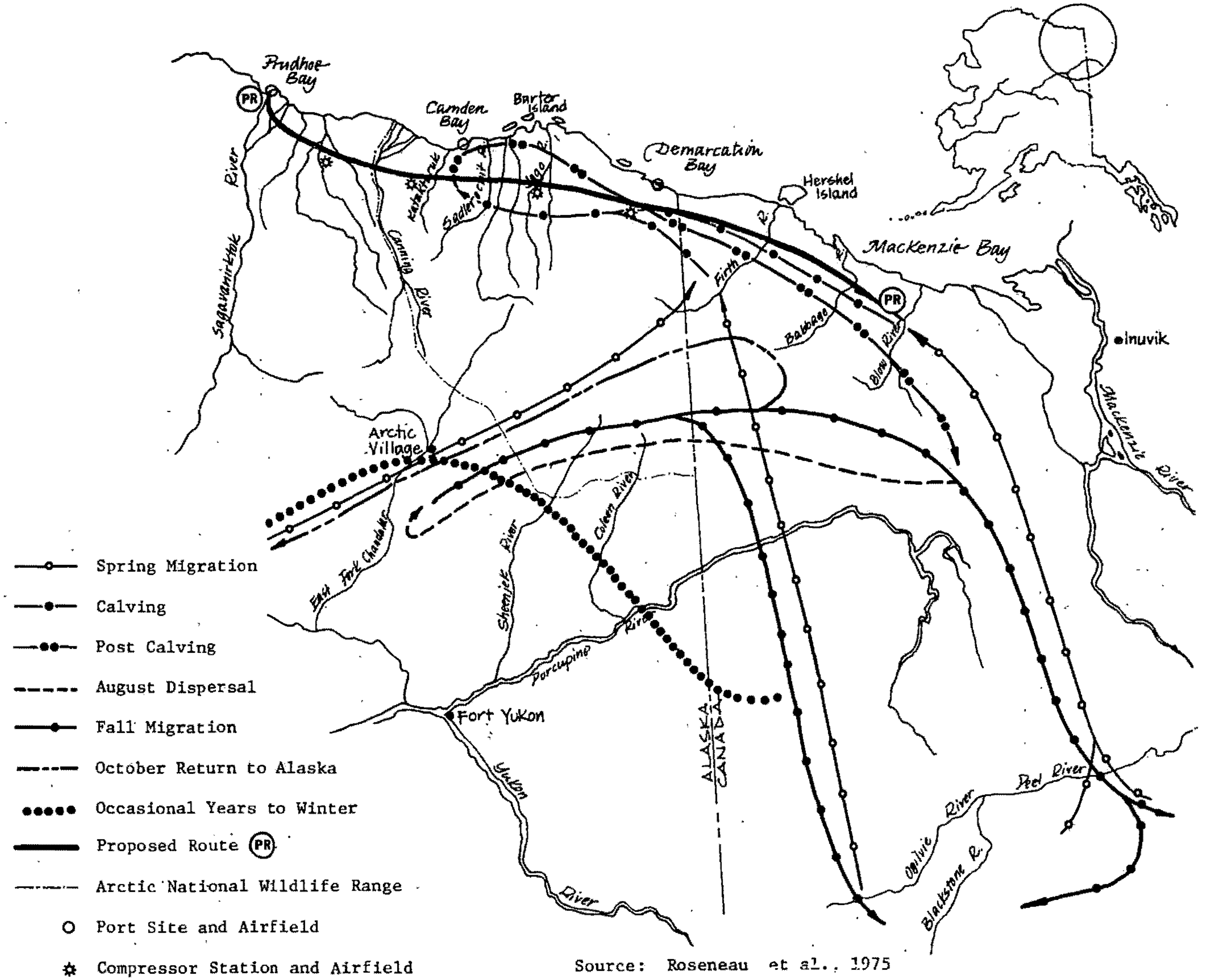
West of the Canning River post-calving movements by a small herd (4,000 to 5,000 animals), probably not belonging to the Porcupine Herd, have also been observed. These animals appear to be from the Prudhoe Bay area and cross the Canning River to the east near its mouth, swing inland crossing the proposed AAGPC pipeline system, then drift westward again. By early July several hundreds of bulls scattered throughout the region between the Sagavanirktok and Ivishak Rivers drift eastward and northeastward concentrating in the lower Canning River where they meet the post-calving aggregation of the Porcupine Herd. It has not yet been determined whether these caribou belong to the Porcupine Herd. It appears that caribou utilizing the migration route in the Sagavanirktok Valley are part of this subpopulation, but their relationship to the Porcupine and Arctic herds is still uncertain.

Subsequently, most of the post-calving aggregation of the Porcupine Herd moves eastward into the British Mountains of the Yukon, generally by about mid-July. During August there is a general dispersal of caribou with large numbers moving westward along the south slope of the Brooks Range to the Arctic Village - Christian River headwaters area. This westward drift is reversed almost as soon as the animals arrive in the latter area. By late August caribou are moving eastward returning to the Yukon.

By mid-September the majority of the Porcupine Herd is well south of the Continental Divide of the Brooks Range and is usually crossing or across the Porcupine River. Large segments move south and east towards wintering grounds, generally between the headwaters of the Porcupine and Peel Rivers and in the southern Richardson Mountains. In October a segment of the herd ususally moves westward to wintering grounds in the Arctic Village - Chandalar Lake region of Alaska. The basic yearly movements of the Porcupine Herd are illustrated on Figure 2.1.1.7-3.

LeResche (1972b) summarizes most recent information on the productivity of the Porcupine Herd. Cow-calf ratios suggest a "healthy herd in terms of productivity." Information obtained by the Applicant indicates that productivity has continued to be high.

The Environmental Protection Board (1974) noted that of all the caribou ranges in North America, the Porcupine Herd had been the least influenced by man during the last 60-years and speculated that the herd size will probably increase very slowly over the next few years in its present, largely undisturbed movement.



Source: Roseneau et al., 1975

Figure 2.1.1.7-3 Basic yearly movement pattern of the Porcupine caribou herd

In the last few years the area between Prudhoe Bay and the Canning River has been undergoing intensive exploration and development. These include the drilling of "wildcat" oil wells, large influx of workers, increasing use of aircraft to move people and supplies, construction of a road and oil pipeline along the Sagavanirktok River as part of the trans-Alaska oil pipeline system and developmental activities in the smaller gas fields such as the Kemik and Kavik fields.

These, plus future developments associated with the Prudhoe Field, may alter or restrict caribou movements on their spring and summer range. The Alaska Department of Fish and Game (1973) notes that it is possible that even slight alterations of caribou movements can produce long-term decreases in productivity by altering natural patterns of range use.

The Alaska Department of Fish and Game concluded that development for oil and gas in the area used by the Porcupine Herd "...must be conducted so that critical habitat areas are undisturbed and caribou movements are unaltered, if this important international resource is to be maintained" (Alaska Department of Fish and Game, 1973).

Moose and Musk Ox

Moose (Alces alces) are at the northern limit of their range along the north flanks of the Brooks Range. Until recent times, moose were rare north of the Continental Divide in the Brooks Range (Leopold and Darling, 1953). Within the area associated with the proposed AAGPC pipeline system, moose are sparse and widely scattered. Weather, limited winter food supplies, and predation by carnivores are believed to be the primary limiting factors to Arctic Coastal moose populations in Alaska.

Generally, moose are found along streams in the Arctic Foothills and Brooks Range, but have been reported all the way to the Beaufort Sea (Thayer, pers. comm., 1974). The moose that live on the Arctic Coast within the influence of the proposed pipeline system are almost totally restricted by the availability of willows. During April 1970, an aerial survey of the coastal portions of the Arctic National Wildlife Range found 100 moose along stream courses with riparian plant communities (especially willow). A major area where moose concentrate during the winter is along the east side of the Canning River (approximately 40 miles (64.4 km) south of the proposed AAGPC route) in the vicinity of Shublik Island and Eagle and Cache Creeks. Of the 100 moose counted in April 1970, 70 were seen in this area (Thayer, pers. comm., 1974). In the fall, 1973, the moose population in the Canning-Kavik drainage was estimated to be about 96 animals (Lenarz et al., 1974). Studies by the Applicant have shown that critical habitat (willow) and the moose population in general occur south of the prime route. Between 25 and 50 moose may be using the area where the proposed AAGPC pipeline system would be built.

For approximately 100 years, musk oxen, (Ovibos moschatus) apparently were extinct in northern Alaska.

According to Stefansson [Vilhjalmur] a band of about 13 musk oxen was reported killed by Eskimos near Point Barrow in about 1858 (Thayer, pers. comm., 1974). After 1860 to 1865 no musk oxen were seen on the Alaskan Arctic Coast.

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 AAGPC pipeline system.

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. Four main groups were seen most frequently: a group of eight adults and two calves in the Kavik-Canning-Tamayariak River area; seven adults and three calves and a second group of five adults in the Sadlerochit drainage; and nine adults and one calf in the Aichilik River area (Figure 2.1.1.7-4).

The Alaska Department of Fish and Game (1973) estimates there were a minimum of 29 adults and there may have been as many as 34 surviving from the original transplant.

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.

Musk oxen are frequently seen on the windswept bluff edges where food plants protrude above the snowpack or in the willow thickets along the streambeds. Their wandering along streambanks from the foothills region to the ocean shore and back is probably the result of their search for suitably windswept areas.

Dall Sheep

Dall sheep (*Ovis dalli*) do not frequent the Arctic Coastal Plain but are found in the Brooks Range. Small bands of sheep are located in the Sadlerochit Mountains of the Brooks Range. Except for a single repeater communication site near the headwaters of Marsh Creek (south of M. P. 100), none of the proposed AAGPC pipeline system is close to known sheep range. Thayer (pers. comm., 1974) reports, however, that the repeater communication site does involve the northernmost Dall sheep range in the nation. This Dall sheep range is considered to be a "major sheep wintering area" by the U.S. Fish and Wildlife Service (APG, 1974). Some sheep might be affected by this part of the proposed AAGPC communication system.

The Brooks Range south of the proposed AAGPC pipeline system contains major concentrations of Dall sheep. Because of its remoteness, accurate sheep population distribution and numbers are unavailable for the area. Nevertheless, approximately 1,000 sheep have been estimated as being in the Canning River drainage, which may become an alternative air route to the Alaskan arctic coast, with development of the proposed AAGPC system.

Barren-ground Grizzly Bear

Barren-ground grizzly bear (*Ursus arctos*) historically have been distributed sparsely throughout the Alaskan Arctic Coast. The species is an indicator of a wilderness environment (APG, 1974). The barren-ground grizzly is the most northerly and smallest of grizzly bears and is adapted to the tundra environment.

General observations and movement studies suggest that the highest population densities are in the Arctic Foothills and mountain habitats. Studies for the Applicant by Quimby and Snarski (1974) in the Canning River drainage showed a density of one bear for each 53-square miles (137.3 sq. km). Curratolo and Moore (1975) reported a similar figure of one bear per 57 square miles (148 sq. km) in the eastern Brooks Range. If a significant area of the arctic coastal plain is included in the estimate, bear densities would probably approach one bear per 100 sq. miles (259 sq. km), a commonly-used factor.

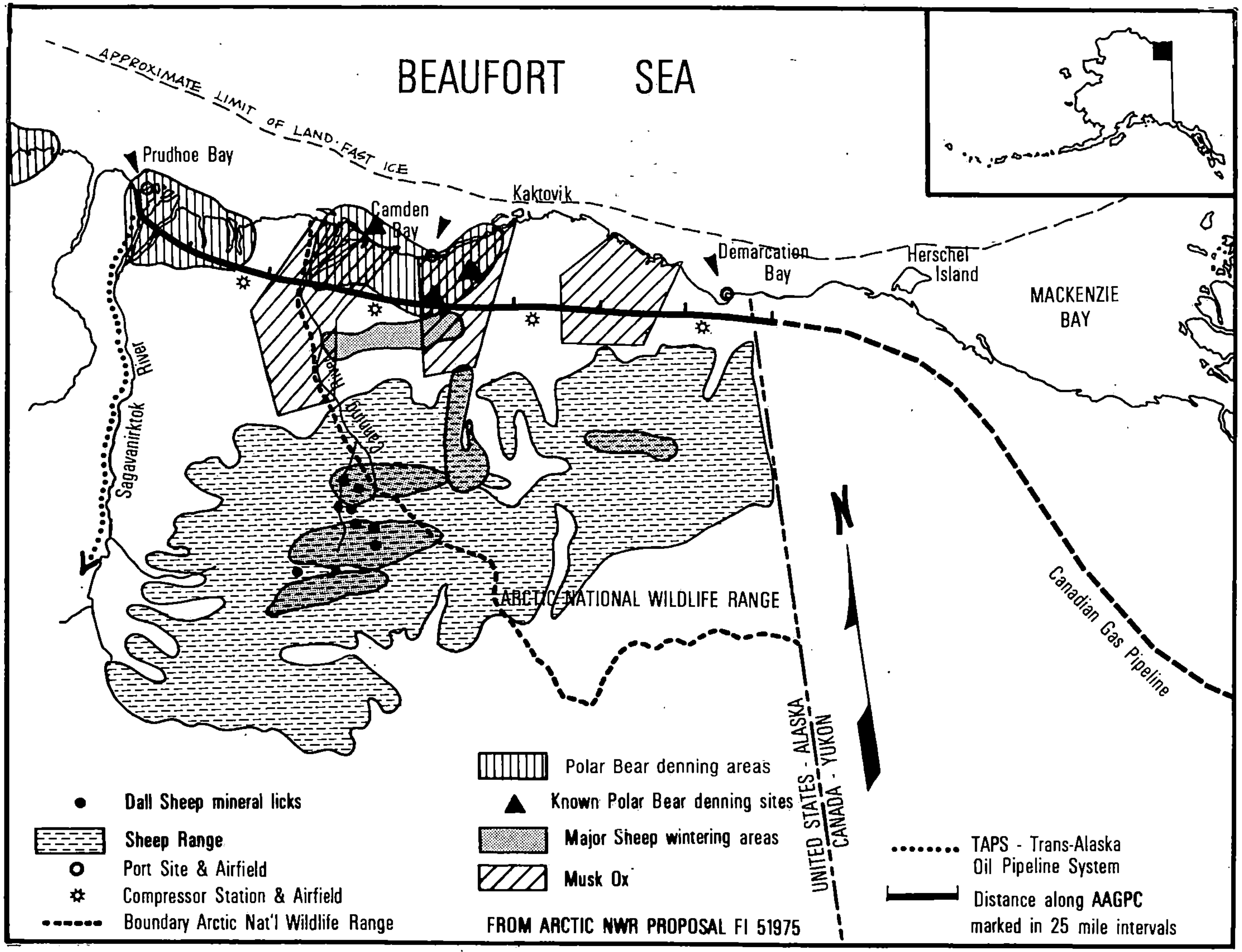


Figure 2.1.1.7-4 Musk ox, dall sheep, and known polar bear denning areas

Barren-ground grizzly bears spend most of their active season in river valleys where food is most abundant. Primary foods are grasses, berries, and carrion, with some predation on moose and caribou.

Barren-ground grizzly bears are frequently observed on the Arctic Coastal Plain near the Sagavanirktok, Kavik, Sadlerochit, and Hulahula Rivers as well as the Canning. Increased densities of grizzly bears have been reported on the caribou calving grounds during the calving period (Quimby and Snarski, 1974).

Denning occurs each year with the advent of snow and low temperature. The majority of grizzlies are in the den by the end of the first week in October. Denning lasts approximately from early October to early May. There are no known barren-ground grizzly bear denning sites associated with the proposed AAGPC pipeline.

It is not known how many barren-ground grizzly bears may come in contact with the proposed AAGPC pipeline system. As many as 25 probably could be found in all major drainages such as the Sadlerochit and Hulahula Rivers where the proposed pipeline route is close to the north flanks of the Brooks Range (Thayer, pers. comm., 1975).

Wolves

The wolf (Canis lupus) ranges throughout northeastern Alaska. While not numerous, more wolves are found on the Arctic Coastal Plain and Foothills in the Arctic National Wildlife Range than farther west.

Wolves travel in small packs which are usually family groups of one or two adult females, one or more adult males, cubs of the year, and perhaps cubs from the previous year. Pack size in the Arctic usually consists of three to ten animals. Absolute population information is lacking but there are about four to five packs associated with the eastern Arctic Slope area.

Numbers and seasonal distribution of wolves change in response to the abundance of lemmings and seasonal movement of large food species such as caribou, moose, and sheep. Wolves use most of the drainages along the proposed route and have been sighted during studies carried out by the Applicant along the Canning, Sadlerochit, Hulahula, Jago, Aichilik, and Kongakut Rivers and their tributaries.

Wolf movements vary throughout the year but are probably more confined after the breeding season until pups are born and raised.

Wolves on the Arctic Slope court and breed during the period March 13 to April 10. The pups are born from about May 9 to June 6, with an average litter of four to five pups. The pups are weaned in about 35 days and abandon the den about 8 to 10 weeks after birth (George Hall, pers. comm., 1975). Dens generally are dug in well-drained soils such as streambanks or bluffs.

Quimby and Snarski (1974) located four wolf dens during 1972 along the Canning and Kavik Rivers south of the proposed AAGPC pipeline route. There are no known dens directly associated with the proposed AAGPC pipeline system.

Wolves feed primarily on caribou, moose, and Dall sheep. They also eat ground squirrels, microtines, birds, other small animals, and carrion.

During the year the remains of animals killed by wolves and grizzly bears are an important food source for a number of small wildlife species including raven, gulls, jays, jaegers, eagles, squirrels, furbearers, and others. During winter, especially, the remains of wolf kills are valuable to foxes, eagles, ravens, and jays, because other food sources are less available (Thayer, pers. comm., 1974).

Fox

Two species of fox are found in the vicinity of the pipeline route: arctic fox (Alopex lagopus) and red fox (Vulpes fulva). The first is common; the second is not.

The arctic fox occurs north of the Brooks Range throughout the area of proposed construction. The Applicant reports that 90 fox dens and 10 fox denning areas have been located on the Arctic Coastal Plain (Quimby and Snarski, 1974). These denning areas are located near the Kavik, Shaviovik, Kadleroshilik, Sagavanirktok, Canning, Katakturuk, Sadlerochit, Hulahula, Okpilak, and Jago Rivers and their deltas and near Marsh and Carter Creeks, where well-drained soils provide good denning sites.

A principal food source of the arctic fox is the lemmings. Other important sources of food include sea mammal and caribou remains, birds and their eggs, and other small mammals and carrion. Birds and eggs appear to be the most important prey species for foxes in the Prudhoe Bay area (Sowl, pers. comm., 1975).

Arctic fox populations of northern Alaska fluctuate, with highs in the population occurring about every 3.6 years and lows about every 3.9 years (Chesemore, 1967). Population numbers are closely associated with the abundance of lemmings (Bee and Hall, 1956).

Arctic foxes breed in late March and April (Ogney, 1962) and may mate again in the fall if circumstances are favorable. The gestation period is 52 days. The number of kits per litter ranges from four to eight with as many as 20 reported for one litter (Cahalane, 1947). The range in the size of arctic fox litters appears to be related to the abundance of lemmings (MacPherson (sic), 1969). Both male and female care for the young.

Young fox leave the den area during September and October. At this time, many foxes move seaward to the coast and onto the sea ice where they are known to follow polar bears to feed on the remains of seal kills (Burton and Burton, 1969-70). In late winter and early spring, they generally move inland to mate and occupy summer den sites (Chesemore, 1967).

The red fox and its cross, silver, and black variations are common along the rivers in the foothills of the North and South Slopes, but they are relatively scarce on the Coastal Plain, although their range and that of the arctic fox overlap.

Like the arctic fox, the red fox utilizes riverbanks and sandy areas as den sites, usually at higher elevations (Quimby and Snarski, 1974). It may, however, den in arctic fox dens or in natural rock caves when available. Reproductive potential is similar to that of the arctic fox.

Wolverine

The wolverine (<u>Gulo luscus</u>) is present throughout the entire Arctic Slope. They are not abundant on any part of the range and are probably more abundant in the Arctic Foothills area than on the Coastal Plain.

Sightings by the Applicant on the Coastal Plain include one just east of the mouth of the Canning River and one on the East Fork of the Shaviovik River. Specific density values are not available.

Specific wolverine habitat requirements are unknown, but ample food sources apparently are the key requirement. Almost any item, from fruit to the largest ungulate, is eaten.

Wolverine feed on carrion when it is available, and are capable of capturing prey (Rausch and Pearson, 1972). Wolverine and their signs have been observed at remains of wolf-killed caribou, moose, and other carcasses (Quimby and Snarski, 1974). Dall sheep provide food as a result of their natural or accidental deaths. Sea mammal carcasses that are washed ashore are also eaten. Small mammals, birds and eggs are probably used on a seasonal basis, as are berries and other vegetable matter.

Wolverines are relatively long-lived animals, with some reaching 13 years of age in the wild. They mature rapidly and all long bones are fused within 9 months. About half of all female woverines are sexually mature at one year of age. They breed in May, June, and July and give birth to an average of 3.5 kits in January, February, or March. Natal dens usually are located on the surface of the ground under snow. Rock dens are also used. The kits emerge in early summer and apparently remain with the female until fall when they disperse.

Shrews, Voles, Lemmings, Ground Squirrels

These small mammals are important food for eagles, gyrfalcons, peregrine falcons, owls, jaegers, weasels, gulls, foxes, wolverines, wolves, and grizzly bears. Their burrowing and feeding activities till and fertilizer to the active soil layer, leading to a period of increased primary productivity.

The common shrew (<u>Sorex cinereus</u>) is found in low, wet meadows along the Arctic Coastal Plain. It is active both day and night and feeds mostly on insects but also on other small animals.

This shrew breeds from March to October, with some females reaching sexual maturity at ages 4 to 5 months. The litter size ranges from 2 to 10, and there may be more than one litter per year.

The tundra vole (<u>Microtus oeconomus</u>) occurs on wet, lowland flats, on river floodplains covered with wet marsh and crossed by low, narrow ridges that form networks of large frost polygons and also on flat marshes along lake and stream borders (Pitelka, 1957). It also occurs in foothill areas of the Arctic Slope where it has a dendritic (tree form) distribution pattern (Bee and Hall, 1956). The tundra vole has been observed near the Sagavanirktok River during studies by the Applicant.

The singing vole (<u>Microtus miurus</u>) is associated with lupine vegetation on both floodplain and upland habitats but on sites which are relatively dry. Typically, the soil is excavatable and relatively deep (Pitelka, 1957). The singing vole has also been observed near the Sagavanirktok River by the Applicant.

The red-backed vole (Clethrionomys rutilus) occurs on floodplains and adjacent higher ground including rock fields, outcrops, ledges, and cliffs (Pitelka, 1957). Pruitt (1966) found the red-backed vole in cottongrass tussocks.

The brown lemming (Lemmus trimucronatus) is most commonly found in extensive areas of low relief or areas of low-center polygons of the wet sedge meadow and/or dwarf shrub-heath vegetation type (Pitelka, 1957). Optimal habitat usually contains grasses and sedges upon which lemmings feed. At times of population abundance, however, the brown lemming spreads onto upland habitats. At these times, it is difficult to distinguish among preferred habitats.

The collared lemming (Dicrostonyz groenlandicus) occurs most frequently in well-drained, relatively dry, and excavatable ground, usually on ridges and on rolling uplands but even on lowlands where small and more or less isolated mounds offer burrow sites (Pitelka, 1957). In uplands, a netlike population distribution occurs due to the broken network of low ridges. Like the brown lemming, it spreads over more than one habitat type when population abundances occur.

Bee and Hall (1956) reported that the collared lemming was found in association with cottongrass and the brown lemming with sedges. More recent studies by Battelle, however, have found the collared lemming also associated with sedges. Pruitt (1966) found the collared lemming in rocky uplands or in areas where soils and vegetation cover are disturbed by frost action.

Pruitt (1966) observed that both lemmings were associated with frost scars, frost heaving, cr broken ground.

Lemming populations are cyclic in nature, with highs and lows occurring at 3- to 4-year intervals.

Arctic ground squirrels (Citellus parryi kenicotti) are widespread and very common along the proposed route. They occur from sea level to as high as 5,700 feet (1,737 m) in the mountains, wherever the permafrost is several feet below the surface of the ground (Bee and Hall, 1956).

Well-drained soils found on gravel hills and ridges are required for dens. Carl (1971) reported that during heavy rains in 1960 and 1961, none of the perennial burrow systems was flooded, even though much of the surface of the study area experienced sheet runoff or standing water.

Ground squirrels eat a variety of plants and occasionally eat carrion.

They hibernate from late September or October until mid-April or early May. Breeding takes place after hibernation, usually in June or July, and young are born in litters of four to eight.

Marine Mammals

Species composition and biology of the mammalian fauna of the Arctic Ocean adjacent to Alaska are well known but data on numerical abundance and actual distribution are few. Some species which normally occur in subarctic regions are occasional visitors to the Arctic Ocean. All species live in international waters at some point in their life cycle and are, therefore, of concern and potential value to several nations.

The Marine Mammal Protection Act of 1972 (P.L. 95-522) prohibits all U.S. citizens except Alaskan Natives from killing or capturing without permit any marine mammal including polar bears. The gray whale is protected under the provisions of the 1947 International Convention for the Regulation of Whaling. The humpback whale has been protected since 1966.

A list of species which are known to occur in the Arctic Ocean near Alaska is presented in Table 2.1.1.7-2.

Ringed Seal

The ringed seal (sometimes called hair seal) (*Phoca hispida*) is circumpolar in distribution and is the most abundant mammal in the Arctic Ocean and adjacent seas. Scheffer (1958) estimates the total population at 2,000,000 to 5,000,000 individuals. Johnson et al. (1966) conducted aerial surveys of ringed seals in the Chukchi Sea and reported an average of 32 animals per 100 square miles over an area of 2,711 square miles (7,020 sq km).

Such a density of seals may be typical for coastal regions but is undoubtedly too high for areas covered by heavy, relatively unbroken ice. Little is known about ringed seals in the area off the proposed AAGPC pipeline but it is noted that 75 ringed and spotted seals are reported in the annual subsistence harvest of people living at Kaktovik.

The smallest of northern seals, the ringed seal, is closely associated with sea ice and moves seasonally with the ice. In late winter and early spring, it is the most abundant seal where shorefast ice exists. In summer it lives along the edge of the polar icepack regardless of water depth (see Figure 2.1.1.1-4 for distribution of ice).

Pups are born in late March or early April in dens within pressure ridges or deep snow on sea ice, with a fairly high proportion of these dens occurring on shorefast sea ice. Shorefast dens of ringed seals are thought to be important to foraging female polar bears with cubs of the year.

Food varies with the season and ocean depth. During spring and in shallow waters primary food items for the ringed seal include shrimp, amphipods, and other bottom invertebrates. In deeper water plankton is its sole diet. In fall and when seals are in shallow waters, fish are their primary food.

Bearded Seal

The bearded seal (*Erignathus barbatus*) is circumpolar inhibiting the diffused edge of broken pack and fast ice during the open water period in summer. Bearded seals are generally found in the zone of drifting, broken pack ice from 30 to 300 miles offshore during the winter months. Scheffer (1958) gives an estimate of 75,000 to 150,000 as the world population, which seems low in view of the animal's commonness and wide distribution; no estimate is available for the Alaska region alone. Residents of Kaktovik (pop. 150) report an annual subsistence harvest of 30 bearded seals.

Harbor or Spotted Seal

The harbor seal (*Phoca vitulina*) has a wide distribution in both the North Pacific and North Atlantic. It is absent from much of the polar region north of Siberia (Naumov, 1933, as cited by Scheffer, 1958). The

Table 2.1.1.7-2 Marine mammals occurring in the Beaufort Sea

Order Finnipedia	
Ringed Seal* *Pusa hispida* (Schreber)	Abundant year around
Bearded seal* *Erignathus barbatus* (Erxleben)	Abundant year around
Harbor or spotted seal seal, *Phoca vitulina* (Linnaeus)	Abundant seasonally
Steller sea lion, *Eumetopias jubata* (Schreber)	Rare north of Bering Strait. Sight record from Herschel Island (McEwen 1954)
Walrus* *Odobenus rosmarus* (Linnaeus)	Uncommon in Beaufort Sea
Order Cetacea	
Bowhead whale* *Balaena mysticetus* (Linnaeus)	Abundant seasonally
Fineback whale, *Balaenoptera physalus* (Linnaeus)	Common seasonally, (Tomilin 1957; Slijper 1962)
Humpback whale, *Megaptera novaeangliae*	Uncommon
Gray whale* *Eschrichtius gibbosus*	Uncommon (ANWR, 1975)
Beluga* *Delphinapterus leucus* (Pallas)	Abundant seasonally
Narwhal* Monodon monoceros (Linneaus)	Rare (Geist et al., 1960)
Killer whale, *Orcinus rectipinna* (Cope)	Rare (SITF 1972)
Order Carnivora	
Polar bear* *Thalarctos maritimus* (Phipps)	Common year around

*Identified as present along coast of the Arctic National Wildlife Range (ANWR, 1975) population in the Beaufort Sea is migratory, moving south to the Bering Sea during the winter where it maintains association with pack ice. In the spring and summer these animals move north with the retreating ice pack and disperse along the coast concentrating in bays and at mouths of major rivers and estuaries. Harbor seals often ascend rivers inland to feed on spawning fish.

The number of seals comprising the arctic population is unknown, although estimates of the total number of seals in the North Pacific, including the northernmost stocks, are given as 70,000 to 250,000 by Scheffer (1958) and 200,000 by Coolidge et al. (1971). Burns (1970a) believes that the northern pagophilic harbor seals are reproductively isolated from the seals that remain in the Bering Sea year around.

Residents of Kaktovik (pop. 150) report an annual harvest of 75 harbor and ringed seals for subsistence purposes. The ratio of harbor to bearded-ringed seals in the 75 animals is unknown.

Walrus and Steller Sea Lion

Both Pacific walrus (*Odobenus rosmarus*) and Steller sea lion (*Eumetopias jubata*) are considered rare in the project area. A single sighting of the Steller 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.

Bowhead Whale

This bowhead whale (*Balaena mysticetus*) 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. Fall migrations from the Beaufort Sea to the North Atlantic occur from mid-September to mid-October. In 1974, the people of Kaktovik took two bow head whales (Herman Aishanna, pers. comm.).

The bowhead whale was a primary species of whale hunted by whalers along the coast of the project area at the turn of the century.

Finback, Humpback, and Gray Whales

All three whales--finback (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*), and gray whale (*Eschrichtius gibbosus*)--are associated with the Beaufort Sea during summer. Population estimates are lacking and all three species are considered uncommon in the area associated with the proposed AAGPC pipeline system. None are taken for subsistence purposes by people living at Kaktovik.

Beluga Whale

The beluga whale (*Delphinapterus leucas*) 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.

Narwhal

Little is known about the distribution of the narwhal (Monodon monoceros) 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.

Killer Whales

The Pacific killer whale (Orcinus orca) inhabits the Beaufort Sea at least during the ice-free season. Its abundance in the eastern Beaufort Sea off the Alaskan Coast is unknown.

Polar Bears

The polar bear Ursus maritimus 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.

The polar bear is considered a "marine" mammal and is protected under the Marine Mammal Protection Act (1972).

An international agreement on conservation of polar bears drafted at Oslo, Norway, in November 1974, directs nations to give special protection to polar bear denning areas. This agreement was signed by the head of the U.S. delegation to the convention and will become effective when ratified by three of the five nations with polar bear populations.

The polar bear is a circumpolar species often denning gregariously in historical sites known as "core" areas. Throughout the whole arctic, there are 17 known core denning areas (Harrington, 1968; Nero, 1971). The northeast Alaska coast has been described as "occasional use" (ADF&G, 1973; Harrington, 1968) and as "limited use" (Moore, 1975).

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 proportion of the Beaufort Sea population dens on various types of sea ice (Lentfer, pers. comm., 1974). The difficulty in locating maternity dens on sea ice has been described by Lentfer (1972). Thus, the importance and contribution of sea ice denning to the Alaska-north population is little understood. However, Lentfer (pers. comm., 1974) reported finding 12 maternal dens, 5 of which were confirmed as occurring in terrestrial habitats. Additionally, 5 dens were reported on shorefast ice but the exact location of two were unconfirmed. 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.

The Alaska Department of Fish and Game (1973) reported that the only known polar bear denning in Alaska occurs on offshore islands and associated shorefast ice from the Colville River east to Brownlow Point and to a lesser extent from the Kuparuk River west to the Point Hope area. Recent denning studies indicate that the area from the Colville River eastward to the United States-Canada border is a significant maternal denning area for the Beaufort Sea population of polar bears.

Gavin (1975) states that polar bears are not common in the Prudhoe Bay area. He reports a single bear at a seal hole just west of Cross Island in June 1971; a mother and cub on North Star Island on August 29, 1972; and two females with two cubs each on islands immediately off Aliktok Point. One polar bear was reported inland in February 1973 by personnel working on a well site in the Prudhoe Bay area. Other sighting reports suggest that although not "common," polar bears do frequent the entire coast between Prudhoe Bay and the Canadian border on a regular basis. Flaxman Island is a known site for polar bear denning (Detterman, 1974). Figure 2.1.1.7-4 shows the location of known polar bear denning sites. These are all closely associated with the proposed AAGPC pipeline system.

On the basis of annual fall surveys starting in 1967 polar bears are known to come onshore in the Demarcation Bay area and travel inland to suspected denning areas (Lentfer, pers. comm., 1974), returning to the pack ice in the spring through the same area. Bears also come on shore in the Camden Bay area and east of the Jago River to den.

Authorities assert that enough dens have been found to enable them to assign relative values to specific drainages. Repeated use of the areas around the mouth of Marsh and Carter Creeks make this area near Camden Bay a primary denning habitat.

A significant number of polar bears come ashore in late October and November to prepare maternity dens, usually in snow-drifts, to give birth in December. Cubs weigh about one pound at birth, and remain in the den until April when they are capable of travel. Polar bears feed primarily on ringed seals but will eat other mammals, carrion, kitchen scraps or garbage while en route from nearshore denning areas to sealing leads.

The polar bear is characterized by a low reproductivity capacity since, unlike black and grizzly bears, it has a relatively late sexual maturity, a small litter size and a protracted reproductive cycle.

Nearly two-thirds of the litters consist of two cubs, followed in frequency by litters of one and three (Harrington, 1968). Lentfer (pers. comm., 1974) reported a mean litter size of 1.6 young compared to 2.2 young per brown bear litter and 2.05 young per black bear litter.

The minimum breeding age is approximately 6 to 7 years of age and the interval between breeding is from 3 to 5 years under normal circumstances (Lentfer, pers. comm., 1974). It is possible that a single female may have no more than 9 offspring within her lifetime.

Tagging studies indicate that bears in the Beaufort Sea north of Alaska form a somewhat discrete population, with only a limited amount of interchange with other Alaskan bears to the west and Canadian bears to the east.

Although polar bear population statistics are few for the eastern portion of the Beaufort Sea, the fact that residents at Kaktovik (pop. 150) report an annual subsistence harvest of five polar bears indicates a relatively high number of bears in the project area.

Birds

The area associated with the proposed AAGPC pipeline system provides habitat for at least 142 species of birds. Most are migratory; some travel to all the continental and, in many cases, international flyways. With the arrival of spring, arctic terns return from wintering grounds in the

Antarctic; golden plovers from the Hawaiian Islands and South America; and wandering tattlers from Ecuador. The yellow wagtail, dotterel, wheatear, and bluethroat migrate from the Beaufort Sea coast of Alaska to Asia, and the buffbreasted sandpiper from India and Africa to the Beaufort Sea coast.

Only six species of birds are reported to winter on the Arctic Slope. In decreasing order of abundance these are: redpoll, rock ptarmigan, willow ptarmigan, common raven, snowy owl, and gyrfalcon.

The principal limiting factor for reproductive success of most bird species in the Arctic is the extremely short breeding season. A late spring breakup coupled with a snow storm in late August could negate the reproductive efforts of most species. Midsummer snowstorms often adversely affect passerine fledglings and disrupt the food supply for many species. Waterfowl die-offs occur in late spring when arrivals cannot find food on the still-frozen tundra. (USFWS 1970-73, unpub. data)

The coastal waters of the Beaufort Sea are used by waterfowl, loons, gulls, terns, and shorebirds for feeding, nesting, and molting. The chief physiographic features of the Beaufort Sea coast that make it an important habitat for birdlife are the barrier beaches, the lagoons, the river deltas (fed by a regular flow of fresh water from the mountains), and the flat tundra plain above the shoreline. The barrier beaches provide nesting and resting areas during the molting period; the lagoons provide sheltered, ice-free feeding areas for adults and young; the river deltas are vital feeding areas; and the tundra provides nest sites close to the shore.

Birds characteristically are associated with certain types of habitat. The following describes the major bird and habitat relations within the area where the proposed AAGPC pipeline system would be constructed, operated, and repaired.

The gravel beaches at the river mouths and offshore bars provide nesting habitat for terns, eiders, Sabine's gulls, glaucous gulls, and snow buntings. Oldsquaws, eiders, scoters, and scaups molt there. Semipalmated sandpipers, red phalaropes, northern phalaropes, black brant, red-breasted mergansers, and snow geese use these beaches for migratory rest-stops or premigratory feeding.

Most of the waterfowl species of the area can be found on streams at one time or another. The ruddy turnstone, semipalmated plover, and arctic tern are often seen feeding in streams and rivers.

Ponded waters are important habitat for all waterfowl (ducks, geese, and swans) and most of the shorebirds. Loons nest on lakes and ponds.

Estuarine areas provide habitat for whistling swans, sandhill cranes, northern phalaropes, pintails, arctic loons, semipalmated sandpipers, and oldsquaws. In August and September, black brant and snow geese feed extensively on these sedge flats.

Birds associated with wet sedge meadows in summer are marsh hawks, rough-legged hawks, American golden plovers, buff-breasted sandpipers, lesser yellowlegs, long-billed dowitchers, pectoral sandpipers, least sandpipers, semipalmated sandpipers, common snipes, red phalaropes, northern phalaropes, parasitic jaegers, snowy owls, common ravens, Lapland longspurs, and Smith's longspurs.

Birds normally associated with the tussock-heath tundra include the following: Lapland longspurs, (the most characteristic bird species), marsh hawks, rough-legged hawks, rock ptarmigan, American golden plovers, buffbreasted sandpipers, stilt sandpipers, least sandpipers, parasitic jaegers, long-tailed jaegers, cliff swallows, common ravens, and savannah sparrows.

Riparian shrubs along streams and rivers provide habitat for the following birds: bald eagles, willow ptarmigan, gray jays, American robins, gray-cheeked thrushes, yellow wagtails, yellow warblers, Wilson's warblers, hoary and common redpolls, tree sparrows, white-crowned sparrows, fox sparrows, black-bellied plovers, dunlins, water pipits, semipalmated plovers, ruddy turnstone, rock ptarmigan, and common redpoll.

Figure 2.1.1.7-5 shows the key bird habitat areas associated with the proposed AAGPC pipeline system.

Waterfowl and Shorebirds

Gavin (1975) and others report that the arctic coastal areas provide valuable habitat for waterfowl. These include significant breeding populations of the lesser Canada goose, white-fronted goose, black brant, pintail, greater scaup, oldsquaw, Pacific eider, king eider, spectacled eider. Somewhat less numerous waterfowl species include American wigeon, mallard, green-winged teal, shoveler, white-fronted scoter, surf scoter, and American scoter. Table 2.1.1.7-3 summarizes waterfowl population observations by Gavin in the Prudhoe Bay area for 1970 through 1973. These surveys included observations inland as far as 10 miles.

Waterfowl on the Arctic National Wildlife Range are represented by 19 species. The relative abundance of waterfowl was significantly high, however, in the pond-dotted areas of the Arctic Coastal Plain to the west.

Among the earliest migrants along the Arctic Coast are the king eiders from western Alaska and the Bering Sea, bound for Banks Island and beyond. Gabrielson and Lincoln (1959) reported that common eiders arrived at Demarcation Point on May 26, and the first king eiders arrived at Point Barrow on April 6. A million birds may be involved. This migration takes place very early, before the breakup of ice. The only places for the birds to stop and feed are the long open leads or cracks in the ice which precede breakup proper. In at least some springs, the winterlike weather increases and open leads do not appear. Substantial portions of the population perish by starvation and exposure in such years (Barry, 1968).

Other waterfowl species start to arrive in the Arctic in late May or early June.

Birds that breed on the Arctic Coast, such as the black brant, common eider, glaucous gull, and arctic tern, tend to concentrate their feeding, nesting, and brood rearing on relatively inaccessible parts of beaches and deltas. Normally, birds nesting in these areas, e.g., islands and barrier beaches, are relatively free from predators and other forms of disturbance (Gollop et al., 1974). Gabrielson and Lincoln (1959) describe the black brant as a strictly littoral species, breeding only in coastal regions. Commonly, eider nests are close to saltwater in depressions in the ground, sheltered by short tundra grasses. The glaucous gull may be found nesting on ledges of cliffs, or on the tundra, where it builds its rather bulky nests on slight elevations. The arctic tern has the most extensive breeding range of any Alaskan water bird. They usually nest in scanty collections of dried vegetation in shallow depressions in the ground (AAGPC, 1974a).

Canada geese, white-fronted geese, and black front nesting on the Arctic Coastal Plain produce an estimated 1,200 young annually in the area through which the proposed AAGPC pipeline and ancillary facilities would be

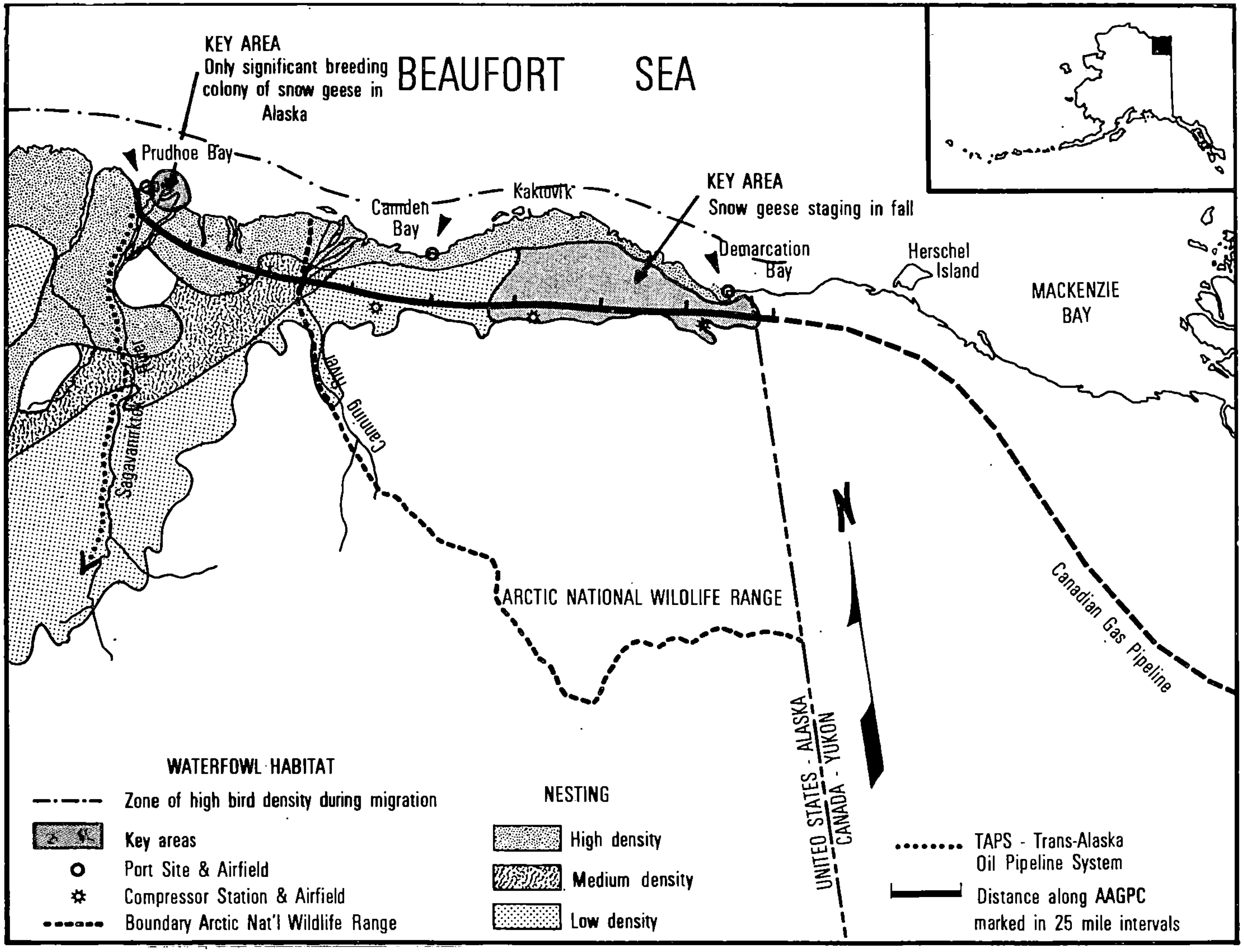


Figure 2.1.1.7-5 Important bird habitat areas along proposed AAGPC pipeline, Alaska

Table 2.1.1.7-3 Waterfowl populations in the Prudhoe Bay area, 1970 through 1973

Species	1970 Water-fowl	1970 Per-cent	1971 Water-fowl	1971 Per-cent	1972 Water-fowl	1972 Per-cent	1973 Water-fowl	1973 Per-cent
Oldsquaw	7,740	34.6	8,623	33.0	7,802	31.2	9,432	32.9
Eiders	6,074	27.2	6,891	26.3	6,524	26.0	4,841	16.9
Pintails	3,466	15.5	3,784	14.4	4,010	16.0	5,211	18.2
White-fronted geese	2,622	11.8	3,856	14.7	3,638	14.5	5,187	18.1
Lesser Canada geese	843	3.8	1,306	5.0	1,233	4.9	1,810	6.2
Black brant geese	872	3.9	891	3.4	842	3.4	1,007	3.5
Snow geese	--	--	100	0.4	174	0.7	136	0.5
Greater scaup	224	1.0	258	1.0	238	0.9	207	0.7
Wigeon	185	0.8	159	0.6	142	0.6	280	1.0
Mallard	24	0.1	6	Trace	18	---	10	---
Green-winged teal	9	Trace	2	Trace	2	0.1	16	0.2
Shoveller	--	--	8	Trace	14	---	30	---
Scoters	283	1.3	308	1.2	418	1.7	511	1.8
	22,342	100	26,192	100	25,055	100	28,678	100
	1970 Average: 2.8 pairs per square mile		1971 Average: 3.25 pairs / square mile		1972 Average: 3.13 pairs / square mile		1973 Average: 3.57 pairs / square mile	

Source: Gavin, 1975.

built. Canada geese prefer to nest inland along the streambanks or on river islands and avoid barren coastal areas; white-fronted choose higher, drier sites on coastal and upland tundra near lakes, washes, and rivers; black front nest on low islands or sand spits in estuaries or river deltas.

Gavin (1975) reports that in 1971 a colony of snow geese established a new nesting area at the mouth of the Sagavanirktok. Until that time there were no breeding colonies of snow geese recorded on the Beaufort Sea coast of Alaska. From the initial colony of some 50 pairs, this colony increased to 67 pairs in 1973.

The arctic and red-throated loon nests at coastal sites and also inland areas. All loon species need seclusion for nesting and are sensitive to disturbance (AAGPC, 1974a).

Pintails and oldsquaws are the most abundant ducks in the area associated with the proposed AAGPC pipeline system.

Overall pintail density for the area is approximately 20 birds per square mile. On favorable small pond nesting areas adjacent to the river deltas, densities reach 16 pairs per square mile. Pintails are paired and on the breeding area the first week in June. Breeding pairs favor polygonal ground interspersed with many small lakes and ponds. Predominantly, these nesting areas are sedge-grass marshes, but small ponds on the wetter tussock-heath tundra are also utilized. (USFWS, 1970 through 1973, unpub. data).

Another abundant duck on the area is the hardy oldsquaw. An estimated breeding pair density of 16 per square mile was calculated from quadrat data. Nesting activity reaches its highest point during the first week of July, when oldsquaw populations peak at about 60,000 birds.

Whistling swans and trumpeter swans follow the spring weather north and are among the first birds to arrive on the Arctic Coast nesting area whenever there is open water in May.

Whistling swans are a common breeder on the Arctic Slope. From surveys conducted by the U.S. Fish and Wildlife Service, peak density is estimated at three swans per square mile. Studies by the Applicant indicate about 62.5 percent of the swan pairs have broods and brood size averages about 2.8 cygnets. Whistling swans raise an average of 40 cygnets per year on the Arctic National Wildlife Range.

Two nesting pairs of trumpeter swans have been noted on the Arctic National Wildlife Range; one pair nested east of Demarcation Bay and one pair, which produced cygnets in 1972, nested on the Canning River Delta.

Both species of swan are traditional nesters who often return to the same nest site if the previous year's brood was successful. They choose a new site, however, if the nest failed. Both require large territories and are very sensitive to human intrusion during the 4- to 5-months that they are on the Arctic Coastal Plain.

Young swans usually are not flying by September. By late September, however, these swans migrate off the slope (Gabrielson and Lincoln, 1959).

After the breeding season, ducks and geese enter a molt period which renders them flightless for several weeks in late summer (Kortright, 1942). During this period of flightlessness they have high energy requirements and are vulnerable to predation, effects of weather, and other disturbances

(King and Farner, 1963). Because of this they group together in sheltered areas that have a good food supply.

Birds such as snow geese and black brant must have sufficient time for undisturbed feeding on the Arctic Coast to store enough energy for the southward fall migration flight. The critical time is from August 15 through mid or late September, depending on the weather (Schweinsburg, 1974).

There is a great increase in numbers of molting waterfowl using the barrier beaches along the route in July and August. These are mostly scoters (both surf and white-winged) and scaup. Eiders are less common (Schweinsburg, 1974). Bartonek et al. (1971) report that the molting oldsquaws number in the tens of thousands, and the greater scaup, eider ducks, and black brant number in the thousands. The fall migration starts after the molting period is over and the birds can fly again.

The largest and most obvious buildup of bird populations on the Arctic Slope in the fall is that of snow geese and black brant. Snow geese first appear about August 15, and build up to large numbers in ensuing weeks. The Applicant reports 100,000 geese on the basis of a straightline survey, indicating that the total number of all snow geese staging on the Slope was probably two to three times that figure.

Surveys by the Fish and Wildlife Service show that approximately 200,000-400,000 snow geese disperse in a broad band of large flocks that predominantly superimposes upon the proposed AAGPC pipeline system.

Snow geese appear to take advantage of ungrazed sedges and berries on the proposed AAGPC pipeline route. They feed from the coast to the foothills and from the Yukon border west to the Canning River. This area is an historical staging ground for snow geese from northern Alaska and northwestern Canada. It is possible snow geese from Northern Siberia form a segment of this staging population (USFWS, 1975). Geese leave the Arctic Slope in response to bad weather, retreating back to the Mackenzie Delta.

Black brant are common migrants. Approximately 1,800 birds a day pass through the area during the peak of migration. As winter approaches, they continue migration westward instead of returning to the Mackenzie Delta like the snow geese.

Project-related surveys by the Applicant noted migratory movements of white-fronted geese, Canada geese, and whistling swans east from Alaska up the Mackenzie Corridor, but in relatively small numbers.

Different species of ducks migrate in different directions; pintails head east to the Mackenzie River, while mergansers and sea ducks mostly head west, apparently following the same route as the brant. Large sea duck movements do not occur until after the third week in September. Most of the loons also go west, following the shoreline.

Songbirds

Surveys conducted by Applicant indicate songbirds (passerines) accounted for more than one-half of all birds observed at sites along the proposed route of the AAGPC pipeline. Of the eight passerine species observed, the Lapland longspur was by far the most numerous. The second most abundant passerine, the yellow wagtail, was observed only one-third as often as the Lapland longspur.

The only two passerines observed at coastal survey areas were the Lapland longspur and the snow bunting. As would be expected, songbirds are more than three times as abundant in the dry, tundra habitat east of the Canning River as they are west of the Canning River where waterfowl are the dominant birds. The Lapland longspur was the only passerine frequently observed in the lake pothole area west of the Canning River.

The finches, sparrows, redpolls, buntings, and longspurs are all thick-billed songbirds, adapted for seed-eating. The redpolls are usually found feeding close to the ground on weed seeds or seeds of low bushes and trees, particularly birch and alder. The Lapland longspur eats about equal amounts of insect foods and seeds of grasses and sedges. These small sparrow-sized birds also eat crowberries in the late summer and fall months (Gabrielson and Lincoln, 1959).

The passerine breeding season along the proposed route begins very quickly in the spring. Nests are usually built and eggs laid by the middle of June. A few young are seen this early. By the first of July, there is little territorial defense singing and some fledglings are already appearing. By the end of July and early August, birds begin to flock in preparation for migration.

Eagles, Hawks, Owls, and Other Birds

Golden eagles and short-eared owls were rarely observed (1 to 5 birds per square mile), during 1971-72 field surveys by Applicant. This is a relatively high population level for these predator species.

Five species of hawks and falcons, or their active nest sites, have been observed by Schweinsburg (1974b) in the vicinity of the proposed route. Sightings included the following species: rough-legged hawk, gyrfalcon, golden eagle, Swainson's hawk, and bald eagle. The endangered arctic peregrine falcon inhabits the area but none was observed or found nesting in the vicinity of the route. Arctic peregrine falcons (estimates range from 5 to 25 birds) would utilize some part of the proposed right-of-way each summer, probably for food hunting.

General Alaskan observations in the Arctic and Subarctic by the Applicant indicate it is uncommon to find gyrfalcons, peregrine falcons, rough-legged hawks, or golden eagles nesting higher than 1,000 feet above the surrounding valley floors. Except for golden eagles, nesting sites are commonly within the lowest 500 feet. A fifth cliff-nesting species, the common raven, is often associated with these raptors in the Arctic and Subarctic and nest in the vicinity of the proposed AAGPC pipeline system route.

During aerial surveys by the Applicant, nine active rough-legged or gyrfalcon nests were seen within 20 miles of the route. The closest nest was 5 miles from the proposed pipeline. Gyrfalcons are opportunistic and will feed on a variety of mammals and birds. The most important food items generally are ptarmigan and ground squirrels. When ptarmigan populations are low, gyrfalcons may move as far south as the northern United States, but arctic populations are never large, even in winters when ptarmigan are abundant (Gabrielson and Lincoln, 1959). Rough-legged hawks depend for food mainly on rodents, although they often take fledgling and post-breeding adult birds in the molt (White and Cade, 1971).

Snowy owl populations are noted for their fluctuations being dependent on the abundance of the lemming, their primary source of food. These birds, however, will eat arctic hares, rabbits, ground squirrels, rats, mice, shrews, and tundra-inhabiting birds (Gabrielson and Lincoln, 1959). Peregrine falcons feed on a wider range of prey than gyrfalcons but are more inclined to taking birds.

Ravens are omnivores. They are known to rob nests and to beachcomb, eating almost anything cast up by the sea. They also eat insects and tundra-growing fruits (Gabrielson and Lincoln, 1959).

The two resident upland game bird species, willow and rock ptarmigan, are found throughout the area. During winter, they gather in the riparian (willows) shrubs where they feed on dried berries, leaves of exposed plants, and the buds of dwarfed willows and birches. They are an important food source for lynx, foxes, wolverines, wolves, and birds of prey.

Jaegers are often seen robbing other seabirds (gulls and terns) of fish (Robbins et al., 1966), but during the breeding season they are active nest-robbers. The long-tailed jaeger was the most abundant jaeger observed by Schweinsburg (1974) along the route. This bird not only robs gulls and terns, but it also eats mice, lemmings, young birds, eggs, insects, crowberries, and sometimes carrion (Gabrielson and Lincoln, 1959).

Fish

The Applicant has conducted several investigations of fish inhabiting streams and lakes of the Coastal Plain. Thirteen species of fish were recorded in the area associated with the proposed AAGPC 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 AAGPC pipeline system involves 120 streams of three different types as it traverses the Arctic Coastal Plain: mountain streams, tundra streams, and spring streams (see 2.1.1.5). All 120 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 that do not freeze completely, can support fish populations during the winter months.

In addition, the movement of supplies and construction materials by ship to port sites at Prudhoe, Camden, and Demarcation Bays involves estuarine and marine systems.

Results of the Applicant's fish-sampling program by summer gillnetting and seining in 49 of the larger lakes in the vicinity of the route are presented in Table 2.1.1.7-4. 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, which is unnamed, known to support a lake trout population is more than 11 miles south of the proposed route.

Most of these lakes are only a few feet deep, and therefore freeze completely each year, making them incapable of supporting permanent fish populations.

Studies by the Fish and Wildlife Service show that the principal fish inhabiting the waters encompassed by the proposed right-of-way are arctic char and arctic grayling. Most arctic char are anadromous. Recapture of tagged char has shown that they move between major drainages, indicating that char may use one drainage for spawning purposes and another for

Table 2.1.1.7-4 Results of summer gillnetting and seining in 49 lakes associated with the proposed AAGPC pipeline system

Predominant species present	Number of lakes	Frequency of occurrence (Percent)
No fish caught	24	50
Several species	10	20
Arctic char	1	2
Grayling	3	6
Lake trout	2	4
Stickleback	8	16
Total	49	98

Source: Ward and Craig, 1974.

overwintering. Small isolated populations of char occur where circumstances prevent migration. Natives refer to these char as "Old Man Fish." (Schmidt, pers. comm., 1974).

During the Fish and Wildlife Service studies, grayling were found to be the most abundant fish in the area. During the spring, many leave the rivers to feed in the lagoon areas between the shore and the offshore islands east of Camden Bay where high river discharges reduce the saline content of the sea water. Their principal food there is brackish water shrimp. Arctic char and grayling were caught in about the same frequency in the lagoons in the spring of 1970. As salinity increases, char and grayling move back into the river systems. (Schmidt, pers. comm., 1974)

Fish found at river mouths and lagoons in the Arctic National Wildlife Range are arctic char, arctic grayling, fourhorned sculpins, arctic cisco, ninespined stickleback, and arctic flounder.

The following brief life histories of the arctic char and grayling describe conditions critical to the species' survival. Craig and McCart (1973) and McCart et al. (1972) report that arctic char spawn in the late summer and fall (mid-August to December). Known spawning areas are in the vicinity of spring water sources. The eggs, which remain in the gravel 6 to 9 months, are killed by freezing and therefore survive only where water flows during the entire winter.

Young-of-the-year fry emerge from the gravel in April or May and spend their first summer in streams. They overwinter in spring areas and may spend several more summers in freshwater as juveniles. After several years, juvenile arctic char undergo a physiological change, and in the spring, they migrate seaward as smolts. Smolts remain in the sea throughout the summer, but return to the stream in late summer (July - August) as immature migrants to overwinter in spring areas. The following spring, the immature migrants again return to the sea. Migrants may make this annual journey between freshwater and the sea several times before they mature. Arctic char do not die immediately after spawning and some may overwinter and make additional seaward migrations, returning to spawn several times during their lifetimes. Apparently, arctic char never remain at sea through the winter, probably because their body fluids would freeze at the temperatures which occur under the sea ice (DeVries, 1971).

All stages in the life history of stream-dwelling arctic char (eggs and larvae, juveniles, immature migrants, mature spawners, mature non-spawners, and residual char) are dependent on springs as a source of free-flowing water during the winter months. For some 8 to 9 months of the year, the entire char population may be restricted to a few, highly localized areas in the river system. (Craig and McCart, 1974). Several age classes are always present in these critical spring areas during the winter. A significant disturbance to the spring during winter, therefore, could destroy an entire population of arctic char.

According to the DeBruyn and McCart (1974), grayling in the area associated with the proposed AAGPC pipeline system migrate to spawning areas in small tundra streams during spring breakup and spawn in late May or early June. The incubation period is about 14 to 21 days with fry emergence in late June.

After spawning, adult grayling usually migrate to large streams or lagoon areas where they spend the summer. Young-of-the-year and juvenile grayling spend the summer in smaller streams.

In the fall all age classes of grayling migrate to overwintering areas which may be spring-fed streams in conjunction with arctic char, in lakes in association with lake trout, or in deeper pools in large rivers. Accordingly, spring overwintering areas are as important to grayling population numbers and distribution as they are for the arctic char.

Spawning periods of fish in the vicinity of the proposed AAGPC pipeline system are shown in Table 2.1.1.7-5.

All fish species that spawn in fall do so in streams or lakes that do not freeze solid during winter. Subchannel flows in interstices of gravel riverbeds underlying deeper pools can continue even when river channels are frozen solid, making some development of eggs and alevins in these areas possible.

Overwintering habitats for both freshwater and anadromous fish species are critical to their survival. These are limited and geographically isolated. As with arctic char and arctic grayling all age classes are often present, particularly in those areas used by fall-spawning species. For example, nearly 1,500 adult arctic char (both resident and anadromous) were seined by the Applicant from a pool in an overwintering area on the Kavik River estimated to be only 30 meters by 10 meters and 0.5 to 1 meter deep. This density approaches 10 adult fish per square meter.

Craig and McCart (1974b) surveyed many of the streams which are crossed by the proposed route in an effort to locate regions utilized as overwintering and spawning areas, primarily by arctic char. Figure 2.1.1.7-6 shows the areas found during these studies.

A number of major streams, including the Okpilak and Jago Rivers, crossed by the route have not yet been surveyed for overwintering areas. Some of the major delta areas, such as those of the Canning and Tamyariak Rivers, also have not yet been surveyed to determine if there are critical overwintering areas for fish.

Little is known about fish in Demarcation and Camden Bays. It is known, however, that these areas are used by fish species inhabiting the nearshore areas in the summer. The presence of overwintering areas is unknown (Thayer, pers. comm., 1975).

Sport fishing in the vicinity of the proposed AAGPC pipeline system occurs to a limited extent, primarily for arctic char and grayling (Yoshihara, 1972). Sport fishing is conducted by visitors and workers at Prudhoe Bay developments and those conducting studies or seeking recreation on the Arctic National Wildlife Range.

Total fishing intensity is less than in regions closer to civilization, although it is quite intense in waters known to support large populations of fish.

Because of slow growth rates, most northern fish populations could not sustain themselves in the event of increasingly heavy fishing pressures characteristic of southern waters (Ryder and Johnson, 1972).

Fish are an important element of the diets of people living at Kaktovik. These fish are harvested annually from streams and estuaries affected by the proposed AAGPC pipeline system. See 2.1.1.9 for a discussion of subsistence use of fish and wildlife resources.

Table 2.1.1.7-5 Spawning season and habitat for fish known to exist along the Arctic coast

Season	Species	Spawning Habitat
Late Winter	Burbot	Lakes
Spring	Arctic grayling	Foothill streams--diverse locations
	Slimy sculpin	spring and--foothill gravel shallows
Late Spring	Ninespined stickleback	Lakes and ponds in vegetation
Summer	Fourhorned sculpin	Shallow inshore
Fall	Arctic char	Mountain streams--spring areas
	Round whitefish	Mountain streams, lakes
	Broad whitefish	Canning delta
	Lake trout	Lakes
	Arctic cisco	Mountain streams--gravel
	Least cisco	Sand, gravel--areas of streams
	Chum salmon	Gravel--Saganavirtok River only
Unknown	Arctic flounder	Ocean

From AAGPC, 1974a; and McPhail and Lindsey, 1970.

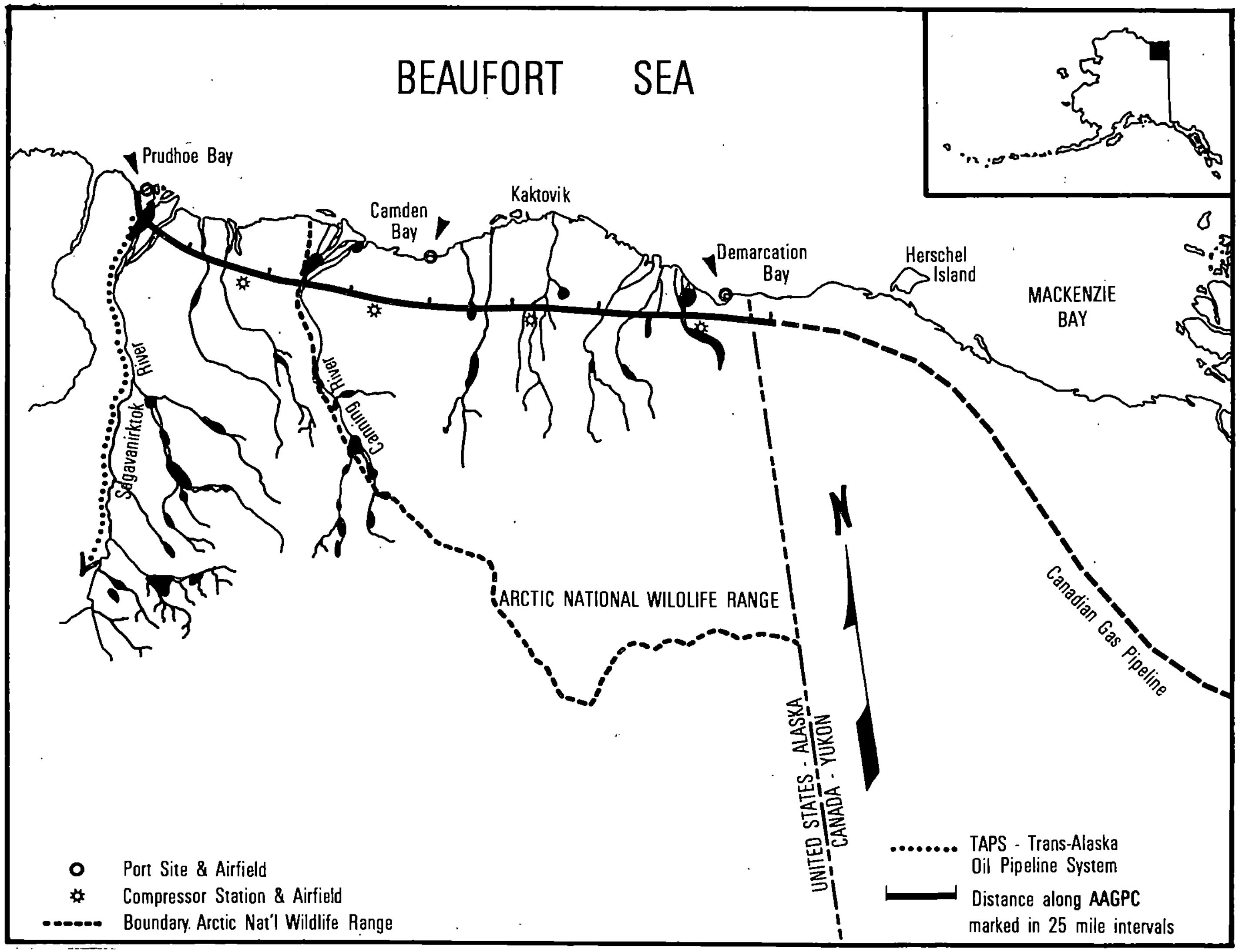


Figure 2.1.1.7-6 Stream areas used by overwintering fish populations along the proposed AAGPC pipeline system, Alaska

Threatened (Endangered) Species

Three animal species listed by the U.S. Department of the Interior as "endangered" may come in contact with the proposed AAGPC pipeline activities. Two, the gray and the bowhead whale, are marine mammals. Their numbers in the vicinity of the proposed project is not known. These animals would be present only during the period of open ocean water in late July to early September. This, however, corresponds to the period of greatest shipping activity during the two years that supplies are to be moved by ship from the Mackenzie River to Prudhoe, Camden, and Demarcation Bays.

The other endangered species is the arctic peregrine falcon, which utilizes the proposed right-of-way to obtain its food (small songbirds, shorebirds, and ptarmigan) for a period of approximately 150 days from spring througt fall. As many as 25 falcons may utilize the right-of-way area during the summer months. This probably is a high estimate. No known nesting sites are directly associated with the proposed AAGPC pipeline system. (T. Schmidt, pers. comm.)

Grizzly bear, polar bear, golden eagles, wolverine, and wolves are not considered as threatened or endangered in Alaska. The polar bear, however, is subject to international treaty, which, when ratified, will require protection of polar bears and especially polar bear denning habitat. The proposed AAGPC pipeline system involves an area which is considered a significant maternal denning site for the population of polar bears living in the Beaufort Sea.

Invertebrates

The Arctic Region is characterized by frequent and strong winds, averaging 10 to 15 mph year-round. These winds interfere with insect flight and may be a limiting factor to distribution of airborne insects, since they must dwell on the ground in shrubs or in lees created by microrelief topography.

Insects are active only during the warmer temperatures of the arctic summer and are dormant in winter. The duration and severity of winter has no cumulative effect on insects adapted to the Arctic. Another adaptation to the cold environment is the reduction in the freezing point of body fluids in certain terrestrial species, as compared to the same species in more temperate climates (Downes, 1964).

Many of the dominant and widespread insect groups characteristic of temperate soils are absent from the Arctic, but the dominant groups (the mites and Collembola) are as diverse as they are in temperate grasslands. Representative forms of this group are usually contained within the top 10 cm of soil, but in the tundra areas, their biomass rarely exceed 0.5 g/cu. m (Edwards, 1972).

The low height of the plants is generally favorable to the development of the terrestrial Collembola and mite fauna. These insects feed primarily on fungi and their spores and on plant tissue in general. The lichens and mosses and roots of higher plants provide excellent sources of shelter. Insects are generally able to move about freely without problems of desiccation because of the relatively high humidity at the surface.

The Arctic has very sparse insect fauna in terms of species diversity because insects have body temperatures that vary with the surrounding medium. Although a few major studies have been done (Weber, 1950, 1953, 1954; Watson, Davis, and Hanson, 1966), the size and constitution of the insect fauna of the Arctic cannot be described with any accuracy. The collecting has often been incomplete, and seasonal or obscure forms are often under-represented.

The majority of the readily visible insects are the Diptera or flies, of which the mosquitoes and midges are the most numerous (Weber, 1950). The Collembola and mites are the major constituents of what might be termed the microscopic fauna of the Arctic.

Various factors of the arctic environment are very limiting to the mere presence of an insect fauna, but specific adaptations have occurred to compensate for the extremes.

The small size of the heat budget seems to be an important and controlling feature of arctic life. According to Downes (1964), a random departure of only a few degrees from the mean would have a great effect on growth and development. Many of the insects of the Arctic have overcome this problem by extension of their life cycles through several seasons, thus having representative numbers of individuals in various stages of development. A small but useful amount of solar radiation penetrates the snow to a depth of 10 to 20 centimeters; therefore, an insect can possibly be warmed sufficiently to start to develop before the snowmelt is complete.

Heteropterous and homopterous plant-sucking insects are present in the Arctic (Weber, 1950), but they do not form a conspicuous part of the total insect population. Lepidopterous caterpillars are present in the Kaktovik (Barter Island) region and coccids are found on the roots of willows. The tundra butterfly appears to be dependent on the microrelief features of the area for protection from the wind. (Sowl, pers. comm., 1975).

There is not sufficient woody growth in the area of the proposed AAGPC route to support most of the wood-boring insects, although sawflies (Tenthredinids) are not uncommon.

The invertebrates play three major roles in the arctic tundra ecosystem (MacLean, 1971):

1. A large amount of biomass is incorporated into invertebrate consumers, and they may use a significant proportion of the energy of the system in respiration.

2. Invertebrates provide food for groups of vertebrate consumers, mainly the shorebird and snowbird (passerine) insectivores.

3. Soil-dwelling invertebrates may be crucial links in the process of decomposition and nutrient release.

Insects are significantly associated with the lemming populations. Lemming nests have been found to contain as many as 5,000 arthropods per nest (Weber, 1950). The mites, Collembola, and midgefly larvae (Spanitoma) are the major insect associates found with lemmings.

Mosquitoes are the major pest insect to both wildlife and man in the Arctic. Weber (1970) and Rhodes (pers. comm., 1974) indicate that mosquitoes present definite problems and occur in great numbers. Among the mosquitoes identified are five species of Aedes (Namtvedt et al., 1974). Mosquitoes are responsible for mortality among young birds, small mammals, and occasionally, in combination with other factors, can cause death in young caribou.

A significant insect-mammal relationship is found among the caribou. The botfly, Oedamagena tarandi, may infest the animals in such great numbers that they render the hides useless to Natives. During periods when botfly numbers are high, caribou habitats are greatly influenced because caribou seek areas where they can escape the flies. Such areas are snowbanks, windswept ridges, or other raised elevations, such as gravel pads, which also are associated with oil exploration and development.

Aquatic insects provide an important food for the whitefish and arctic grayling. Probably of greatest significance are the caddisworms, Trichopters, and stonefly nymphs, Plecoptera, (Weber, 1950).

Little information is available about aquatic insects in the area of the proposed AAGPC pipeline system. Studies by the Applicant on arctic char included stomach analyses of fish taken at spring areas near the route. These analyses are useful as an index of at least some of the aquatic invertebrates in the area. See Table 2.1.1.7-6 for a list of fish food items.

2.1.1.8 Ecological Considerations

No organism can exist in an environment that is bereft of the special requirements of the organism for space, food, and shelter. The interdependency of living organisms and their natural abiotic (nonliving) setting is circular. Exchange of materials between living and nonliving parts of this circular path of obligatory relationships, interdependence, and causal relationships comprise an ecosystem.

An ecosystem is elastic in that its components adapt to change. The degree of change that successfully can be accommodated in a particular ecosystem is limited, and each change produces ripples throughout the circle. Should the change be introduced at a critical point in the circle, ripples become waves. For example, changes affecting caribou migration routes or wintering areas are not as serious, if there are adequate alternative routes or areas, as changes in the calving area.

In the arctic environment, the transfer of energy within ecosystems is extremely sensitive to change. The relationship of the arctic sun, its low-angle continuous sunlight in summer and long periods of twilight and darkness in winter, to the vegetative cover and permafrost represents a delicate heat balance. A small change in the insulating characteristics of the vegetative mat changes the depth of the active layer (thawed soil during the summer). Such changes affect the water table and, in turn, the vegetation.

The general conceptual model in Figure 2.1.1.8-1 helps frame this discussion. Basically, two elements operate in any ecological system: energy and matter.

Solar energy is captured in photosynthesis by primary producers (mainly green plants). A fraction of that energy is passed up the food chain to consumers--first to herbivores, then to carnivores. Death and waste products represent energy transfer to decomposers. Decomposers utilize this energy, and function chiefly in returning nutrients to the system for reuse by primary producers.

Table 2.1.1.7-6 Frequency of occurrence of various food items in stomachs of Arctic Char from Shublik Spring and on Unnamed Spring.

Food item		Stomach analysis			
		Shublik Springs		Unnamed spring	
		Occurrence (percent)		Occurrence (percent)	
Plecoptera	nymphs	58	(47)	10	(12)
	adults	8	(7)	7	(9)
Diptera	larvae	71	(58)	55	(68)
(inc. chironomids)	pupae	16	(13)	16	(20)
	adults	12	(10)	15	(19)
Simulids	larvae	9	(7)	2	(3)
Tipulids	larvae	3	(2)	1	(1)
Ephemeroptera	nymphs	38	(31)	3	(4)
	adults	1	(1)	3	(4)
Trichoptera	larvae	26	(21)	20	(25)
	pupae	6	(5)	-	-
	adults	3	(2)	2	(3)
Orthoptera (grasshoppers)		9	(7)	-	-
Coleoptera (terrestrial)		6	(5)	3	(4)
Hymenoptera	adults	3	(2)	15	(19)
Arachnida (hydrocarinida)		3	(2)	3	(4)
Amphipods		-	-	15	(19)
Plant material		4	(3)	3	(4)
Unidentified debris		25	(20)	19	(24)
Empty		2	(2)	2	(3)
No. stomachs sampled		123		81	

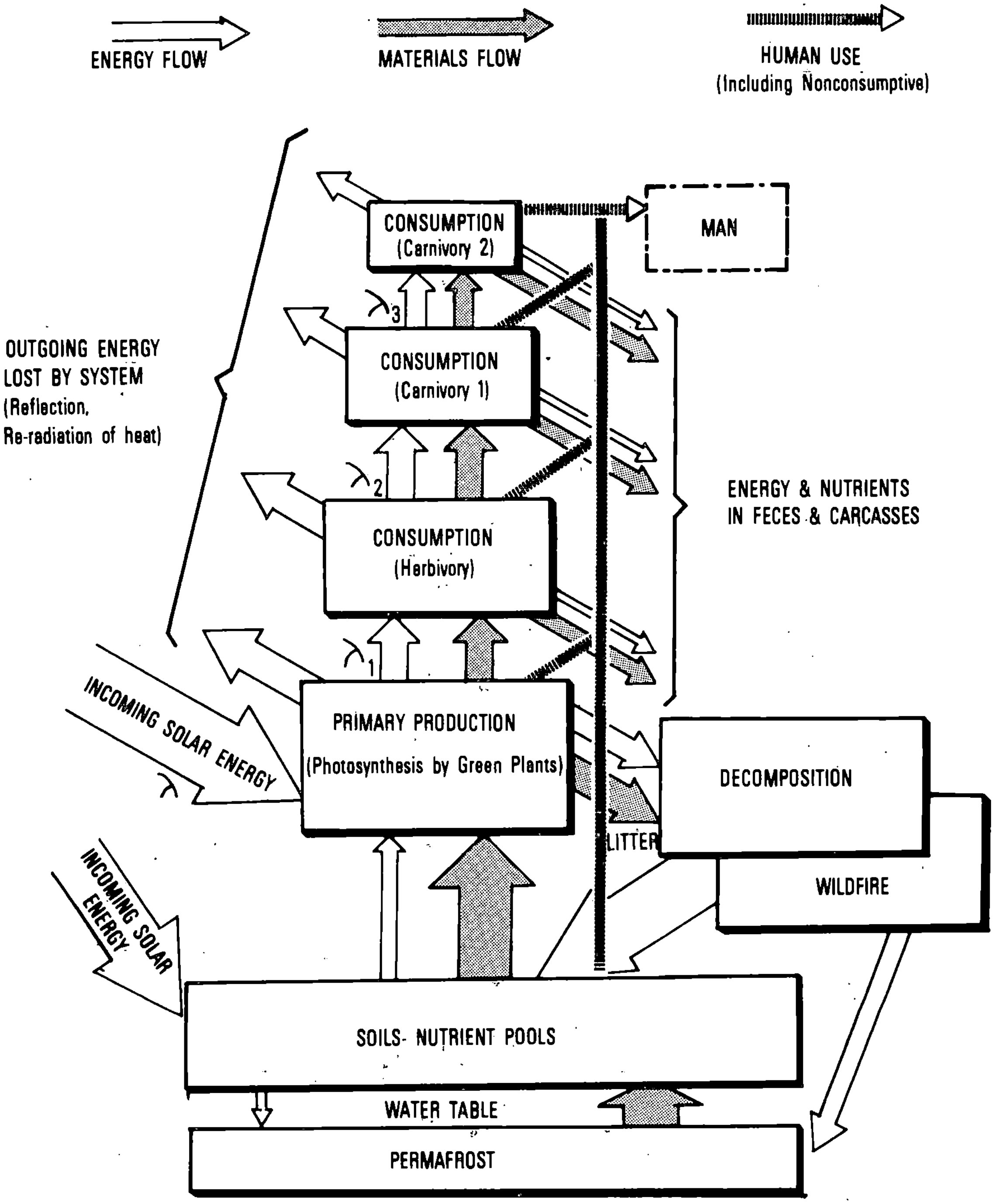


Figure 2.1.1.8-1 Solar radiation and photosynthesis at Barrow, Alaska

Major Ecosystems

The major ecosystems along the proposed natural gas pipeline project may be divided into three types: terrestrial, fresh water, and marine. These three primary ecosystems may be subdivided into smaller units based on the dominant vegetation types or physiographic location, or, with fresh water ecosystems, whether the fresh water is in a stream or lake. For comprehension of the dynamic, interrelated processes of these systems, discussion of the three major ecosystem types is adequate.

Terrestrial Tundra Ecosystem

The main components of the ecosystem, soils (2.1.1.4) primary producers (vegetation,2.1.1.6), consumers (wildlife,2.1.1.7), and abiotic factors (environment) have been described in the previous sections. Only certain processes and inner relations are discussed.

Fresh-water Ecosystems

The proposed pipeline route will cross two types of aquatic ecosystems, stream and lake. Flowing water ecosystems include the numerous large and small streams that flow eventually into the Arctic Ocean. Shallow ponds and small shallow lakes are extremely numerous along nearly the entire pipeline route in Alaska.

Considerable information on the tundra pond ecosystem is available from the International Biological Program studies at Barrow, where a coastal plain situation exists similar to that along the pipeline route. Information on the flowing water ecosystem in arctic Alaska is scant as to food chains. Most information from the International Program is directly related to the fisheries resource.

Arctic aquatic ecosystems are characterized by: (a) extremely low primary productivity, and (b) low species diversity. The result of low primary productivity is that secondary productivity is absolutely limited, since all animals depend on primary production for required energy. Nutrient limitation, low levels of energy input from the sun during winter months (further reduced by snow and ice cover), and low water temperatures (even in summer) apparently control primary productivity. In rivers and streams, turbidity may be important. Low species diversity, which is apparently caused by a small number of niches available to arctic organisms, results in simplified food webs.

Marine Ecosystems

The proposed wharves at Camden Bay and Demarcation Bay and the present wharf facilities at Prudhoe Bay all impinge upon the Arctic Ocean marine ecosystem. This marine environment has not been described as well nor studied as intensively as have marine ecosystems in more temperate climates.

Rivers originating within the zone of continuous permafrost virtually cease flowing into the Arctic Ocean during winter. For a period of several months, no fresh water or sediment is transported into the ocean, but with spring breakup a sudden influx of comparatively warm fresh water into the cold marine ice-covered system results in drastic changes in the physical, chemical, and biological nature of nearshore waters.

Ecosystem Productivity

Terrestrial Ecosystems

Primary productivity in tundra ecosystems is low because of low energy input values and because there is little to no productivity during the long winter.

At Barrow (a coastal plain site) yearly production ranges from 78 to 190 grams per square meter (g/m^2) of above ground phytomass. The annual productivity in the wet sedge meadow is about 86 g/m^2. while the tussock communities have an annual primary productivity of approximatley 95 g/m2. Differences in productivity between different tundra ecosystems are related to community structure.

While annual production of tundra is low, daily production during the short growing season is relatively high. At Barrow, productivity ranges from 1.5 g/m^2/day to 1.8 g/m^2/day during the height of the growing season.

Aquatic Ecosystems

Primary Productivity

The productivity of arctic waters is considerably less than that of most oligotrophic lakes of northern temperature latitudes. Production is virtually nonexistent for the period November through February. Adaptation by phytoplankton to extremely low light levels often allows measurable photosynthesis shortly before and after these dates. Nearly all primary production takes place from the end of April to the end of September, and rates of production are quite low during this short season.

In the summer, low nutrient levels are the chief limitation placed on primary productivity (Hobbie, 1973; Kalff, 1970). Phosphate appears to be the nutrient in shortest supply. Nitrate may be critically limited in lakes, but less so in ponds and rivers. Trace metals and vitamins may be limited during periods of increased photosynthesis (Hobbie, 1973; Kalff, 1970, 1971). Nutrient levels in the Colville River and its tributaries are generally higher than those in adjacent lakes and ponds, indicating that primary productivity is lower in rivers. The turbidity of rivers, however, makes productivity measurement difficult.

Primary production may be broken into three categories, representing phytoplankton, benthic algae, and vascular plants (eiphyton have not been described). Phytoplankton have traditionally been taken as the measure of productivity of a water body (Frey and Stahl, 1958; Hobbie, 1966; Howard and Prescott, 1971; Kalff, 1967), but their contribution to total production depends on the particular situation. In shallow lakes or ponds where enough light penetrates to the bottom and where sediment conditions are favorable, the contribution of benthic algae may be much greater than that of phytoplankton. Where a pond supports a shore fringe of vascular plants, their contribution may also be relatively great.

Table 2.1.1.8-1 gives the productivity of a tundra pond and three tundra lakes as computed by Hobbie et al., 1972.

Table 2.1.1.8-1 Primary productivity of some Arctic Alaskan and temperate waters

Type of Community	($g\ C/m^2/yr$)	Reference
Tundra pond		
Benthic algae	14	Hobbie et al., 1972
Macrophytes	15	Hobbie et al., 1972
Phytoplankton	1	Hobbie et al., 1972
Phytoplankton	0.4-.8	Kalff 1967
Phytoplankton	0.3-.7	Alexander et al., 1972
Tundra Lake		
Phytoplankton	8.5 †	Kalff 1967b
Phytoplankton	9,6[1]/ ‡	Howard & Prescott 1971
Phytoplankton	8[2]/ §	Howard & Prescott 1971
Phytoplankton	30[2]/ //	Howard & Prescott 1971

After Hobbie, et al., 1972
(EPAC, 1974, Vol. IV, p. 2A.6-44)

† Imikpuk Lake

‡ Estimated from data provided by referenced author

§ Ikroavik Lake

// Malikpuk Lake

Marine Ecosystems

Spring breakup represents a significant transfer of kinetic energy from the mountainous headwaters to the river deltas. Also, water surfaces absorb up to five times as much solar radiation as snow and ice.

Nutrient concentrations in the surface layer of the Beaufort Sea are lower than those observed in the bottom waters. This is due to the deficiency of inorganic nutrients in water from ice melt. The warmer river water also lowers dissolved oxygen concentrations in the nearshore marine waters (Hufford, 1974).

Oxygen and chlorophyll data indicate a low inshore primary production rate. River-contributed turbidity, which reduces light for photosynthesis, is probably the major limitation on production (Grainger, 1974).

Annual productivity rates for the nearshore Beaufort Sea appear to be substantially lower than for the Bering Sea or the Gulf of Alaska (Alexander, 1974).

Ecosystem Parameters and Interrelationships

Terrestrial Ecosystems

Food Chain (consumers)

The consumer link in the tundra food chain consists of a small number of species (herbivores) that feed on the live vegetation and insects (saprovores) that feed on the dead and decaying vegetation.

One unusual feature of tundra consumers is their mobility and widespread migratory tendency. More than a hundred bird species may be encountered in summer, but most of these are absent from the tundra in winter. Mammal movements are largely seasonal. Caribou generally move out of the region to winter south of the Brooks Range. Many arctic foxes move out onto the Beaufort Sea ice in winter. Even indigenous man traditionally has been mobile (nomadic) in this part of the world, capitalizing on cyclic and noncyclic changes in the availablity of biological resources. Mobility is important to the large herbivores, such as the caribou and musk ox, in reaching their foraging habitats.

In general, the diversity or number of herbivore species in the community increase north to south in the Arctic. At Barrow, for example, only the brown lemming is a significant herbivore. The lemming's well-known but unexplained population density fluctuations, often by factors of 1000, provoke marked changes in the abundance of carnivorous species that prey upon this rodent for food. Through this one herbivore, energy is passed along to an array of predatory birds and mammals: snowy owls, short-eared owls, three species of jaegers, least weasels, and arctic foxes. When lemmings are not sufficently abundant, the predators are virtually absent in many seasons over large areas of tundra. Such dramatic changes in mammal and bird populations become less pronounced farther south, as the diversity of herbivore species broadens. The consequences of an ecosystem where many predators depend on one, or a few, herbivores limits the species diversity and cause dramatic changes in the abundance of the carnivores.

Saprovory consumption of dead plant and animal material exists to a major degree in the tundra, perhaps because it fills the functional vacuum left by the paucity of herbivores. The saprovore food chain crosses the indefinite boundary between consumption and decomposition. Even the brown lemmings contribute significantly to the decomposition process by changing living and standing dead vegetation into litter and feces. But the workhorses among the saprovores are the assorted soil invertebrates that live in the rich, organic, peaty soils.

The saprovore chain culminates in higher carnivory, often by the same species that consume the herbivores, such as owls, jaegers, foxes, and weasels. In years of lemming abundance, there is widespread predation on shorebird eggs and young birds by carnivores (Norton, 1973).

The food chain culminates with the carnivore species, both mammals and birds. Because of their location at the top of the food pyramid, mammals and birds are vulnerable tc the progressive concentration of nonmetabolizable toxic compounds. In the tundra food chain, the carnivores include the weasel, wolf, and a variety of predatory birds including the gyrfalcon, peregrine falcon, jaegers, and owls.

Decomposition

Organic decomposition rates in tundra soils are low. The explanation of this basic observation and the effect of slow rates of decomposition on the whole system are essential to understanding arctic ecology and to predicting system alterations following disturbance.

Optimum incubation for most microbes occurs in warm and moist conditions. Above-ground atmospheric conditions in the Arctic are cold and dry. This, in part, explains the severely limited organic decomposition. Further, micro-biological activity is limited by the short summer and the shallowness of the active soil layer over permanently frozen ground. Mineral nutrients are "locked up" to a large extent in underlying frozen mineral soils and become available only during occasional seasons of greater-than-average thaw depths or after certain forms of perturbation. Although soil organisms in the Arctic show certain adaptations to these adverse conditions, the number of decomposer taxa is strictly limited.

The most intensive relevant studies of decomposition in Alaskan arctic tundra are the current U.S. Tundra Biome efforts. Benoit et al. (1972) characterized high latitude peaty soils typical of the Arctic coastal plain by four features: 1) The large organic litter compartment; 2) immobility of much of the nitrogen in above and below-ground dead compartment; 3) general paucity of available essential minerals; and, 4) slow mineral flux rates of soil of microorganisms.

Aquatic Ecosystems

Food Chain

The simplicity of food webs in aquatic ecosystems of the Arctic is apparent at many taxonomic levels. Sponges, larger arthropods, reptiles, and amphibians are absent. The number of genera and the numbers of species within genera are fewer than those found in temperate waters. Fish are absent from ponds and from the least productive lakes, but are abundant in many rivers. Some lakes harbor only a single species of herbivore (a microscopic crustacean), and occasionally, even this species is absent. There may be only one species of primary consumer. Given this low diversity and the relatively short lives of many lakes and ponds, the tenuous nature of life in the Arctic becomes apparent.

Zooplankton are the major herbivores of arctic aquatic ecosystems. It is possible that phytoplankton are not the chief source of food, and that dissolved and particulate organic matter and detritus are more significant in the zooplankton diet. This observation is supported by the high zooplankton-to-phytoplankton biomass ratio usually found. Even considering all sources, zooplankton populations may be limited in these waters (Hobbie, 1973).

The biomass of benthic microfauna varies greatly with water depth and substrate. These organisms are an important part of aquatic ecosystems, and frequently exhibit densities greater than 10,000 per m2, and occasionally near 100,000 per m2, (McCart et al., 1973). These densities compare favorably with those found in more southerly latitudes, but productivity is nontheless low. Insects (the dominant organisms numerically) and crustaceans appear to have extended life cycles and corresponding slow growth.

Chironomid (midge) larvae dominate the benthic microfauna in arctic and subarctic waters and are most abundant in shallow ponds with organic sediments and in streams originating from springs. They frequently constitute 50 to 90 percent of the fauna. Tundra ponds have about 10 species of chironomids, an order of magnitude less than temperate shallow lakes (Hobbie, 1973). Oligochaetes, plecoptera, and ephemeroptera are generally secondary in importance, and several other groups are found in smaller numbers.

Tributaries of the Sagavanirktok River, including springs, beaded foothill streams, and mountain streams, have benthic fauna similar to the ponds. Species composition varies greatly between locations and seasons as insect species, the dominant group, change densities with life stage. Chironomid density may approach 100,000 per m2, but may only be 10 to 100 per m2, and a small percentage of the total organisms present. At present, only preliminary information is available on macrofaunal densities and biomass, and little information is available concerning life histories and population dynamics.

Macrofauna occupy an important ecological position. They are the primary herbivores in flowing waters, feeding on benthic algae, bacteria, and decaying plant material. Through their physical activity they cause suspension of algae, bacteria, and detritus, which can be eaten by zooplankton in lakes and ponds. Macrofauna are the most important food for fish and shorebirds and are particularly important in rivers where most fish production occurs.

Slow growth and development and long life spans characterize fish in arctic fresh waters. Low productivity of the waters and the short growing season are probably responsible. Despite slow growth, arctic fishes may reach large sizes, and the lifespan of some of them is as long as 40 years.

Decomposition

As with the terrestrial ecosystems, decomposition in arctic aquatic systems is limited, especially in shallow lakes and ponds with heavily organic sediments. The rate of decomposition largely determines the rate of supply of nutrients to the aquatic community. In the region of the proposed gas pipeline, however, very little specific information exists on types of organisms, their biomass, or important functions.

In a Barrow pond, the biomass of bacteria in the water was twice that of the phytoplankton, while the biomass of sediment bacteria was 1000 times that of the water on an areal basis (Hobbie et al., 1973). High uptake rates of dissolved organic carbon and low turnover times for the pool of organic compounds indicate a moderately high level of activity for these bacteria.

Decomposition is assisted by benthic macrofauna, such as the chironomid larvae. These organisms are detritovores; they mix and break sediment material. Microfauna may also contribute to the decomposition process. Fungi are generally important in decomposition, but apparently have not been investigated in Alaskan arctic waters.

Marine Ecosystems

Biological activity beneath the winter ice cover near river mouths lowers the dissolved oxygen content. Fish populations use some of these areas for spawning and overwintering. The overwintering areas may comprise a delicately balanced and temporarily closed system, in which the nitrogenous excretion products of fish and other fauna are assimilated and nitrified by microflora. This process consumes oxygen necessary to the survival of the fish.

Human activities upstream that would appreciably increase the loading of dissolved organic nitrogen into the water could have deleterious effects on this balance.

Ecosystem Parameters and Critical Factors

Soil Nutrients

The slow rates of decomposition in tundra ecosystems reduce available nutrients for plant growth.

Cold tundra soils are deficient in available nutrients, especially nitrogen (Bliss, 1971). Haag (1973) has shown that in a low arctic, wetland sedge and upland willow-birch-dwarf heath shrub communities, available nitrogen limits protein content and dry matter production, while phosphorous does not. Nitrogen is metabolized into organic compounds at low temperatures, while phosphorus metabolism is limited by low soil temperature and low available nitrogen. These metabolisms limit nucleoprotein formation (Bliss et al., 1973).

In very cold soils, however, phosphorous and potassium become limiting. "Cold phosphorous" seem to be more limiting than "cold potassium" (Bliss, 1971). Thus, as soil temperatures are lowered, the unavailability of nutrients limits plant growth.

Fertilization experiments have supported these hypotheses concerning nutrient limitation. In Canada and Alaska experimentation, the addition of nitrogen and phosphorous both peat and mineral soil have demonstrated stimulated plant growth (Bliss, 1971; Van Cleve and Manthei, 1972).

Lower soil temperatures decrease productivity. A small experimental plastic greenhouse significantly increased dry plant weight, soil temperature, and soil moisture on Devon Island (Bliss, 1971). This effect is well known to gardeners in interior Alaska where plastic mulches are commonly used to increase garden productivity. The importance of increasing soil temperature for plant growth was found by McCown (1973) in his study of the effects of hot oil pipelines on plant growth in cold-dominated soils.

Within a tundra system, especially a low arctic one such as that on the Arctic Slope, the increment of nutrients within the mineral soil in relation to the nutrient pool of the surface peats (often 5 to 20 cm) and the standing vegetation may be quite low. This, coupled with slow below-ground (some 5 to 10 years) and above-ground (some 3 to 5 years) turnover times, suggests that the organic horizons of bog and tundra soils serve as a nutrient sink, which has a low release rate. This sink and its nutrient release rate may be expected to control primary productivity in bogs and the accompanying low primary and secondary productivity of bog systems represents a failure of the decomposition process. A slow rate of nutrient recycling depresses turnover rates in the functional compartments of primary production and consumption.

Vegetation-permafrost Interaction

Vegetation forms an insulating blanket that effectively maintains a shallow active soil layer less than a meter in thickness for most vegetation types.

Permafrost is an important factor in the tundra ecosystem. The permafrost forms an impervious layer to moisture. This results in the wet substrate of most tundra ecosystems. Disturbance of the vegetative mat increases thaw and raises soil temperatures. This may result in thermal erosion if the underlying soils are ice-rich. Under some conditions, disturbance of the vegetative layer results in a release of nutrients and may result in increased productivity of the ecosystem.

Fire in the Tundra

Fire in the tundra is neither as common nor as extensive as in the boreal forest regions of Alaska, because tundra plant communities differ from forests in the following ways: 1) tundra has more frequent discontinuities in plant cover; 2) its biomass is much less combustible, and 3) a moist surface organic layer is present throughout much of the summer in most tundra plant communities (Wein and Bliss, 1973; Cochrane and Rowe, 1969; Barney and Comiskey, 1973).

At Rankin Inlet on the northwest shore of Hudson Bay, Cochrane and Rowe (1969), found that heaths and lichens burned more completely and severely than did other species. Low shrub-heath communities and others dominated by these species groups were more susceptible to fire and slower to regenerate. Communities on moister sites did not burn.

Although usually occurring in moist sites, cottongrass tussock tundra communities are able to carry fire because of the large dead and dry above-ground standing crop which forms most of the tussock. These communities recover relatively rapidly after fire (Wein and Bliss, 1973). Annual production approaches that of unburned areas within 2 years although fewer species contribute to it. Standing crop may be replaced in 7 to 17 years, with plant growth and nutrient flow returning to equilibrium. Greater flowering and greater plant nutrient content in recently burned cottongrass communities may be results of the following: (1) increased soil volume available for nutrient extraction by roots, (2) increased microbial activity in warmer soils (both of the above result from deeper thaw), and (3) to nutrients released by the burning of the standing crop (Wein and Bliss 1973).

Tundra may be created by fires in permafrost areas near the northern limit of trees (Bowe and Scotter, 1973). This process has been described for moist cottongrass forest-tundra communities of northeastern Siberia by Kryuchkov (1969). In the years following a fire, thaw depth in these moist communities often decreased with the rapid rediscovery of cottongrass. Bliss and Cantlon (1957) discussed the natural conversion of tall shrub communities growing beside rivers in northern Alaska to cottongrass tussock tundra with scattered alder as thaw decreased with litter accumulation.

Unique Ecosystems

The Arctic Slope of Alaska is a region of treeless tundra well clothed by an arctic flora. The tundra ecosystems represent an extreme on the Earth which, when compared to temperate ecosystems, can help biologists sort out universal ecological mechanisms from purely local adaptations. Tundra comprises 20 percent of the earth's land area, and Alaska is about one-third covered by tundra. Tundras can take many forms. Some are wet, while others are drier, and some are dominated by sedges and grasses while others are dominated by low shrubs and herbaceous plants. What they all have in common, though, is their low heat budget and that determines the characteristic biology of the tundra ecosystems. Although the summer sun shines continuously for more than 80 days, with long days before and after that, the actual growing season is much shorter. The winter snow cover is not melted until late in June on the Alaskan Arctic Coast, which means that half the annual solar radiation is spent before plants can begin to photosynthesize. (See Figure 2.1.1.8-2.)

When the snow cover melts and the ground is exposed to sunlight, most tundra plants begin to grow very rapidly. This very rapid initiation of growth is possible partly because a large amount of each plant is below the ground surface. The very large underground biomass, as much as 17 times more below ground than above, also favors vegetative reproduction of the plants which may not successfully produce viable seeds in the short growing season.

Diminished solar radiation, short growing season, frozen ground, low air temperatures, and nutrient deficiencies present conditions which tend to limit annual production of biomass. Because of this, the annual gross primary production of plants in the wet tundra near the Beaufort Sea is only about 170 grams per square meter. This compares to 1,600 grams per square meter in the temperate deciduous forest and about 1,000 in the grasslands.

The factors which tend to limit annual production in the tundra ecosystem also limit decomposition. In the cool summer temperatures, microbes can digest only about 10 to 30 percent of the standing dead material each year. This leads to a substantial buildup of undecayed organic materials in the soils, the nutrients remain tied up, and lack of nutrients limits the amount of new growth. It appears that a shortage of phosphorus is the most serious nutrient limitation in the arctic tundra.

On the Arctic Slope, the land is dominated by surface water. During the spring meltoff, much of the tundra surface is under water until the excess evaporates or is carried off by surface drainage into ephemeral streams. Ponds and lakes are active repositories for much of the litter and nutrients washed off the land.

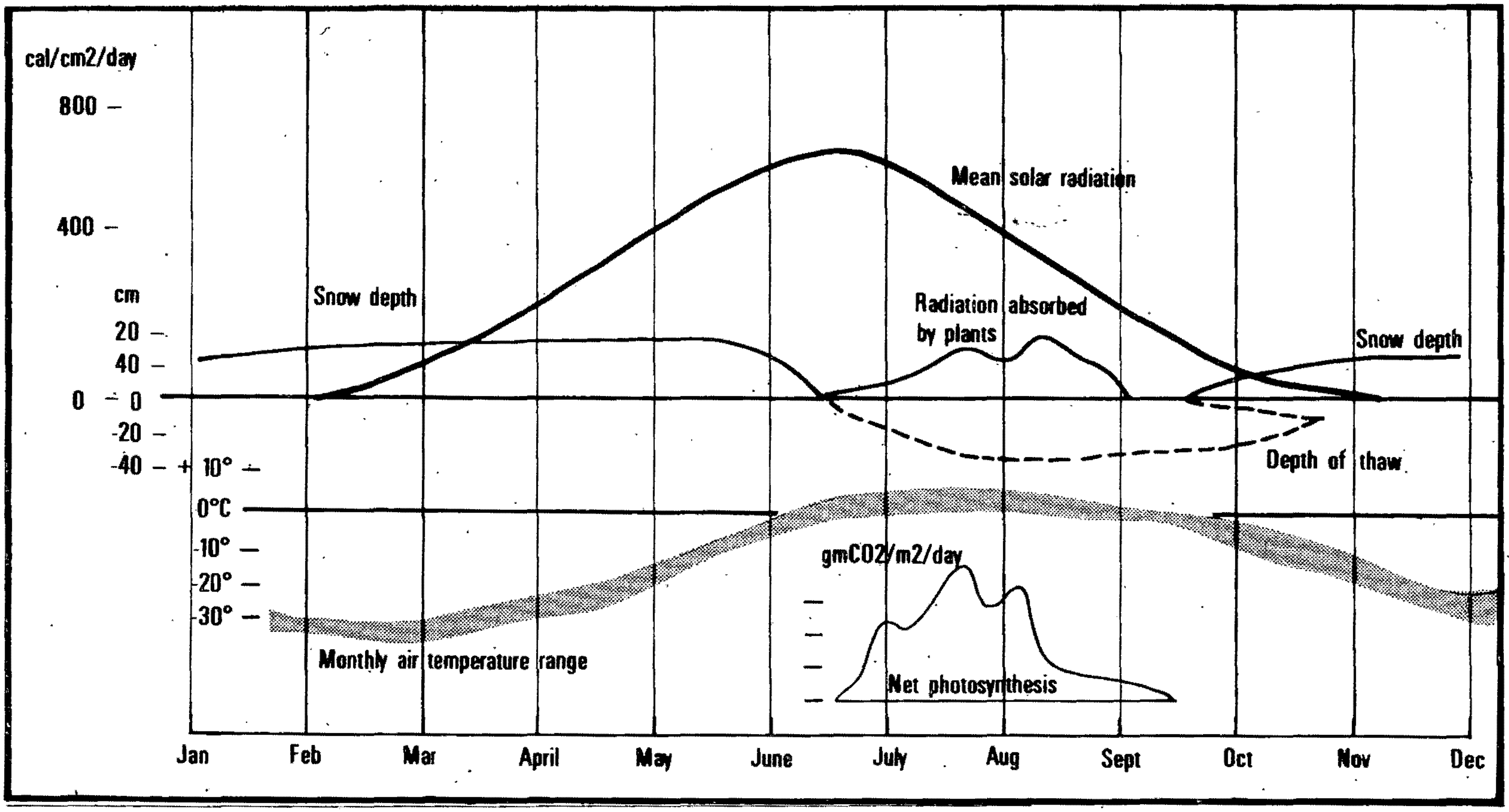


Figure 2.1.1.8-2 Constraints on the tundra vegetative community resulting from limited solar radiation

2.1.1.9 Economic Factors

History of Economic Development

Alaska

Alaska's economic development began with the fur trade in the mid-1800's and expanded with fisheries and timber and the discovery of gold, copper, and now petroleum resources.

The following discussion is quoted from the Special Interagency Task Force Final Environmental Impact Statement for the proposed trans-Alaska pipeline, vol. II, pp. 287-290 (SITF, 1972).

The importance of Alaska to the nation and the national economy can be expressed in terms of defense considerations reflected in expenditures for personnel, procurement and construction and the gross value of products from natural resources which are exported from the State to other domestic markets or enter into international trade. Although the strategic position of Alaska was Secretary of State Seward's primary concern in promoting the purchase of Alaska from Russia in 1867, it was not until the 1942 invasion of the Aleutian Islands by the Japanese that the national defense importance of this northern territory of the United States was generally recognized. Prior to that event, Alaska's national importance was as a source of fishery products (for the most part canned salmon), gold, copper (for a brief period) and raw furs. During the 1931-40 decade the average annual value of out-shipments from Alaska was $58,758,000, composed of canned salmon (55.1 percent of total value), gold (26.6 percent), other fish products (6.4 percent), furs (4.4 percent), used machinery, scrap metal and other miscellaneous items, (7.5 percent).

During the 1950's and 1960's Alaska, from the national point of view, became primarily an exporter of military defense. Between 1951 and 1954, while the DEW line and other facilities were under construction, spending by the Department of Defense in Alaska averaged $412.9 million annually. This declined from a peak of $512.9 million in 1953 to annual amounts fluctuating between $264.6 million (1962) and $352.0 million (1968) during the 1960's.

While defense spending declined in the late 1950's, the value of natural resources production began to climb. Fishery products increased in value as salmon catches stabilized and the base was broadened and diversified by the expansion of shellfish products. Forest products increased in value with the addition of two pulp mills and expansion of other timber plants during the 1950's. The real boom in natural resources values, however, was set off by the discovery of oil on the Kenai Peninsula in 1957 and the discovery and development of other fields on the Peninsula and in Cook Inlet in the early 1960's. By 1965, the total natural resources products exceeded expenditures by the Department of Defense and this trend has continued at an accelerating rate (Table 2.1.1.9-1).

Statistics on Federal spending in Alaska for national purposes and the total value of resource production give an impression of Alaska's economic importance to the nation, but they do not present a true picture of the Alaskan economy. Much of the construction and procurement expenditures of the Department of Defense never enter the resident economy because much of the equipment, supplies, and specialized labor force must be imported. Some local resources may be converted into construction materials and local resale of equipment and supplies may be generated but only a fraction of the total money spent actually enters the State and the multiplier effect in the Alaskan economy is low. A great deal of the total value of natural resources likewise escapes the resident economy in the form of profits and

Table 2.1.1.9-1 Department of Defense expenditures in Alaska and estimated value of major Alaska natural resources production, 1950, 1960, and 1970

Calendar year #/	Dept. of Defense expenditures	Total natural resource products value	Crude petrol & nat. gas	Fisheries products	Forest products	Other minerals	Raw furs	Commercial agricultural products
1950	$455.9	$130.6	$ --	$100.2	$ 6.1	$ 17.7	$4.4	$2.2
1960	307.5	176.1	1.5	96.7	47.3	20.4	4.8	5.4
1970	333.4	632.8	256.7	213.9	108.0	42.7	6.0	5.5

*Military and civilian employee payrolls, contract construction, and procurement expenditures within Alaska.

†Fisheries products: Wholesale market value, final stage of processing within Alaska.

Petroleum and natural gas: Crude oil and natural gas at wellhead price. Does not include estimate of value added by manufacturing.

Other minerals: Average selling price of refined metals as computed by U. S. Bureau of Mines; land, gravel, stone at estimated value to construction industry.

Forest products: Value of pulp and lumber f.o.b. mill.

Furs: Raw fur value, includes U.S. share of sales of Pribilof furs at auction.

Commercial agricultural products: Wholesale market values.

#Dept. of Defense expenditures for fiscal year. Value of natural resource products for calendar years.

Sources: Dept. of Defense from U.S. Bureau of the Budget. Natural resource data from U.S. Department of the Interior agencies, U.S. Forest Service, and Alaska Dept. of Natural Resources and Fish and Game.

interest to nonresident corporations and investors, in equipment and supplies purchased outside Alaska, and transportation costs and seasonal wages paid to nonresident workers.

The economic growth of the State is reflected in the rural to urban intra-Alaska migration. More than 61 percent of the State's population is concentrated in three major areas: Anchorage, Fairbanks, and Juneau. The Anchorage area currently has almost one-half of the State's population; it is becoming a manufacturing and service center for the entire State. Fairbanks has become the commercial and trade center for the central and northern regions of state. Juneau, the present State capital, has increased in importance as State expenditures have become a larger part of the Alaskan economy in relation to Federal monies.

The Alaskan electorate voted in 1974 to move the State capital to an interior location which has not yet been selected.

North Slope Borough

The North Slope Borough encompasses 88,281 square miles north of the Arctic Circle in an area extending roughly 650 miles east to west and 225 miles north to south. The Borough is larger than 41 of the 50 states, but it contained a population of only 3,757 persons in 1973 (North Slope Borough estimate). The North Slope Borough was incorporated as a First-Class borough in 1972, with responsibility for tax assessment and collection, education, planning, platting, and zoning (Figure 2.1.1.9-1).

Economic development in the North Slope Borough was slow until oil was discovered at Prudhoe Bay. In 1969 the State granted development leases to oil conpanies which led to extensive planning and stockpiling of materials for oil resource development.

Transportation problems also slowed development. The only reliable connection between Borough residents and other Alaskans is by air. Opening of the highway now constructed as part of the trans-Alaskan oil pipeline project is the first highway connection from the borough to the road net in the rest of Alaska. Except for this highway, the vast North Slope Borough is almost completely roadless.

Winter haul roads, for moving heavy loads overland when the ground is frozen, have been the historic method for moving oil and gas exploration equipment. These routes usually are constructed for special needs on a short-time basis, taking advantage of best local conditions.

Principal Economic Activities

Alaska

Commercial Fisheries

Commercial fishing for salmon, halibut, and herring began in Alaska during the late 1800's. The first salmon cannery in Alaska was established at Klawock in 1878, and salmon canning rapidly became the dominant fish-processing activity in Alaska. Fishing for shrimp, crab, and clams began in Alaska about 1920, and shellfish products now are the State's second highest value seafood.

Among the states, Alaska usually ranks first in the value of fish products produced, and third or fourth in terms of volume. This difference

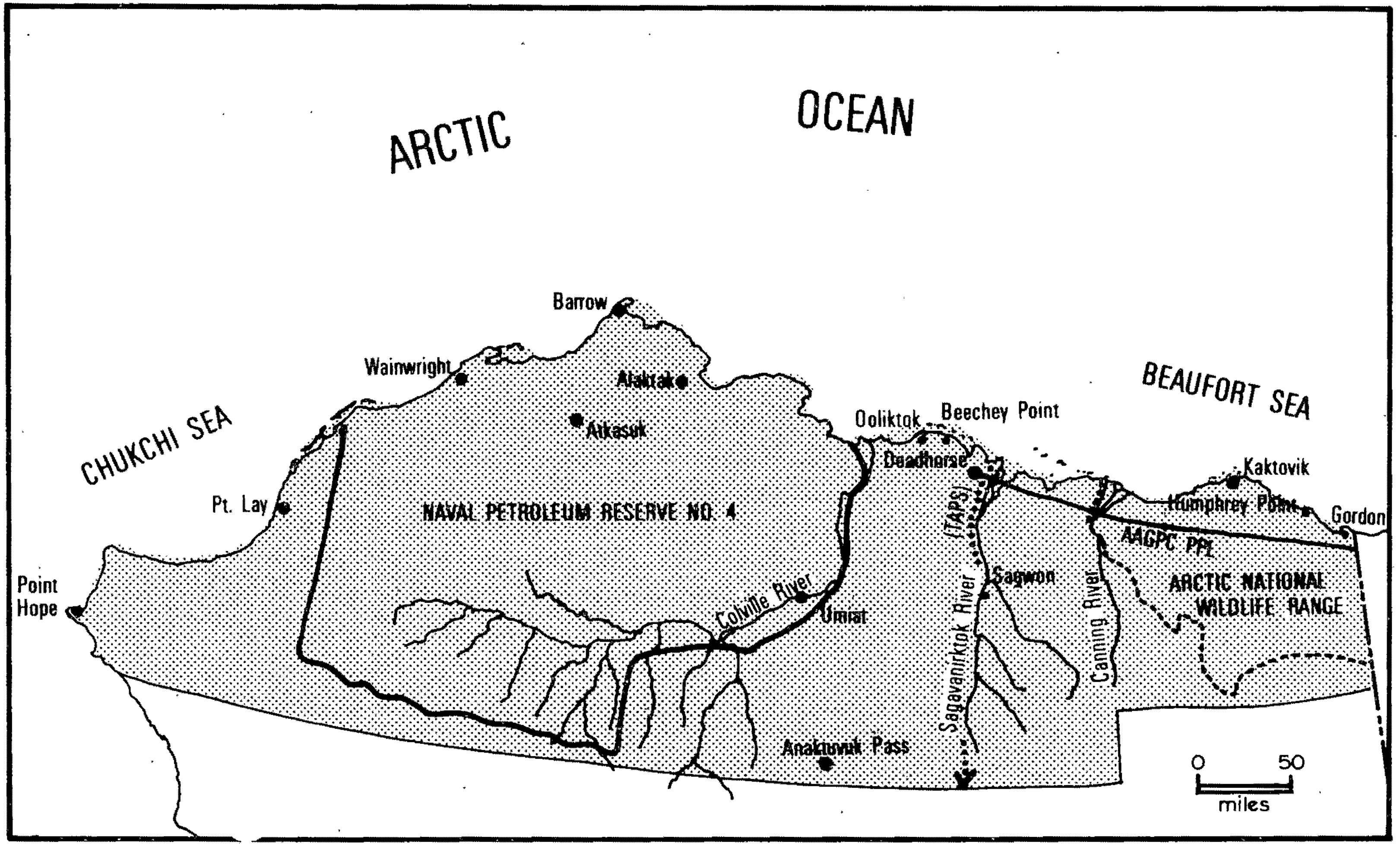


Figure 2.1.1.9-1 North Slope Borough

in rank for value and landings results from the fact that most Alaskan fishery products have high unit value while those from other states contain large volumes of low-value animal food and industrial products. Overall, Alaska produces 10 to 12 percent of the total value U.S. fishery products.

Fish processing was Alaska's major manufacturing activity in the years before statehood. Employment fluctuates yearly (and seasonally), with from 8,000 to 11,000 persons employed in some 200 operating plants.

Forest Products

Alaska's annual harvest of timber has increased steadily over the last 20 years to a present figure of over 650 million board feet per year, with an end product value exceeding $120 million. In the 1950's nearly all the timber cut was made into pulp, but by the end of the 60's some 43 percent was going into cant (rough squared logs) for the Japanese market (Alaska Department of Economic Development, 1972).

Alaska exports more than 70 percent of its forest product output, and more than 90 percent of that goes to Japan (NBA, 1974).

Tourism

Tourism is a major inaustry in Alaska. Tourists have increased in number at an annual rate of 15 percent for the past 10 years. Tourist expenditures have increased even faster. An estimated 215,000 persons spent an estimated $72 millicn in Alaska in 1973. The tourist trade that year accounted for about $10.5 million in State revenues.

Airline travel has become the most popular tourist transportation mode and the 70 weekly flights by Japan Airlines carry a large share of the foreign visitors. Cruise ships, some with accommodations for as many as 1,000 passengers, carry 20 percent of the tourists.

Services catering to tourists are labor intensive; tourist dollars have higher multiplier effects on Alaska's economy than most other types of industrial transactions. Thus, a relatively large share of tourist dollars tends to remain in Alaska's economy (Alaska Department of Economic Development, 1972).

Minerals

Miners and minerals have played a major role in Alaskan history. Hard-rock miners were producing copper and gold from the coastal areas of the Alaskan Peninsula, Prince William Sound, and Southeastern Alaska before the Klondike gold rush in 1898-99. A large but mobile population followed a succession of placer gold discoveries across Interior and Arctic Alaska, but the gold rush waned by 1910 and the population of interior Alaska shrank.

Hard-rock mining remained active into the 1930's but the Kennecott Mine closure in 1938 ended major copper mining, and closure of the Juneau gold mines at the start of World War II ended major hard-rock mining activity. Petroleum has dominated mineral industry statistics since statehood, and demand for construction aggregates, sand, gravel, and stone has produced the second largest mineral product value on a statewide basis.

Oil and Gas Industry

The oil and gas industry became significant in the economic activities of the State in the late 1950's, with systematic exploration and development of the Upper Cook Inlet Basin. Associated with the Upper Cook Inlet production area is a small chemical processing industry. Collier Carbon and Chemical Company, located near Kenai, a subsidiary of Union Oil Company of California, produces ammonia and urea. A liquified natural gas (LNG) plant, two small refineries (Standard Oil and Tesoro-Alaskan), and an asphalt plant comprise the present complex. LNG is shipped to Japan and a Japanese firm is associated with the fertilizer plant. The two refineries produce heating oil and jet fuel for local consumption with a combined throughput of 51,000 barrels of oil daily. Crude gasolines are either shipped to California for further refining or blended with imported petroleum products to produce motor fuels.

A $200,000 expansion of the Collier Carbon and Chemical company plant soon will double its capacity. The Tesoro-Alaskan Petroleum Corporation also plans an $11 million expansion of its Cook Inlet refinery facilities. An application (CP75-40) has been filed with the Federal Power Commission by Pacific Alaska LNG Company to construct new LNG facilities at Nikiski. This facility (with an initial capacity to liquefy and transport 200 MMSCF/D and potential of 400 MMSFC/D would liquify Cook Inlet natural gas and ship it to California in cryogenic tankers. Terminal facilities in California also are under application (CP74-83) by Western LNG Terminal Company.

Altantic Richfield Company maintains a topping plant at Prudhoe Bay which processes 6,300 barrels of oil daily. Crude oil for this plant is obtained from one well in the Prudhoe Bay Field which is operated exclusively to provide feedstock for the refinery used to produce fuel for heating, vehicle operation, and some aviation purposes in the immediate Prudhoe Bay area.

With the start of intensive development at Prudhoe Bay in 1969, a marked shift in statewide emphasis took place from the Cook Inlet to the Arctic Slope and from Anchorage to Fairbanks. In 1969, Earth Resources Company announced plans to construct a $30 million petroleum refinery and electrical generating complex in Fairbanks in anticipation of crude oil availability from Prudhoe Bay. Tussing, et al., 1971 stated:

> ...the long term impact of North Slope oil will come mainly from production revenues. It is not correct, therefore, to attribute all or most of the projected growth to the proposed (oil) pipeline as such; the bulk of the gains to the State would occur whatever route were chosen to transport the crude oil to markets...

Alaska, unlike the rest of the nation, experienced an overall 10 percent increase in economic activities during the first half of 1974 above the level of the first four months of 1973. This trend has continued through 1974 and is singularly related to the start of construction of the trans-Alaska pipeline.

According to the National Bank of Alaska (1974), construction activities led all statewide indicators as a result of over $1.5 billion in contracts awarded for the oil project.

The total dollar value of contracts awarded represented an increase of 1,658.9 percent over the comparable period of 1973.

North Slope Borough

The Borough lies generally north of the treeline and has no forest product industry. Some driftwood is scavenged along the coast for fuel, but all other wood products must be imported. There is no commercial fishing in the Beaufort Sea, but the various rivers flowing into the sea provide a subsistence fishery for Borough residents. Subsistence hunting of sea mammals, birds, and land mammals is also an important segment of the economy of this area.

The Prudhoe Bay area contains one of the largest known oil reservoirs in North America. It holds a substantial portion of the known U.S. petroleum reserves.

Since the North Slope Borough was organized from portions of three census divisions (Kobuk, Barrow, Upper Yukon) after the 1970 census, there is no reliable statistical base from which to describe economic activities other than in general terms (Figure 2.1.1.9-1).

Although not specifically identified, almost all the "certified value" represents investments by the oil and gas industry. Because of the intense focus on the Prudhoe Bay Field and general closure of almost all other lands in the Borough, it is assumed that the vast majority of the $741 million "certified value" of the North Slope Borough is in the Prudhoe Bay area.

This assumption is strengthened by the fact that values of the five principal communities in the Borough total approximately $3.3 million (Table 2.1.1.9-2).

The economy of the impact region historically has been based on subsistence hunting and fishing, with social status and relative wealth depending on the subsistence skills of the individual. As the North Slope became an important military and scientific location (DEW-line) and its vast natural resources known, its Native inhabitants have increasingly moved toward a cash economy.

Barrow is the local government seat, the major service center of the North Slope Borough, and it is a well-developed permanent settlement. Barrow has a few service outlets including three general stores, two restaurants, and several retail vehicle dealerships. Tourism is an important local industry. The city currently has one hotel and plans a second. Wien Air Alaska serves Barrow with daily flights from Fairbanks. This airline also offers tourist packages which include lodging, meals, and sightseeing tours in the vicinity. The Naval Arctic Research Laboratory is just outside of the city.

The average yearly income in Barrow is $9,400, but fully 30 percent of all local residents earn less than $4,000. Of these, many receive cash only through State or BIA public assistance.

In contrast, smaller Native villages on the North Slope continue to depend heavily on a subsistence economy. Even in Barrow, employment is seasonal, with Native unemployment ranging as high as 80 percent in winter months and dropping in summer.

The only Native settlement near the proposed route of the pipeline is Kaktovik, an Eskimo community of approximately 150 people on Barter Island. It long was a trading center for the northern aboriginal Eskimos and later for whalers hunting on the Beaufort Sea. The development of a military radar in the 1940's and the DEW-line construction in 1953 provided employment for some village residents and introduced a cash economy.

Table 2.1.1.9-2 Assessed value of communities, north

COMMUNITY	POPULATION	PERSONAL	REAL	BUSINESS	TOTAL
Barrow	2,104	$674,200	$687,100	$1,300,500	$2,661,800
Kaktovik	123	35,500		28,400	63,900
Wainwright	315	66,500		307,100	373,600
Point Hope	386	53,400		156,900	210,300
Anaktuvuk Pass	99	12,300		7,200	19,500

Source: Dupere and Associates 1973

Currently, 13 villagers (2/3 of total wage employment based on a total of 19 counted jobs) work at the DEW-line station. The Barter Island DEW-line station presently houses some 60 to 70 men on a full-time basis. During summers, the number may be double that.

Annual barge service to Kaktovik serves the Barter Island DEW station. The village consists of a community hall, a DEW station, a post office, a store, a National Guard Armory, a BIA school, a health clinic, an airport, two churches, and private residences.

Under the provisions of the Alaska Native Claims Settlement Act (P.L. 92-203), some 1.9 million acres probably will pass from Federal and State ownership and these anticipated shifts in land ownership and land uses, including expansion of exploration and development for oil and gas, provide an optimistic economic future for the Borough. (See 2.1.1.11 for detailed disscussion of land ownership.)

Employment and Income

Alaska

According to the Alaskan Arctic Gas Pipeline Company, the current work force in Alaska is approximately 162,000 persons. Fully 42 percent of the total state work force consists of government employees.

During 1970-72, the civilian work force grew from about 115,000 to about 130,000. In addition to government and service employment, secondary service industries have also grown; hotel employment has increased along with business, medical, and personal service employment.

Total civilian employment in the first four months of 1974 rose 6.8 percent above the same period in 1973. This rise reflects growth in overall economic activity in Alaska resulting from the start of the trans-Alaska oil pipeline project from Prudhoe Bay.

Unemployment, a persistent problem in Alaska, recently has grown at a faster rate than has the work force as a whole. The 1970 unemployment rate of 8.6 percent grew to 9.9 percent in 1971 and 10.1 percent in 1972, a 37.3 percent rise in the absolute number of unemployed over a two-year period. Although overall economic activity increased in the first 5 months of 1974, the unemployment rate increased to 13.7 percent (NBA, 1974). This rapid rise in Alaskan unemployment in part reflects a marked increase of migration into the State following the discovery of oil and gas at Prudhoe Bay and the severe seasonality of Alaska's basic industries. Many of the people who were attracted to the State because of anticipated pipeline jobs did not find work.

In spite of repeated warnings, there has been, and will continue to be, considerable migration of workers to Alaska in search of employment. Some of these will find employment in the expanding economy resulting from the trans-Alaskan oil pipeline.

Historical patterns indicate that for every oil pipeline construction job, a total of one and one-half secondary and indirect jobs will be generated. Estimates indicate that Alyeska (the consortium building the pipeline) will employ a peak of 20,000 workers.

Most of the secondary and indirect jobs associated with oil pipeline construction will be located in the major population centers--Anchorage and

Fairbanks-causing these cities, already dominant communities in the State, to continue to grow at a rate faster than that of the State as a whole.

It has been estimated that the increase in the State work force caused by the influx of migrants will outstrip the available job market. Thus, unemployment rates will continue to rise above normal for the first years of oil pipeline construction. Once the peak employment is passed, the construction work force will be reduced, increasing unemployment rates. The increase is due to the fact that when oil pipeline employment declines in 1977, even those unemployed construction workers who choose to leave the State will draw unemployment benefits and thus will be included on Alaska's unemployment rolls for a period of time.

The basic pattern likely to develop is that additions to the work force will outstrip the additional jobs created during oil pipeline construction. The State predicts an addition of 3,000 to 4,000 unemployed per year. The consultants to AAGPC estimate an even higher increase in unemployment. As the phenomenon of high in-migration trails off, oil pipeline construction will end, and employment will decline unless further economic stimulus is provided. The construction employment decrease will reduce numbers of secondary and indirect jobs, after some lag.

Although the "northern region" of Alaska encompasses the entire northern half of the State, Fairbanks dominates regional employment patterns and accounted for 75 percent of the 1972 regional work force of 26,100. As in the State as a whole, the military presence in the northern region is decreasing as government and service industry employment rises. Alyeska pipeline construction delays caused oil and gas industry employment to decline temporarily by some 700 jobs, from 1,100 in 1970 to 400 in 1972.

Oil and gas employment has increased since then to the point where Fairbanks is experiencing a shortage of service employees because local service workers are finding pipeline employment more profitable than their previous jobs.

From a monetary standpoint, the Alaska Native Claims Settlement Act (ANCSA) provides for a grant of $962.5 million to the Alaska Native Regional Corporations. Of this amount, $462.5 million will be paid in installments by the United States Treasury over an 11-year period.

The remaining $500 million is to come from a 2 percent royalty on gross revenues from mineral sales, leases, bonuses, and royalties from State and Federal lands, excluding bonuses and rentals received by the State at their September 1969 oil rights sale.

For additional discussion of ANCSA see Section 2.1.1.10. While military expenditures are a powerful influence on the Alaskan economy, Federal assistance programs provide significant aid to Alaska residents. In Table 2.1.1.9-3 Federal aid programs are summarized.

North Slope Borough and the Village of Kaktovik

Employment in the North Slope Borough tends to be erratic. The area has small labor base and is susceptible to rapid changes, caused by large but short-lived construction projects.

The seasonality of most local employment creates recurrent periods of recession and unemployment. Although present labor trends indicate that additional jobs will become available to Natives, many jobs require skill levels which local residents do not possess. As a result of the lack of a

Table 2.1.1.9-3 Federal aid programs in Alaska

Program	Type of assistance	Level of funding
Rural Electrification Loan Program	Guaranteed and insured loans (g) 2% for 35 yrs. to aid rural electrification	$3.9 million (1972) $6 " (1974)
Economic Development Administration - Public Works and Development Facilities	Grants up to 10% for Native communities and partial grants for others to aid construction of public works	$807,000 Native of $3,326,400 total FY 1974
BIA Social Services Program	Direct payments to Alaska Natives for general assistance, child welfare and counseling. In 1974, 22.8% of Alaska Natives (13,617 persons) received payments.	FY 1974 $3,505,000 (general assistance) 658,000 (child welfare) 880,836 (administration) $5,269,858 Total
Supplemental Security Income Program	Monthly payments for needy aged, blind, and disabled of $185-250 (individual) and $285-350 (couple). Approximately 2,500 Alaska beneficiaries. (2/3 Native).	$3,550,000 estimate per P.L. 92-603
Public Assistance (Aid to Families with Dependent Children)	Direct payments to needy families. In August 1974, 7,718 families (65% Native) received payments.	$18,230,000 (50% paid by Federal Government)
Food Stamps	Provides coupons free or at a percentage of their worth which can be used to purchase food at retail stores. Of 6,135 Alaska recipients in 9/74, 53% were Native.	$8,226,407 FY 1974
Unemployment Insurance	Weekly grants of $18-120 including $10 for each dependent up to 3 children. In May 1974, there were 6,205 beneficiaries including 1,241 Natives.	$25,320,943 FY 1974
Rural Alaska Community Action Program	Provides $30,000 grants to regional development corporations and $1,000 to villages within such regions. Recipients are generally low-income rural Native villages.	$874,000/yr. 1972-1974
Community Enterprise Development Corporation (CEDC)	Grants, loans, technical and training assistance to over 38 rural communities, 95% of which have been Native.	$2,369,468 for May 1, 1974 - April 30, 1975

skilled local work force, past increases in regional work force levels have generally been attributable to in-migration of skilled workers rather than to a significant expansion of local employment. The only employable population near the proposed AAGPC pipeline system is located in Kaktovik (population 150).

Subsistence Economy

A subsistence economy has been and still is a very important element of Alaskan society. As the human population increases, competition for natural resources becomes more intense. This fact has brought the subject of subsistence economics into recent public debate and as of this writing there has been no clear definition of the term "subsistence economy" that is acceptable to all the elements of the society.

For the purpose of this discussion, a subsistence economy is considered one where the use of any natural resource by groups or individuals is for the satisfaction of personal needs and may be contrasted with commercial use of natural resources.

The natural resources of Alaska are extremely diverse and the personal uses of them even more so. Patterns of use develop over time and these add to the material value and enjoyment of the resource. The development of use patterns also leads to conflicts when different groups with different value systems compete for the use of natural resources.

On the basis of a comprehensive survey, Nathan (1974) concluded that Alaskan Natives have a lifestyle that is unique, not because it differs from that of other Alaskans, but because it combines use of traditional elements emphasizing a self-contained, subsistence-oriented life with the recent need to move into cash economy. Although many rural Alaskans depend upon a subsistence lifestyle, a fundamental difference is that non-Natives chose that way of life while, to Natives, subsistence living is traditional.

Nathan (1974) reports that subsistence-type activities are both necessary and time consuming. Approximately 75 percent of the people living in small or medium sized villages obtained at least 50 percent of their food by subsistence activities and they spent between 6 and 7 months in subsistence activities. Hunting and fishing and berry picking were consistently listed by those interviewed as the most important elements of the traditional lifestyle. At the same time, 75 percent contend it is getting harder "...for people to get the food they need by hunting, fishing, berry picking, and things like that." Game laws and restrictions were listed as common problems, followed by reduced game, competition from outside sportsmen, development, and the cost of fuel and equipment.

For the purpose of this report a discussion of subsistence is presented only for the North Slope Borough. A partial list of the annual food harvest and consumption is in Tables 2.1.1.9-4 and 2.1.1.9-5.

It is difficult to assign dollar values to products from subsistence, (see following discussion on subsistence) since their pursuit is cultural and recreational as well as economic. If subsistence resources are valued in terms of Anchorage prices for substitutable items, annual per capita gross dollar from subsistence would be about $475 without the cost of transportation included. Annual per capita return from both subsistence and sale of pelts from trapping would be about $510.

Table 2.1.1.9-6 shows a more detailed listing of the average yearly harvest of meat, fish, and furs by residents of Kaktovik and its approximate

Table 2.1.1.9-4 Summary of Subsistence harvests for selected north slope villages, Alaska

Village	1970 Population*	Pounds of food +		
		Mammals	Fish	Fowl
Barrow	2,153	1,734,600	61,400	7,600
Wainwright	326	417,250	550	1,200
Anaktuvuk Pass	99	153,700	3,500	900
Kaktovik	123	47,500	15,500	2,070
Total	2,701	2,353,050	80,950	11,700

* Dupere et al. 1973.
+ RPT 1974a

Table 2.1.1.9-5 Annual consumption per person of subsistence harvest items

Village	Average consumption per person (pounds per year)		
	Mammals	Fish	Fowl
Barrow	806	28	4
Wainwright	1,279	2	4
Anaktuvuk Pass	1,552	35	9
Kaktovik	386	126	17

* RPT 1974

Table 2.1.1.9-6 Average yearly harvest estimates for Kaktovik and approximate dollar values of meat, fish, and skins

Species	Harvest	Average utilizable weight(lbs)	$ Value per pound of meat or fish††	Average $ value of skin§	$ Value per animal	Total $ Value
Big game						
Caribou	100	100	$1.35	$ 5.00	$ 140.00	$14,000
Polar bear	5	450	1.35	400.00	1,007.00	5,038
Grizzly bear	.2	225	1.35	//	303.75	608
Sheep	30	100	1.35	//	135.00	4,050
Furbearers						
Wolverine	5			120.00	120.00	600
White fox	60			20.00	20.00	1,200
Red & Cross fox	30			45.00	45.00	1,350
Wolf	10			120.00	120.00	1,200
Groundsquirrel	250	1	.69	//	.69	173
Porcupine	5	10	.69	--	6.90	35
Sea mammals						
Hair & spotted seal	75	80	1.35	20.00	128.00	9,600
Bearded seal	30	400	1.35	20.00	560.00	16,800
Walrus	1	800	1.35	120.00	1,200.00	1,200
Birds & waterfowl						
Willow & Rock ptarmigan	750	1	.69	//	.69	518
Geese	30	5	.69	//	3.45	104
Brant	150	2.5	.69	//	1.72	258
King & Pacific eider	150	5	.69	//	3.45	518
Oldsquaw	750	1.5	.69	//	1.03	773
Pintail	75	2	.69	//	1.38	104
Fish						
Arctic char		2,500	1.00	//		2,500
Whitefish		2,500	1.00	//		2,500
Lake trout		1,000	1.00	//		1,000
						$64,129

Source: APG 1974, pp. 96-97

†Approximate dollar values are in terms of Anchorage store prices for similar products if the wild game or fish were not available. Harvest data are for a period of several years. Estimates made by village mayor and others, May 1973.

††Big game and sea mammal prices are based on average price of beef; furbearers, waterfowl, and game bird prices based on price per lb. of whole chicken; fish prices based on an average price for fish. All prices from Gambell Safeway Store, Anchorage, February 1973. Village store prices, which are higher than Anchorage prices, could not be used because the village store does not regularly stock fresh or frozen food.

§ Polar bear and sea mammal hides could not be sold to non-Natives after December 1972 due to passage of the Marine Mammal Protection Act. Thus, these values may decline in the future.

//Not determined.

dollar value. Dupere and Associates (1973) reported that at Kaktovik almost all subsistence activities (hunting, fishing, and trapping) are done within a 30- to 40-mile (48 to 64 km) radius. They further state:

> There is a mutual agreement within the village that sharing is necessary among the community and it is estimated that the employed residents of the community have a 30 percent dependency on subsistence and unemployed residents have from 40-80 percent dependence on subsistence. Furs are used for clothing and occasionally sold tc local residents.

Subsistence activities are the most widely recognized symbol of the traditional Native culture.

Subsistence activities are often the best-liked feature of village life.

There is basic worry about the future of subsistence pursuits (75 percent contended it is getting harder "for people to get the food they need by hunting, fishing, berry picking and things like that").

Four interrelated problems appear especially significant to Alaskan Natives: Game laws and restrictions (33 percent of respondents); reduced game; development; and cost of fuel and equipment. Much resentment was expressed about people who didn't live in the area but hunted there.

Residents of Kaktovik (pop. 150) depend very heavily upon subsistence activities for their food. Dupere and Assoc. (1973) state that dependency on subsistence activities to obtain food ranged from 30 percent to 80 percent. Annually residents take an estimated 100 caribou, 30 Dall sheep, 5 polar bears, 2 barren ground grizzly bears, 75 hair seal and spotted seal, 30 bearded seal, 1 walrus, 750 ptarmigan and approximately 1,200 waterfowl. An estimated 6,000 pounds of arctic char, whitefish, and lake trout are also harvested. Total annual value of food taken by subsistence based upon similar foods in a supermarket in Anchorage is $64,129 (Table 2.1.1.9-6). These values are low since February 1973 costs were used and the cost of replacement food in Kaktovik is substantially more expensive due to transportation costs and because no fresh foods are available in Kaktovik (APG, 1974).

Dupere and Associates (1973) report that subsistence activities take place within 30 to 40 miles of Kaktovik. Within this distance the Applicant proposes to construct the Camden Port area, a compressor station, and ancillary facilities and a communication repeater site, and major aircraft facilities (2,400 foot gravel runways).

Local Tax Structure, Base and Expenditures

Alaska

During fiscal year 1973, State of Alaska revenues totaled $369,097,600, an increase of only 1 percent over FY 1972. Of the revenues generated in FY 1973, the three largest sources of State income were Income, Excise, and Occupational Taxes ($84,190,300 or 23 percent of total revenues), Income from Investments ($43,248,300), and Federal Receipts (136,605,800, or more than one-third of the total). In comparison with other States, Alaska depends heavily on Federal receipts and on income from investments. (See Table 2.1.1.9-7.)

Table 2.1.1.9-7 Alaska State revenues, fiscal years 1973-74

Revenue Sources	Actual FY 1973	Revised Estimate FY 1974
General Fund		
Unrestricted revenue		
Income, excise and other direct taxes	$ 84,190.3	$ 89,445.6
Oil and gas taxes	12,027.6	13,905.0
Business licenses, permits, and fees	3,206.9	3,421.6
Miscellaneous licenses, permits, and fees	6,552.4	7,984.7
Charges and other miscellaneous revenue	16,884.5	21,952.0
Revenue from State lands	32,672.5	61,747.1
Revenue from Federal lands	7,732.8	7,015.6
Income from investments	43,248.3	42,619.4
Alaska Court System revenue	1,638.3	1,909.0
Total unrestricted revenue	208,153.6	250,000.0
Restricted revenue - operating programs		
Special fund reserve accounts	585.5	641.1
Program receipts	2,873.4	4,188.0
Federal receipts	70,828.0	81,672.6
Total restricted revenue - operating programs	74,286.9	86,501.7
Restricted revenue - capital improvements		
Federal receipts	65,777.8	79,212.0
Total restricted revenue	140,064.7	165,713.7
Total general fund	348,218.3	415,713.7
Special Funds		
Training and building fund	65.8	64.0
Federal revenue sharing fund	2,820.2	2,882.0
School fund	2,028.3	2,107.9
Fish and game fund	4,523.0	4,910.5
World War II Veterans' loan fund	568.8	543.2
Agriculture loan fund	194.5	158.6
Small business loan fund	5.7	30.4
Commercial fish loan fund		14.3
Tourism loan fund	2.4	44.0
International airport revenue fund	10,670.6	11,879.1
Total special funds	20,879.3	22,634.0
Total all funds - general and special	$369,097.6	$432,432.7

Source: "Revenue Sources," Alaska, Fiscal Years 1973-74; State of Alaska, Department of Administration, Division of Budget and Management, January 1974, p. 53.

The combination of these factors and trends makes it clear that the future stability of the Alaska revenue and budget system will be based partially upon the generation of additional revenue through oil and gas production.

The annual budget deficit grew to $8.3 million in 1973 and $42.5 million in 1974.

Significant increases in the State budget have continued, with expenditures growing from $377,300,000 in FY 1972 to $480,900,000 in FY 1974 (proposed), an increase of 27.5 percent. Moreover, the increases have been responsive to the population impact of the oil pipeline construction.

Trans-Alaska Cil Pipeline

The construction of the trans-Alaska oil pipeline and the eventual flow of oil through it will have both a direct and indirect impact on State revenues. Indirect revenues gained by the State will be primarily through personal income taxes and certain excise taxes. The major revenue impact of the oil pipeline will be direct, based on increased oil production tax revenues, royalty payments to the State (after oil begins to flow), and on State property taxation of the pipeline itself.

Indirect revenues, except for Alyeska corporate income taxes, will subside with the completion of the construction phase of the project. As these revenues diminish, however, the oil production and pipeline direct revenue impact will begin.

North Slope Borough

There are two revenue-collecting entities in the impact region: the North Slope Borough and the City of Barrow. The Borough generates its revenues through a local property tax and through a 3 percent tax on sales, rents, and use or consumption of tangible personal property.

Exemptions from these taxes include groceries for home consumption, educational materials, "casual sales," sales to government entities, fuel for home consumption, and "basic necessities of life in the Arctic" such as clothing, medical and housing supplies, tools, and minor hardware. The scope of the Borough's property tax has been challenged by an oil company law suit, <u>Gulf Oil Company, et al. v. North Slope Borough</u>, et al., Actions 73-294 to 73-302; 73-305; 73-306; and 73-336. The oil companies have objected to the taxation of pre-production oil leases and intangible drilling costs. Although no final decision has been rendered, the Borough tentatively lost the right to tax pre-production oil leases and won the right to tax intangible drilling costs. Since the taxation of pre-production oil leases is in doubt, the assessed valuation of taxable Borough property is currently approximately $195 million, and the Borough has raised the mill rate to 24.9.

The Borough budget for FY 1974 (because of the two law suits, the first fiscal year of the Borough is actually July 1, 1972, to June 30, 1974) anticipates total expenditures of approximately $5.2 million. The sources of Borough revenue are indicated in Table 2.1.1.9-8. The Borough budget for FY 1974-75 ordinance 74-4B reflects the impact of a requested level of $3.6 of State impact funds, as well as increases in property taxes, primarily resulting from the oil pipeline. The 80.5 percent increase in revenue in one year is particularly notable.

Table 2.1.1.9-8 General budget summary, North Slope Borough, fiscal year 1973-74 and 1974-75

	FY 1973-74*	FY 1974-75† ORD. 74-4	FY 1974-75† ORD. 74-4B
Revenue			
Property taxes	$4,148,800	$3,400,000	$3,200,000
Sales taxes	707,000	1,687,700	687,700
Licenses & permits	1,000	100	100
Use of money and property	--	160,000	160,000
Intergovernmental revenue	294,800	1,471,300	4,254,300
Charges for services	5,000	5,000	5,000
Miscellaneous	--	--	--
TOTAL	$5,156,600	$6,724,100	$9,307,100
Expenditures			
Operating			
Assembly budgetary reserve	$ 192,500	$ 165,000	$ 165,000
General government	2,242,100	2,128,100	2,279,100
Community services	--	285,000	682,000
Education	390,000	1,822,000	3,205,000
Capital			
General government/education/roads	2,332,000	2,724,000	2,976,000
TOTAL	$5,156,600	$6,724,100	$9,307,100

Source: North Slope Borough Budget Document, 1974.

* Year ending June 30, 1974

† Year ending June 30, 1975

State legislation passed in November 1973 (As 29.53.045(c)) limits the oil and gas property taxes permitted the North Slope Borough to approximately $3,800,000 ($1,000 per resident); limits the sales tax on sale of oil and gas related property to the first $1,000 of sale; and bars the application of use taxes to oil and gas properties. It also reduces the North Slope Borough's family dwelling property tax exemption from $20,000 to $10,000 (URSA, 1974).

The restrictions on sales and use taxes is expected to reduce sales and use tax revenues by 90 percent (URSA, 1974).

The new State legislation does not apply to any "taxes levied or pledged to pay or secure the payment of the principal and interest on bonds." Taxes for these purposes "may be levied without limitation as to rate or amount." As a result of this exception, the North Slope Borough may tax oil and gas property subject only to their ability to issue bonds. This exception to the per capita taxation restriction may effectively render the per capita restrictions ineffective.

2.1.1.10 Sociological Factors

Alaska's population is expected to continue to increase at a rate greater than that of the rest of the nation. Historically rapid population growth in Alaska has coincided with major resource developments or national defense. Table 2.1.1.10-1 shows the State's population from 1880 to 1970. The State Department of Labor estimates that 432,000 people will live in Alaska by 1980. This represents an increase of almost 43 percent since 1970 and more than 95 percent since 1960.

Five major population trends are notable in Alaska at this time:

1. Urban areas, such as Anchorage and Fairbanks, are receiving the greatest portion of growth.

2. The military population of the State has leveled off and begun to decline.

3. The proportion of the Alaskan Native population is declining (from 26.3 percent in 1950 to 16.7 percent in 1970).

4. In-migration, especially as a result of construction of the trans-Alaska oil pipeline system, is a major factor in population growth.

5. Natives are migrating to large, central and predominately Native places. Examples are Barrow, Kotzebue, and Bethel. Complete abandonment of the small villages is not likely.

North Slope Borough

Current Population

In 1970 the estimated population of the North Slope Borough was 3,385. Eskimos comprised 82 percent of the total population; 16 percent were Caucasians (Table 2.1.1.10-2).

There are no permanent populations outside the areas listed in Table 2.1.1.10-2 (see Figure 2.1.1.9-1). During summer months, however, subsistence hunting and fishing camps are established, some in areas that have been used for many generations. The Prudhoe Bay industrial complex,

Table 2.1.1.10-1 Alaskan population growth, 1880-1970

Year	Alaska Total	Native	Non-Native	Military
1880	33,426	32,996	430	--
1890	32,052	25,354	4,298	--
1900	63,592	29,542	30,450	--
1910	64,356	25,331	36,400	--
1920	55,036	26,558	28,228	250
1930	59,278	29,983	29,045	250
1940	72,524	32,458	39,566	500
1950	128,643	33,863	74,373	20,407
1960	226,167	43,081	150,394	32,692
1970	302,173	50,554	221,619	30,000

Table 2.1.1.10-2 1970 population by race--North Slope Borough

Community	Eskimo	Caucasian	Negro	Indian	Other	Total
Barrow	1,901	237	4	8	3	2,153
Wainwright	308	18	-	-	-	326
Anaktuvuk Pass	97	2	-	-	-	99
Cape Lisburne	1	70	10	2	-	83
Kaktovik	107	15	-	1	-	123
Deadhorse	13	148	-	2	-	163
Prudhoe Bay	4	45	-	-	-	49
Point Hope	369	17	-	-	-	386
Totals	2,800	555	14	13	3	3,385

Source: Dupere and Associates 1973 p. 27.

with year-around living facilities, is expected to remain for the duration of the oil and gas production in that area. In 1970, Deadhorse and Prudhoe Bay had a combined population of 212 people.

The Native population of the North Slope Borough generally is increasing; although historically, traditional areas of Native population have the slowest overall growth (Table 2.1.1.10-3).

In the Barrow Census Division, 1,012 births and 250 deaths were recorded between 1960 and 1970, which would make a natural increase of 862 persons. Since the Barrow Census Division had a net gain of only 550 people during this time, it appears that at least 312 people migrated out of the Division in the 1960's (Dupere and Associates, 1973).

The concentration of Natives in established communities continues as their lifestyle changes from complete dependence on subsistence resources to some combination of cash and subsistence economies. The location of schools, modern transportation services, and medical facilities has influenced the more or less nomadic Eskimo groups to settle in permanent villages. This permanence is strengthened by the relatively new concept (for Eskimos) of land ownership. The passage and implementation of the Alaska Native Claims Settlement Act (ANCSA) is forcing Eskimo people to assume the rights and responsibilities of land ownership, and this will stabilize established villages such as Kaktovik.

A recently completed study of Alaskan Natives by Nathan (1974) showed that approximately 75 percent of the Native people living in small villages such as Kaktovik still obtain more than 50 percent of their food by subsistence activities. Of all Alaskan Natives surveyed, 87 percent wanted more paid work than they were able to find and most wanted job opportunities in their own villages. Only 12 percent wanted non-Natives to be involved in community economic development and only 50 percent were willing to accept Natives from other areas of the State.

Government

Alaska

Alaska was admitted to the Union in 1959 with the enactment of the Alaska Statehood Act (P.L. 85-508). The Alaska State Constitution provides for an executive branch headed by a governor who is assisted by a lieutenant governor; a legislature consisting of a Senate with a membership of 20 and a House of Representatives with a membership of 40; a judiciary of a Supreme Court with final appellate jurisdiction, a Superior Court which is the trial court of general jurisdiction, and other courts as established by the legislature. Each legislature has a term of 2 years and meets annually. Legislative functions are performed through nine standing committees and special committees as needed in each house.

Local Governments

Alaska is divided into boroughs (organized or unorganized) and cities. These are established and classified by the legislature according to standards which include population, geography, economy, transportation, and other factors. The legislature also prescribes powers and functions. Organized boroughs are governed by an elected assembly which sets the service areas in which various functions are performed, such as parks and recreation, sewer, etc. (Article X, Alaska Constitution). Areas not within

Table 2.1.1.10-3 Historical population trends of the North Slope Borough communities

	1939	1950	1960	1970
		Numbers of People		
Barrow	363	951	1314	2104
Wainwright	341	227	253	315
Point Hope	257	264	324	386
Anaktuvuk Pass	NA*/	66	35	99
Kaktovik	NA	46	NA	123
Prudhoe Bay†	--	--	--	49
Deadhorse†	--	--	--	163
Point Lay	117	75	NA	28

Source: U.S. Bureau of Census, 1970

*NA--not available

†Prudhoe Bay and Deadhorse are new, mostly non-Native communities, related to oil exploration and development and settlement began after the 1960 census (Namtvedt et al., 1974, p. 307).

the boundaries of an organized borough are combined into a single unorganized borough.

The powers granted to the local governments in Alaska vary according to the general law classification under which they are incorporated. Generally, all the local governments are classified as home rule (12 cities) or general law municipalities which include 1 first-class borough and 10 second-class boroughs, 9 first-class cities and 80 second-class cities or cities subject to reclassification.

The principal differences between a second-class city (the lowest-class city in Alaska) and other types of cities relate to their property taxing authority. While other types of cities have the authority to levy property taxes up to 30 mills, a second-class city may levy such a tax only up to a rate of 5 mills by referendum.

North Slope Borough

The North Slope Borough is the only first-class borough in the State. It has three basic powers--taxation, education, and planning--but it may also assume other municipal services delegated to it by the cities within its boundaries. Five villages are second class cities; Point Hope, Wainwright, Barrow, Anaktuvuk Pass, and Kaktovik. In addition, Point Lay, and Nuiqsut are villages recognized under the Alaska Native Claims Settlement Act (ANCSA). Under ANCSA, each certified village is required to set up village corporations. These corporate bodies often are composed of the same people who make up the village councils.

Kaktovik

Incorporated as a fourth-class city March 26, 1971, Kaktovik was reclassed a second-class city on September 10, 1972, as a result of State legislation changing the types and classes of cities permitted in Alaska (Dupere and Associates, 1973).

As a second-class city, Kaktovik is a general law city and therefore, may exercise all municipal powers except those granted to the Borough (tax assessment and collection, education, and planning, zoning, and platting). In addition, State law provides that the City of Kaktovik: shall have a seven-member council selected by voters at large; must meet once a month; will have a Mayor, elected by the Council, who is to serve as chief administrative officer; may transfer any power or function to the Borough; and may levy a sales and use tax upon all sources taxed by the Borough in the manner provided by the Borough (Dupere Associates, 1973).

Education

Alaska

The educational system in Alaska must cope with long distances, sparse population, and expensive transportation. Table 2.1.1.10-4 summarizes the educational status of residents of Alaska in 1970.

Major trends in State enrollment are toward slight increases in rural schools, slight increases for private and denominational schools, a decrease in BIA schools, and a sharp decrease in schools on military bases. The Alaska Department of Education anticipates that the rate of statewide enrollment increases will stabilize at 1 to 1.5 percent per year. This rate

Table 2.1.1.10-4 Educational attainment of Alaskan urban and rural population by sex, over 25 years old, 1970

Population/School Years Completed	Natives and Others						Whites and Blacks					
	Total		Urban		Rural		Total		Urban		Rural	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Population over 25 years old	10,720	9,937	2,761	3,203	7,958	6,734	63,168	51,181	48,060	41,409	15,108	9,772
School years completed by percent of population over 25 years old:												
No school	13.8	13.8	3.9	4.9	16.7	18.2	0.5	0.4	0.5	0.3	0.4	0.7
Elementary												
1-4 years	19.5	17.8	7.3	7.3	23.3	22.8	0.8	0.5	0.8	0.5	1.0	0.4
5-6 years	13.6	14.3	7.7	8.5	15.4	17.2	1.1	1.0	0.9	1.0	2.0	0.9
7 years	7.7	7.0	5.7	6.2	8.2	7.6	1.7	1.0	1.4	1.1	2.2	1.3
8 years	10.9	13.1	10.0	12.7	11.2	13.5	7.1	5.2	6.2	4.7	10.2	7.4
High School												
1-3 years	12.6	13.7	19.4	21.0	10.5	10.6	15.1	15.5	14.3	15.1	17.5	17.3
4 years	13.7	13.2	25.5	26.0	10.1	7.4	39.9	44.6	40.5	45.5	38.6	41.5
College												
1-3 years	5.2	4.4	11.3	10.0	3.3	1.9	16.3	17.2	17.0	17.4	14.1	16.3
4 years	1.8	1.4	5.1	3.1	0.8	0.6	8.6	9.3	9.0	9.3	7.2	9.0
5 or more years	1.1	0.3	3.3	0.4	0.5	0.3	9.1	5.2	9.9	5.3	6.8	5.3
Median Years of School Completed	7.4	7.6	12.0	10.7	6.1	6.0	12.6	12.6	12.6	12.6	12.5	12.5

Source - Nathan, 1974, Task I, Pt. A, Sec. 2, pg. 12

of increase, however, does not reflect major shifts in the State population and economy which will result from anticipated oil and gas development.

North Slope Borough

Provision for education within the North Slope Borough is the responsibility of three governmental entities: the North Slope Borough, the State, and the BIA. All three entities are responsible for both elementary and secondary education. In fiscal year 1974, the North Slope Borough assumed responsibility for the former State-operated schools in Point Hope, Point Lay, and Anaktuvuk Pass, and is in the process of establishing a school at Nuiqsut. The BIA operates elementary schools in Barrow, Kaktovik, and Wainwright.

The Kaktovik school houses grades 1 through 8 in two classrooms with one apartment. School enrollments there average approximately 35 students (Dupere and Associates 1973).

North Slope Borough high school students must go out-of-state, to Anchorage, or to a regional high school. The new school at Barrow probably will attract future high school students from Kaktovik.

Health

Alaska

The health care needs of Alaska's 51,000 Natives are met by the U.S. Public Health Service/Indian Health Service (PHS). PHS employs physicians in clinical, research, and administrative positions as well as nurses, technologists, dentists, and village health aides. It also contracts with private physicians to provide specialist care when needed. The Alaska Native Medical Center, a large hospital complex in Anchorage, and seven service units offer comprehensive health services to all Natives and to non-Natives who live in remote areas of the State.

Remote villages are served by trained community health aides who maintain communication with physicians based at the service unit hospital.

The U.S. Department of Health, Education, and Welfare (HEW) has two health oriented programs in Alaska. These are the Health Services Development Project which is administered through the Alaska Federation of Natives, though not necessarily a Native program, and the Food Stamp program. The latter provided $6.5 million in benefit payments to Alaskans in fiscal year 1974 (Nathan, 1974).

The State of Alaska provides public health nurses at 11 public health centers located throughout the State. Basic environmental health services are provided through the Department of Health and Social Services, which has responsibility for monitoring the safety, quality, and quantity of food, drug, comestic, and other manufactured or prepared products, and for controlling environmental health hazards.

State licensed sanitarians inspect public accommodations, schools, institutions, and industrial camps to monitor sewage drainage, water supply, and food preparation.

The U.S. Department of Defense provides health care services for military forces in Alaska.

In 1971, there was one physician for 976 non-Native civilian Alaskan residents (nationally the ratio was 1:625). Given difficulties caused by Alaska's vast size, limited transportation system, small and scattered population, and extreme climate, the physician:population ratio would have to be considerably lower than the national 1:625 ratio if comparable health care were to be provided in Alaska.

North Slope Borough

Three health service units serve the general Borough area; hospitals are located in Barrow, Tanana, and Kotzebue. The Barrow Service Unit covers Wainwright, Barrow, and Kaktovik. The Barrow hospital is a 14-bed acute-care facility with a staff of 45. Kaktovik is served locally by one health aide under a contract with the U.S. Public Health Service. Most illnesses are treated in Kaktovik by the health aide under the guidance of a service unit hospital at Barrow. In more serious cases, patients are flown to the service unit hospital, to the Alaska Native Medical Center in Anchorage, or to a private hospital within the state. Additional medical care is provided by traveling State public health nurses, tuberculosis control teams, and the Public Health Service dentists, who make yearly trips to Kaktovik.

A medical director is also available at the DEW-line station at Kaktovik for emergencies. A resident nurse maintains a private clinic at Prudhoe Bay, and physicians are on call to support local efforts. This is a private industry operation, but it is available to North Slope Borough residents requiring emergency assistance.

Homicides and Crime Rates

Crime rates in Alaska were similar to rates of the nation as a whole in 1970, although Alaskan rates for reported violent crimes were somewhat higher. Within Alaska, arrest records show a much higher rate of arrests of Natives than of non-Natives. For violent crimes, Natives have a rate of 107.8 per 100,000, versus 29.3 for non-Natives. For property crimes, the rate was 447.9 for Natives and 197.8 for non-Natives (Nathan, 1974).

Social Services

Federal and State agencies share many social assistance programs. The BIA provides basic assistance to Alaskans of 1/4 or more Native lineage who do not otherwise qualify for State assistance programs. In fiscal year 1974 the BIA made assistance payments of $3.5 million to 13,160 persons (Nathan, 1974).

BIA also has an employment assistance program which helped 666 Alaskan Natives find employment in 1974. Under the Social Security Act of 1935, HEW supplies 50 percent of the assistance funds for the State's Aid to Families with Dependent Children (AFDC) program. The public assistance amounted to $18.2 million in fiscal year 1974 (Nathan, 1974).

Except in Barrow and Wainwright, the AFDC caseload has not increased significantly, although statewide caseloads have risen.

The Office of Economic Opportunity through its Rural Community Action Program, provides approximately $500,000 to low-income villages and regional development corporations, in addition to various training and technical assistance programs (Nathan, 1974).

The Rural Electrification Administration (REA, USDA) provides long-term, low-interest loans to the Alaska Village Electric Cooperative, Inc. (AVEC) to assist rural areas in acquiring adequate electric power systems.

Social service assistance to residents of Kaktovik is minimal. State general assistance programs are administered through the Barrow district office, but only two village families receive such assistance. The BIA provides financial support to four families. There are no manpower programs in Kaktovik.

Housing

In comparison to the residents of other states, Alaskans rank among the most poorly housed. According to housing indices, Alaska housing is well below the national average. Housing units in the State are smaller, more crowded, and more substandard than in the United States as a whole. The lack of adequate housing springs from three basic problems. The first is the high cost of construction; housing costs in Anchorage are 177 percent of the cost of a comparable single-family, detached unit in Seattle. Housing construction costs in rural Alaska are even higher. The high cost of housing construction in Alaska reflects the additional cost of transportation, labor, and the cost of financing. The second cause of inadequate housing in Alaska is low personal incomes. Although nearly 10 percent of all families in the State have incomes below the poverty level, the percentage is much higher in rural areas where 90 percent of all families, primarily Native, are below the poverty level. The third factor limiting the quality of housing is Alaska's size and sparse population. In 1970, nearly 25 percent of all year-round housing units in the State were in need of replacement or extensive renovation.

Homes in Kaktovik are typically constructed of dunnage such as plywood and used Quonset materials obtained second hand from the DEW-line station. Kaktovik is not served by the DEW-line barge. Native houses generally lack adequate insulation and plumbing, and rarely have sufficient space for comfortable family living. Of the 23 houses in Kaktovik, 21 have been designated by the village corporation for replacement. Heat is provided by fuel oil stoves. All houses in Kaktovik have electricity from a privately owned generator in the Village. Recent public assistance included the earmarking of eight prefabricated houses for Kaktovik. Until the economic base of the community improves, however, and/or lower income housing programs are available, any new housing does not appear to be economically feasible (Dupere and Associates, 1973).

Public Safety

The responsibility for public safety in the North Slope Borough is with the State and the individual municipalities. Barrow has the only State trooper post in the Borough. The State recently announced plans, however, to station a State trooper at Prudhoe Bay. Oil companies provide their own security forces, which are without arrest authority. In addition to serving the law enforcement needs of Barrow, State troopers respond to requests for assistance from village councils. Village councils appoint local enforcement officers who are responsible for day-to-day law enforcement. The nearest magistrate is located in Barrow; he hears and enters judgments on misdemeanors arising under local ordinances and, if the defendant agrees in writing, he also may hear and enter judgments on State misdemeanors.

Fire protection resources within villages are inadequate throughout the region. All communities depend entirely on volunteer fire departments and, except at Barrow, lack fire-fighting equipment. Structural fires are common and often result from unsafe methods of heating and cooking. At Kaktovik, the DEW-line station has a fire truck, which can be used to assist residents of Kaktovik in emergencies.

Wildfire control is the responsibility of BLM, but there has been only one fire of record within the last 10 years (BLM fire records).

Communications

Radio and radio-telephone are the primary communications systems.

Kaktovik has two telephones connected to the DEW-line phone system. The Public Health Service facility also has a radio with direct contact to the Barrow hospital, which is available for medical emergencies (Dupere and Associates, 1973). Private industry is establishing an extensive radio network to service the Prudhoe Bay Field. These include satellite facilities.

Communications are generally oriented toward defense and the oil industry. The DEW-line communications corridor follows the Arctic Coast, with stations at Flaxman and Barter Islands. From Barter Island, a corridor extends southward to join the White Alice system at Fort Yukon (Archibald, 1974).

RCA provides commercial communications to Kaktovik, Deadhorse, and Prudhoe Bay. In addition, the State Division of Aviation, the Federal Aviation Administration, and Wien Air Alaska operate communications facilities in Deadhorse.

2.1.1.11 Land Use

Historic Land Use Trends

Historically the Beaufort Sea coast has been used by nomadic people living in delicate balance with their available food supply. Until recently, contacts with the rest of Alaska and the world have been limited, and the Eskimo Alaskans still maintain a strong affinity for the land and sea; both for spiritual inspiration and as sources of food. (See 2.1.1.10.)

It is highly probable that early man lived in the area of the proposed AAGPC pipeline system at least 30,000 years ago (Hopkins, 1967). Historic Native trade routes are reported to have followed the entire Beaufort Sea coast and the Canning and Kongakuk Rivers. Whalers who arrived in 1848, were the native Eskimos' first contact with outside influences. The Eskimos competed with whalers for food (whales and other sea mammals) and traded with them. (See 2.1.1.12 for a detailed discussion of historic and cultural values.)

Until discovery of the Prudhoe Bay Oil Field in 1968, the basic use of the land and its resources has been by Native Eskimos. Exceptions include development of military defense facilities such as radar surveillance (DEW-line sites) and sporadic exploration for oil and gas by private industry.

Land ownership has been almost exclusively Federal until the past few years. Now substantial portions are being transferred to the State of Alaska (the Prudhoe Bay field for example) under the provisions of the Alaska Statehood Act. Similarly the Alaska Native Claims Settlement Act provides for transfer of land and minerals to Alaskan Native Regional and

Village Corporations. Both land transfer programs are still in their infancy.

The State of Alaska owns all land along the proposed AAGPC pipeline system between M.P. 00 and 61 (Figure 2.1.1.11-1).

Land available for Native selection under the provisions of the Alaska Native Claims Settlement Act includes 108 square miles of land within the Arctic National Wildlife Range near Kaktovik.

The Borough has the right to select up to 10 percent of unreserved State land. These State lands have not yet been selected by the Borough.

The remainder (more than 70 percent of the proposed pipeline system) involves land administered by the Federal Government. These include the Arctic National Wildlife Range, Barter Island DEW-line 4,359 acres and 60-foot wide strip along the International Border between Alaska and Yukon Territory, Canada. Two former DEW-line sites (Simpson Cove - 420 acres and Camden Bay 456 acres) are pending transfer to the Range (Federal Register, October 30, 1971).

Three navigational aids maintained by the U.S. Coast Guard are associated indirectly with the proposed pipeline system. These are Brownlow Point, Cross Island, and Savakvik.

No private lands are known to be directly involved with the proposed AAGPC pipeline system.

Current Land Use

Agriculture and Forestry

The harsh arctic climate precludes farming on the Arctic Slope and for all practical purposes, there are no trees. There is no livestock grazing; however, there may be potential for establishment of domestic reindeer herds which would involve grazing (Resource Planning Team, 1974a). Competition for the same range and conflicts in behavior between reindeer and caribou reported elsewhere in Alaska by Snodgrass (1974b) make it unlikely that domestic reindeer herding might be developed significantly in the vicinity of the proposed AAGPC pipeline system.

Industrial

The western portion of the proposed AAGPC pipeline system (M.P. 00 to 61) is situated where the dominant land use is becoming exploration, development, and transportation of oil and gas reserves of the Prudhoe Bay Field. At this time, only the oil committed to a definite transportation route and mode -- the trans-Alaska oil pipeline system from Prudhoe to Valdez is a hot oil pipeline.

All but 10 miles (16.1 km) of the 61 miles (98.2 km) of the proposed route outside the Range are included in oil and gas leases (Figure 2.1.1.11-2). Typical facilities include roads, drilling pads, drill sites, operational wells, camps for construction workers, airfields, topping plant, flow station, a shallow-water port, and storage yards. Expansion now under way in the Prudhoe Bay area includes construction of facilities to separate oil and gas and to transport oil through the oil pipeline system being constructed by Alyeska. Separated gas will be reinjected into the producing reservoir pool of the Prudhoe Bay Field.

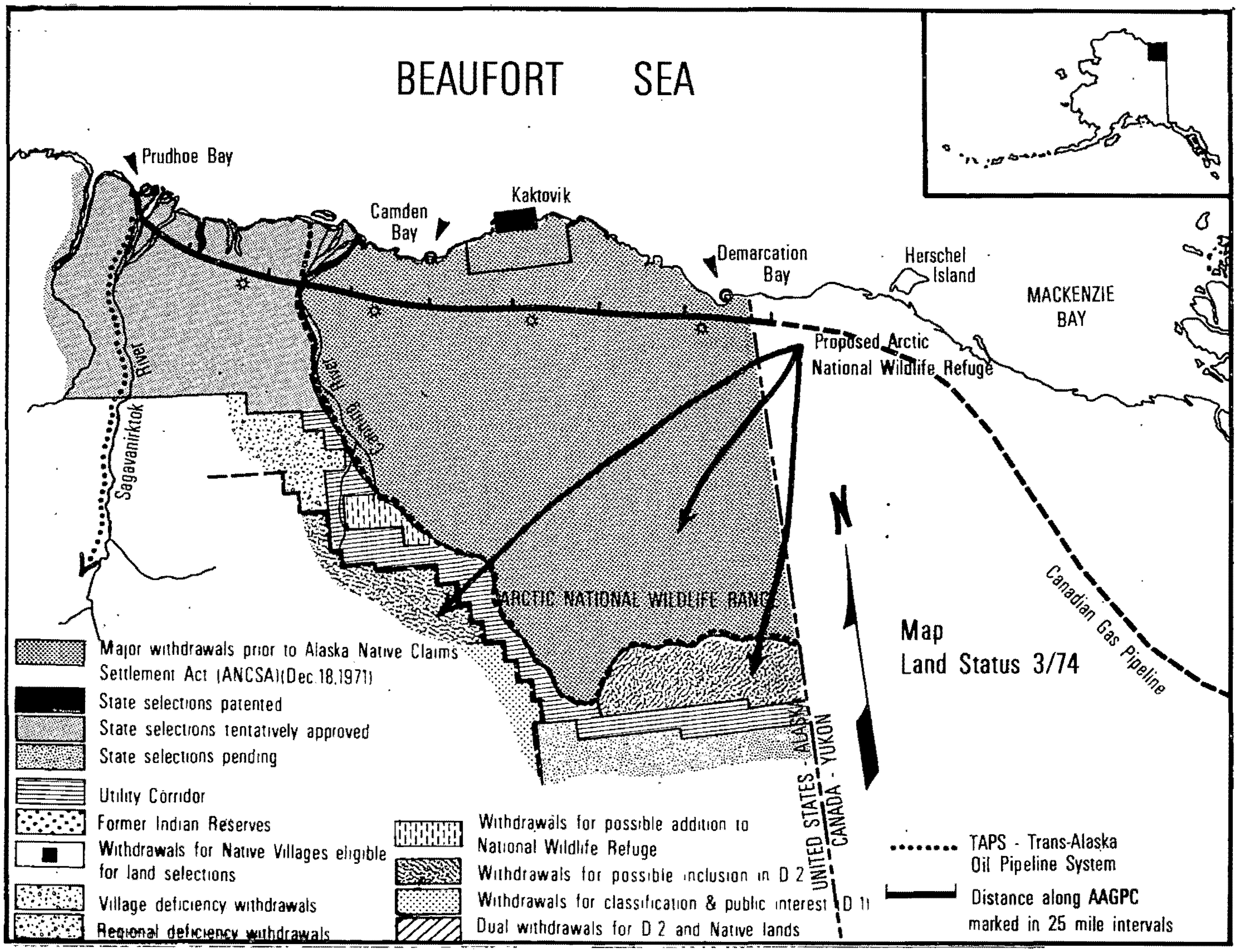


Figure 2.1.1.11-1 Generalized land ownership patterns along the proposed AAGPC pipeline, Alaska

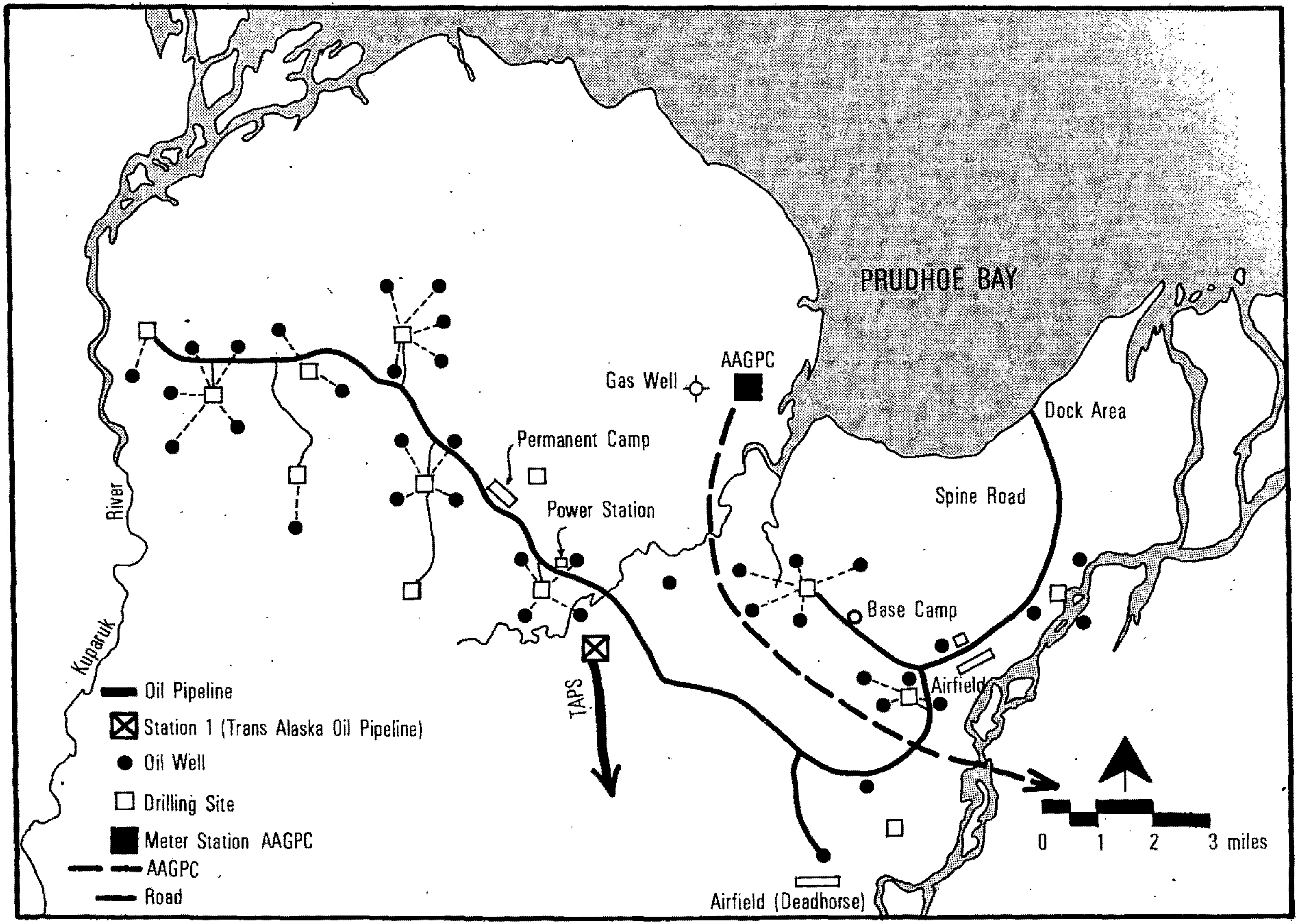


Figure 2.1.1.11-2 Development within the Prudhoe Bay area, Alaska

Commercial Fish

There are no known commercial fisheries in the area; however, residents at Kaktovik use fish for subsistence purposes (see 2.1.1.9 for subsistence).

Residential

No urban areas are associated with the proposed AAGPC pipeline system. The largest permanent population is in Kaktovik (pop. 150). Workers at Prudhoe Bay cause an extreme fluctuation in population in response to activities of the petroleum industry. The future status of Prudhoe Bay as a permanent population center is speculative. Brooks et al. (1971), however, indicate that establishment of9 small company communities seems probable. Considering the proven and anticipated oil and gas reserves in the Prudhoe Bay area, it appears that a major but fluctuating work force will be located in the area for at least the next 20 to 25 years and probably longer. Technically, these workers may not be "permanent," since they will probably maintain their homes and families elsewhere. Facilities for housing, heating, transportation, and sanitation necessary to support these workers in arctic conditions, however, must be considered "permanent." See 2.1.1.10 for discussions of population and Kaktovik.

Minerals

Except for gravel, no hardrock minerals (gold, silver, tin, copper, etc.) have been extracted or processed along the proposed AAGPC pipeline system. Total volumes of gravel removed from the Sagavanirktok River or other sources east of the Canning River at the Arctic National Wildlife Range boundary are not known because the State of Alaska (the landowner) does not keep cumulative records on gravel extraction.

It is assumed that most, if not all, gravel removed in recent years has been for use by the petroleum industry. No gravel has been removed from the Arctic National Wildlife Range since its establishment in 1960. See 2.1.1.3 for a detailed discussion of mineral potentials associated with the proposed AAGPC pipeline system.

Recreation

The area associated with the proposed AAGPC pipeline system contains a diversity of features and opportunities. The Native Village of Kaktovik and the petroleum developments at Prudhoe Bay are the only settlements. The former is permanent; the latter may be "permanent."

River and lakes afford sport fishing, and several species of birds and mammals provide sport hunting. Winter sports possibilities are cross-country skiing, snowshoeing, dog mushing, snowmobiling, and locally, ice skating. Larger rivers, such as the Ivishak, Canning, Hulahula, Jago, and Kongakuk, provide opportunities for boating in small nonmotorized water craft. Beachcombing opportunities are considered good by the Resource Planning Team (1974b). Crosscountry hiking is possible and sightseeing is varied.

Although there are numerous opportunities for recreation, no more than 150 people visited the entire Arctic National Wildlife Range between June 1 and September 10, 1974. These included hunters (56 for sheep), fishermen, photographers, mountain climbers, boaters, and students (Thayer, pers. comm., 1974). The number of these people using the area also involved with the proposed AAGPC pipeline system is unknown. The Range manager reports that in 1970 a party of two skied from Kaktovik southward more than 175 miles to Arctic Village on the south side of the Brooks Range. In 1974, three people covered this same distance on skis. During 1973 approximately 28 people are estimated by the Range manager to have crossed the proposed pipeline route in their recreational visits (20 hikers, 8 boaters). Sport fishing is very limited and no reasonable estimate is possible other than to say it is "very light." (See 2.2.2.12,13 for further discussion of recreational use.)

Federal and State Reserves

More than 70 percent of the proposed AAGPC pipeline system is located on the existing Arctic National Wildlife Range. Established in 1960, the land-use planning responsibility for the Range has been delegated by the Secretary of the Interior to the U.S. Fish and Wildlife Service. In December 1974, the Department of the Interior recommended to the Congress that the existing Range and adjacent areas (well to the south of the proposed AAGPC pipeline system) be added to the National Wildlife Refuge System as a Refuge. At that time it was proposed that the Range, subject to existing valid rights, be withdrawn from location and entry under the public land laws; that the area be studied for suitability for inclusion into the National Wilderness Preservation System; and that the Secretary of the Interior be authorized to issue permits for the exploration and development of mineral deposits.

Objectives for management of the Arctic National Wildlife Range as a Refuge are to protect and maintain as nearly as possible:

1) All fish and wildlife resources and associated habitat for the following: (a) calving grounds of the Porcupine Caribou Herd; (b) musk oxen, (c) barren-ground grizzly bear; (d) estuarine nesting and molting areas for oldsquaws, eiders, and other waterfowl; (e) resting areas for white-fronted geese, black brant, and whistling swans, and (f) raptors such as gyrfalcon and the endangered Arctic peregrine falcon.

2) An unbroken continuum of biotic communities from the Arctic Ocean to the boreal forest.

3) Wild and scenic rivers.

4) Quality recreational use of fish and wildlife consistent with other objectives.

5) Opportunities to interpret scientific and educational resource areas.

6) Archeological and historic values.

7) Resources in a way that will leave the environment unipaired for future generations. (Arctic National Wildlife Refuge Final EIS, 1975).

During 1970, 1971, and 1972 the U.S. Fish and Wildlife Service conducted field investigations of the Arctic National Wildlife Range to determine if all or portions of the area met the criteria established by the Congress for inclusion in the National Wilderness Preservation System. A preliminary report concluded that the area of the Range associated with the proposed AAGPC pipeline system was suitable for designation as wilderness except for small, previously developed areas along the Beaufort Sea (see land ownership).

Transportation

Until the fall of 1974, transportation to and from the Prudhoe Bay area primarily was by air. At present approximately 100 miles of local service roads have been constructed and are maintained by the petroleum industry. In the fall of 1974 the 400-mile long gravel haulroad from the Yukon River to Prudhoe was completed. This all-weather highway will connect the Prudhoe Bay area with the existing State highway system when a bridge is completed across the Yukon River in 1976. Prior to the completion of this new road, overland travel was restricted to winter months when the ground was frozen (Figure 2.1.1.11-3).

No deepwater ports exist. Prudhoe Bay has facilities to receive barges with lighterage. This port facility was the receiving point for the pipe to be used to construct the oil pipeline and heavy, bulky items such as completed modular structures for worker housing, assembled electrical transformers, and oil and gas equipment. Rivers in the immediate area are not used for commercial navigation.

There are no railroads into the Prudhoe Bay area. The Alaska Railroad (an agency of the U.S. Dept. of Transportation), however, has considered extension of the existing rail net northward to the Prudhoe area from Fairbanks. The route under consideration generally follows the trans-Alaska oil pipeline system except that the railroad would require construction of a 4 1/4-mile tunnel through the Brooks Range under Dietrich Pass.

Transmission Facilities

The trans-Alaska oil pipeline system from Prudhoe Bay to Valdez is currently under construction. Transportation of oil from Prudhoe Bay by the trans-Alaska oil pipeline is scheduled to start in 1977.

Land Use Planning

The Alaska Native Claims Settlement Act established a Joint Federal-State Land Use Planning Commission for Alaska. The Commission is to undertake a process of statewide land-use planning, review laws, policies, and programs, and recommend changes. Initial efforts of the Commission have been to assemble a current, statewide inventory of Alaska's resources. In August 1973, the Commission submitted its recommendations to the Secretary of the Interior on 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 (Senate Committee on Interior and Insular Affairs, June 1974 Comm. Print). In its recommendations to the Secretary, the Commission noted:

> Alaska's transportation system is in its infancy...large distances and sparse population create a unique set of transportation needs...[which] cannot be met by haphazard development.... The Commission finds that land use should determine transportation patterns, rather than the reverse.

In the Appendix of its August 1973 report, the Commission indicated a special need for a "Policy for the Arctic" as follows:

> Delicate as the ecology [of the Arctic] may be, it is certain that the resource wealth of the Arctic will ultimately be used.... One civilization long ago learned to live in harmony with the land, and the ability to attain another type of harmony

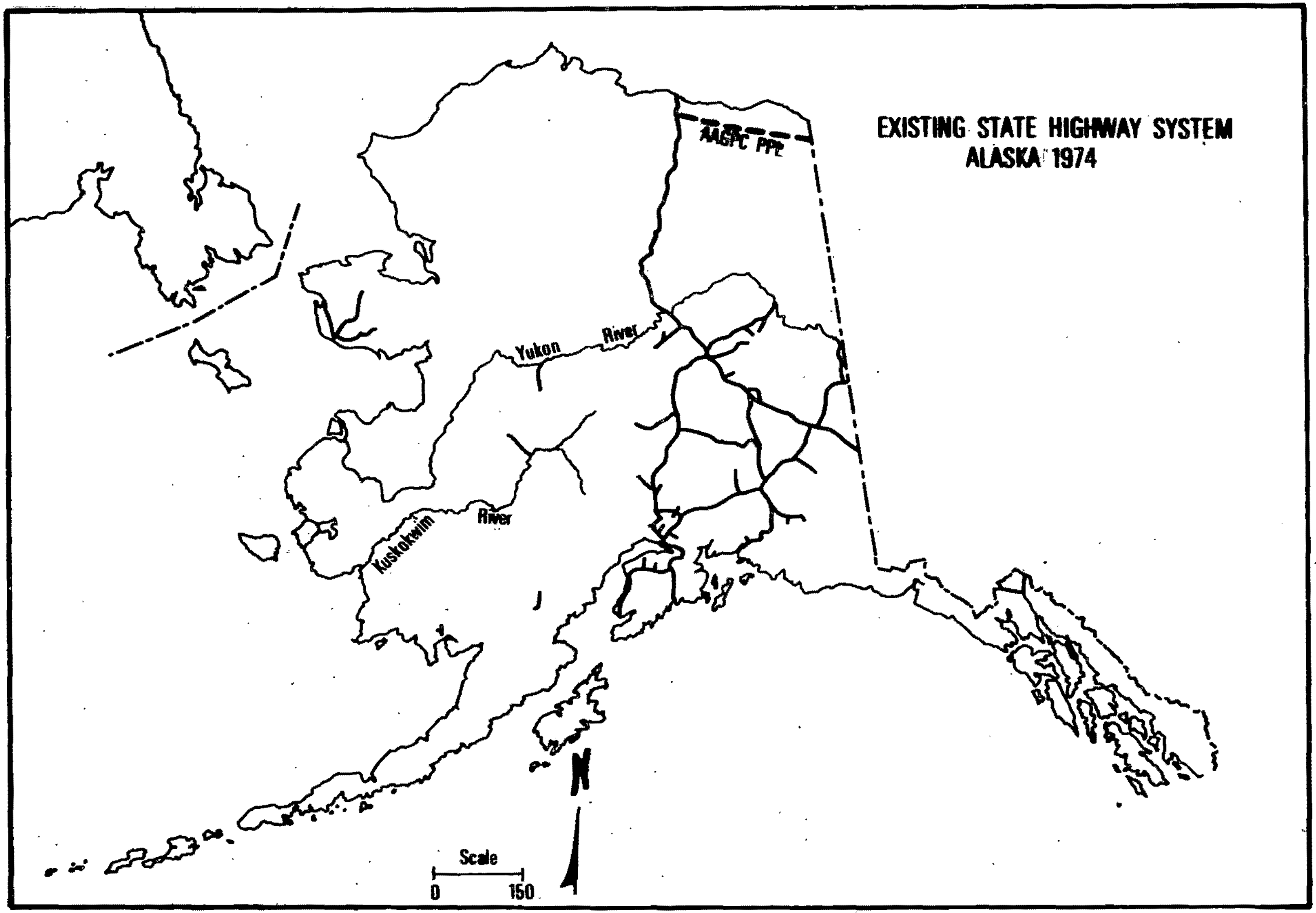


Figure 2.1.1.11-3 Existing state highway system, Alaska, 1974

in the Arctic now exists. Achieving this balance will require a new kind of cooperation and control, an acceptance of the need to utilize the elements of the Arctic, and a determination to find new ways to survive and work without leaving permanent imprints. It means the recognition of necessity to minimize man's imprint...and to adhere to the implications of this in such crucial areas as transportation and settlement patterns.

To date there is no statewide land use plan for Alaska and no policy for the Arctic.

Principal planning agencies and organizations in the area of the proposed AAGPC pipeline system are: North Slope Borough and its seven communities; State Division of Planning and Research; North Slope Regional Corporation and Village Corporations (formed under the Alaska Native Claims Settlement Act); and the U.S. Fish and Wildlife Service.

Recent studies and reports on land use include the following: Federal Field Committee's Alaska Natives and the Land (1968); Joint Federal-State Land Use Planning Commission (ongoing); Institute of Social Economic and Government Research, Man in the Arctic, University of Alaska, (ongoing); Dupere & Associates, Inc., North Slope Borough Reconnaissance Study (1973); and Namtvedt et al. (1974) The Alaskan Arctic Coast, a Background Study of Available Knowledge.

The North Slope Borough is charged with the mandatory, areawide responsibilities for planning, platting, and zoning. The planning function of the Borough was established through the enactment of Ordinance 9301. This ordinance provides for the establishment of a Borough Planning Commission, delineates the mechanics of Commission organization and operation, and sets forth the responsibilities, functions, and procedures of the Commission in planning, platting, and zoning. These land-use planning responsibilities are still in the formative stages due to the recent (1972) organization of the North Slope Borough. Accordingly, zoning actions affecting land uses are not known at this time.

The State of Alaska has classified a large part of the lands under its control in the Prudhoe Bay area as resource management lands. Most State land is leased for oil and gas exploration (Figure 2.1.1.11-2). The State has granted several rights-of-way across State lands in the Prudhoe Bay area. Most notable is the right-of-way for construction of the trans-Alaska oil pipeline system by Alyeska. Similarly, the State has issued leases for airfields in the vicinity of the proposed AAGPC pipeline route where active oil and gas exploration is under way. About 40 leases also have been granted for land uses in the Prudhoe Bay area, primarily for oil connected activities. Less than 30 percent of the proposed AAGPC pipeline system is located on State lands.

Under the provisions of the Alaska Native Claims Settlement Act, the Village of Kaktovik will be able to acquire surface ownership of lands now part of the Arctic National Wildlife Range. When transferred, these Native-owned lands would be subject to land use policies established by the Village.

Expected and Potential Trends

The dominant land use of the Prudhoe Bay Field is becoming exploration, development, and transportation of oil and gas reserves.

Considering the proven and anticipated oil and gas reserves in the Prudhoe Bay area, it appears that a major but fluctuating petroleum industry work force will be located in the area for at least the next 20 to 25 years, and probably longer.

2.1.1.12 Historic, Archeological, and Unique Area Values

History

Written history of northeastern Alaska spans only a short time. It began in 1826 when Sir John Franklin sailed west from the Mackenzie River to explore the Alaskan eastern Arctic Coast (Gubsev, 1965 in APG, 1974).

In about 1854, the first whaling vessels rounded Point Barrow and sailed east to hunt in the Beaufort Sea. The whalers permitted their vessels to become frozen in protected shore ice, where they remained over winter in order to be on the Beaufort whaling waters early in the openwater season. The ships were bases for inland exploration by hunters, messengers, scientists, and deserters.

The whalers, prospectors, trappers, and scientists re-explored and renamed geographic features known for centuries to the Eskimo people who had named them descriptively: Ivishak--red earth; Sagavanirktok--swift current; Itkilyariak--route by which the Itkillik travel. Their tribal names referred to life patterns rather than arbitrary classifications. The Tareumiut were people of the sea; their lifestyle was primarily sea mammal hunting. The Nunamiut were people of the land.

The real history of the area lies in the silent ruins of stone shelters, the limestone caves, and the subtle changes of tundra where ancient dwellings stood.

During the Itkillik glaciation, extensive valley glaciers prohibited human occupation of the Brooks Mountain Range. As the ice front retreated, people gradually penetrated the area in about 10,000 B.C., subsisting on Dall sheep, fish, caribou, wildfowl, bears, moose, berries, and roots. They killed animals with arrow, spears, and snares, relying greatly on the caribou for food, clothing, shelter, and dog food. These early nomads posted lookouts on hilltops where they would wait for days and weeks for the approaching caribou. Here, they used their time to prepare weapons of flint and bone.

These people built stone-walled shelters to protect them from the wind. Today, the place to watch for the caribou's approach is still from these hills where the stone wall ruins and the scraps of flint are found. The early people captured migrating caribou by diverting them with fences made of brush, rocks, and poles. The fences, often a mile or more in length, led to corral traps where the people built gaps in the fences and set snares to tangle the caribou's antlers. These fences are collapsed but still visible.

The Arctic Coast served as a major migration route of early nomadic hunters who came to America from Asia across the Bering Land Bridge.

In the early days, the Tareumiut (the People of the Sea) from the village of Nigalik on the Colville River traveled east along the Arctic Coast to Barter Island. Here, they traded seal oil and ivory with the Nunamiut (People of the Land) for the fur of lynx, marten, and other land mammals. The Nunamiut had to cross the mountains of the Brooks Range to reach this ancient trading site (Stefansson, 1913 in APG, 1974).

Prior to the coming of the whalers, Siberian Eskimos brought metal knives and pots, and glass beads to Alaska's west coast (Gubsev, 1965 in APG, 1974). These goods were traded across Alaska, finally reaching the northeastern coast. Then whaling vessels brought goods to many points along the Arctic coast where both coastal and inland people obtained them more directly.

Demarcation Bay is associated with the establishment of the demarcation boundary between the United States and Canada and served as winter rendezvous of Eskimos. Barter Island was a rendezvous point for whalers and later a jumping-off point for historic flights by explorers.

Leffingwell Camp, located on Flaxman Island, was placed on the National Register of Historic Places in 1972. Built for a scientific expendition dating from 1906, Leffingwell Camp consists of a cabin built from the dismantled schooner "Duchess of Bedford," remains of an ice cellar, and a storage shed. A report that the cabin collapsed in 1967 has not been officially confirmed by the State Historic Preservation Officer. If the report is true, the property's National Register status presumably would have to be re-evaluated (see Figure 2.1.1.12-1).

Archeology

Very little is known about the prehistory of the State. Cook, in his statement to the Alaska Natural Gas Transportation information gathering meeting in Fairbanks, Alaska (January 8, 1975), emphasized the fact that the number of archeological sites, both historical and prehistorical, is very much larger than was previously believed.

Paleoenvironmental Settings

This segment corridor crosses the Arctic Coastal Plain Paleoenvironmental Zone and passes near a portion of the Brooks Range Paleoenvironmental Zone. During the time span considered, the climate here has always been arctic with the period of greater cold much exceeding the short periods of warmer temperatures. Although the Coastal Plan land area was significantly wider during glacial maxima when sea level was lowered, this area undoubtedly had a more improverished ecosystem then than now, as it was between the ice-covered glacier area and a sea more constantly frozen than is presently the case.

In spite of the always harsh climatic setting, the productivity of this corridor has always been capable of supporting some human occupation. Much of the corridor is covered with alluvial and aeolian sediments deposited during the last ten thousand years. Consequently, archaeological sites predating the glacial maximum have a high probability for having been destroyed or obscured by these environmental forces.

Archeological Evaluation

Because the Arctic Coastal Plain Province has remained virtually unknown archeologically, the Solecki investigations in the foothills of the Sadlerochit and Shublik Mountains and adjacent coastal plain have been seminal for interpreting the cultural chronology of this region and assessing patterns of east-west movement through the northern corridor between the mountains and the sea. Although no deeply straitified sites were found, the discovery of a series of game observation and hunting encampments oriented to caribou migration routes and river and stream

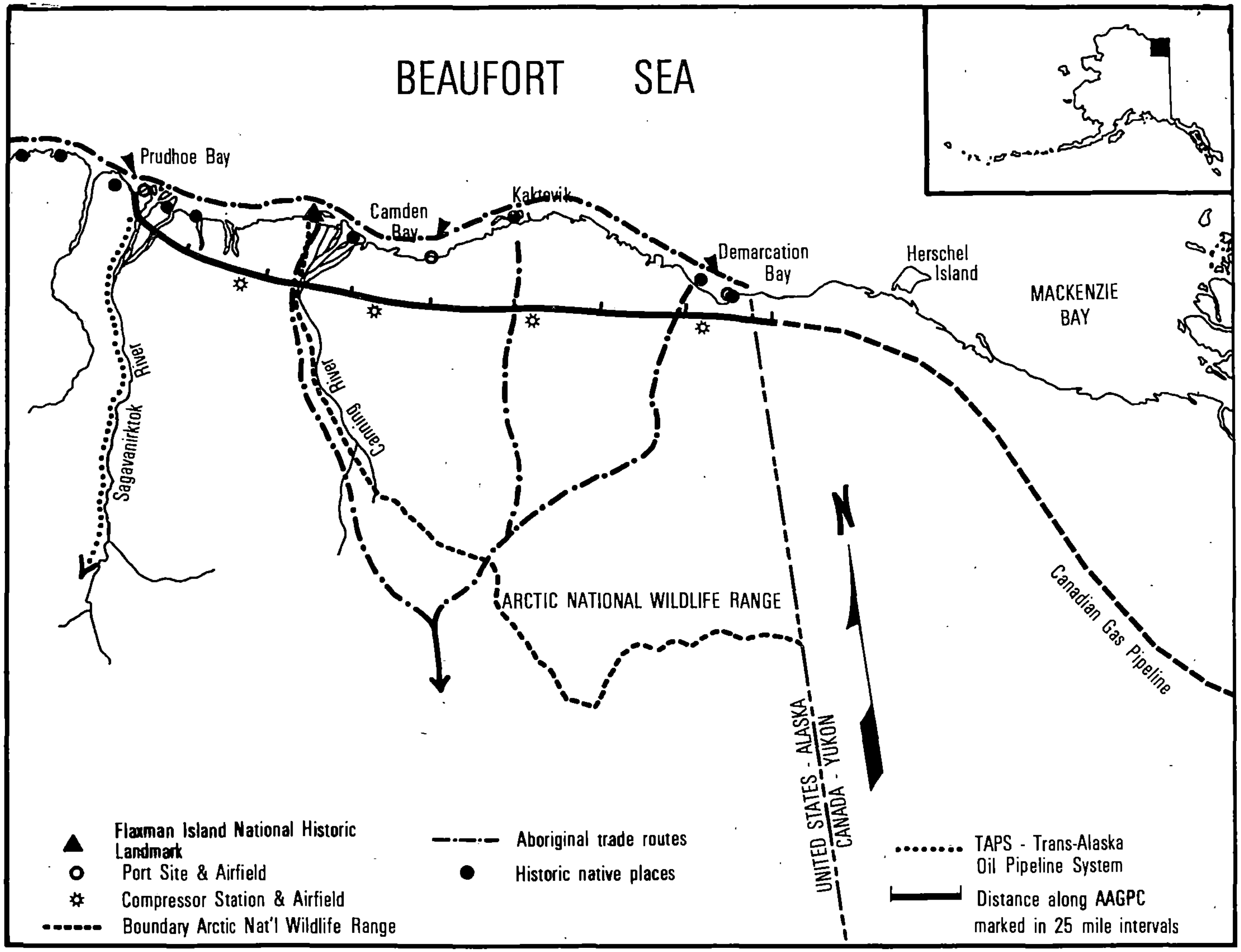


Figure 2.1.1.12-1 Historic and archeological areas associated with the proposed AAGPC pipeline, Alaska

drainages suggest that the points where the pipeline route crosses major arteries and tributary creeks are critical for survey work, particularly on exposed bluff and terrace edges and eroded hillocks adjacent to waterways.

Historic Summary

There are no recorded sites of historic interest within the corridor of Segment Thirty. Gordon (XDP 002), on the northeast shore of Demarcation Bay, is located six miles north of the route.

Historic Trails--A winter trail which runs south from Foggy Island Bay to the Arctic Foothills is crossed by the pipeline alignment about one mile east of the Kadleroshilik River in T 9 N, R 18 E.

A north-south trail connects Rampart House, Canada with the Beaufort Sea near the international boundary, crisscrossing the boundary many times. The trail is crossed by the pipeline alignment about four miles south of the Beaufort Sea coast.

Archeological and Historic Locales--Early Eskimo or Denbigh occupation is indicated by artifacts recovered from this site. The archaeological finds consist of a surface collection of tools for working wood or skins, suggesting the site may have been a hunting encampment oriented to the Katakturuk River caribou migration route. (Solecki et. al., 1973, Site Four.)

A site situated on the north side of an eastern tributary of the Itkilyariak Creek at an elevation of 172 feet above the stream, this particularly excavated and tested site appears to be a small habitation and tool manufacturing station. The most diagnostic artifacts relate to the Denbigh Complex. Specimens include one microburin, flakes probably utilized as borers, notched flakes, burins, and a nosed scraper. (Solecki et al., 1973, Site Two.)

R. S. MacNeish located 24 archeological sites on the Canadian Yukon Arctic Coast and along the Firth River (which flows into the Arctic Ocean less than 50 miles (80.5 km) west of the Alaska-Yukon Territory, Canada boundary). MacNeish's excavations demonstrate that the region was inhabited by a succession of Native cultures over a period of several thousands of years. MacNeish's investigations are reported in Bandi (1969).

The archeological investigations most relevant to the proposed AAGPC pipeline system are the survey and excavations along the route of the trans-Alaska oil pipeline. Full results of this undertaking are not yet available. A report on the first summer's work by Cook (1970), however, lists a total of 113 sites found along the Sagavanirktok River, which is the portion of the oil pipeline route analogous to the proposed AAGPC system. The sites range from quite recent to as much as 13,000 or more years old. It should be noted that the oil pipeline system parallels the Sagavanirktok River; whereas, the proposed AAGPC pipeline system crosses 120 rivers and streams.

Cook (testimony January 8, 1975) indicated that archeological sites along the trans-Alaska oil pipeline system ranged in size from a diameter of 9.8 feet (3 m) to 656.2 feet (200 m). His studies suggest that a distance of 100 to 200 yards (91 to 182.9 m) can make a great deal of difference in the potential and the actuality of a site being present. Accordingly, three major unknowns are associated with the proposed AAGPC pipeline system: the archeology has been examined only superficially; there are no comprehensive archeological studies which can be used to speculate with any certainty on what will be found; and the proposed pipeline route does not have a sufficiently definite location. The last is especially important since it delays intensive archeological investigations.

Preliminary investigations by the Applicant show the presence of caribou stone fences and all river and stream crossing and coastal areas must be considered to have some archeological potential. Coastal areas, the Canning River, and the Hulahula River must be considered to have very high archeological potentials since these were trade routes. The Canning and Hulahula Rivers may be especially important because these routes were used by both Eskimos and Indians. The coastal areas are significant since they may contain evidence of eastward migration of early man from the Bering Sea Land Bridge connecting Asia with North America.

The following areas are considered to have potentially important archeological values:

Brower Village - (FFC, 1968), Seasonal campsite at west entrance to Foggy Island Bay

Canning River - (FFC, 1968) Trade route used by Eskimos and Indians

Hulahula River - (Alaska Division of State Parks) Trade route used by Eskimos and Indians

Canning River Delta - (FFC, 1968) General area used as historic trade meeting place called "Shinagru"

Camden Bay - (Alaska Division of State Parks) mouth of Kakakturuk River (information unavailable).

Unique Areas

Several studies have been conducted during recent years to identify and protect unique areas along the Alaskan Arctic Coast prior to development. It is still possible to preserve those areas which appear to have the most potential value. One objective would be to establish select areas on "bench mark" investigations as the Arctic is developed to determine how best to minimize adverse effects of human activities.

The following discussion is based upon studies by the Joint Federal State Land Use Planning Commission for Alaska, Tundra Biome Center (University of Alaska), the Arctic Environmental Information and Data Center of the University of Alaska, the Lawrence Radiation Center, and Robert Detterman of the U.S. Geological Survey.

The Joint Federal-State Land Use Planning Commission for Alaska recommended in 1973 that a systematic statewide analysis of nominated Science Research and Natural areas be undertaken to develop a balanced and representative statewide system of such areas. Five areas in the vicinity of the proposed AAGPC pipeline system were nominated in 1972: Prudhoe Bay, Jago River, Neruokpuk Lakes (Peters Lake and Schrader Lake), Shublik Spring, and Beaufort Lagoon.

At Prudhoe Bay, it has been proposed by the Institute of Northern Forestry, (INF) USDA, that several small plots (between 100 and 500 acres) of undisturbed coastal wet tundra be preserved. The site, to be selected, would be located on State land within the Prudhoe Bay Field as a control against which to measure effects of future disturbance.

The entire drainage of the Jago River was also nominated by INF to maintain a complete array of tundra of flood plain vegetation types from the Beaufort Sea to the crest of the Brooks Range. In addition to vegetation, the Jago River drainage includes use by Arctic Coast animals as well as an entire hydrological system with delta sand dunes, offshore islands and interface between an arctic river, lagoon, and the Beaufort Sea. The Jago River basin is approximately 400,000 acres (625 sq mi), all of which is within the existing Arctic National Wildlife Range. It is managed by the U.S. Fish and Wildlife Service.

Neruokpuk Lakes (Lake Peters and Lake Schrader) were nominated by INF as large arctic-alpine lakes. Considerable base data on these two lakes now exist. Both are within the existing Arctic National Wildlife Range well removed from the route and involve a total area of 60,000 acres (93.8 sq mi).

Shublik Spring, a tributary of the Canning River, has a unique isolated stand of balsam poplar trees (populus balsamifera) well north of their normal range. Shublik Spring is a year-round warm water spring, providing key overwinter habitat for fish. In addition to balsam poplar, several other plants well north of their typical range are found in the general vicinity of the spring. The size of the recommended reserve is 10,000 acres (15.6 sq mi), all are within the existing Arctic National Wildlife Range.

Beaufort Lagoon has been nominated by the U.S. Army Corps of Engineers as an area where large populations of white fish (Paregonus) and arctic char (Salvelinus) are found. It is probable that there is a very large population of invertebrate fauna. Approximately 36.2 by 5.2 miles (22.5 by 3.2 km) of the Lagoon is connected to the Beaufort Sea. Offshore sand bars outside river mouths, however, reduce intermixing of saline and fresh water so that the lagoon is essentially fresh water. Land areas are within the Arctic National Wildlife Range; submerged areas are in State ownership.

In addition to the above nominated Science Research and Natural areas associated with the proposed AAGPC pipeline system, the National Park Service has under consideration designation of 11 areas as Natural Landmarks. Designation would preserve distinctive geological and ecological characteristics of the Alaskan Arctic Coast. Studies that involved several of the nominated areas were discussed above. Sites are: Flaxman Island, Sagavanirktok River, Kadleroshilik River and Plain, Kadleroshilik Mound, Fire Creek, Sadlerochit Spring, Jago River, Clarence Plain, Demarcation Bay, and Icy Reef (Figure 2.1.1.12-2). The following data are from Detterman, 1974.

Flaxman Island at the mouth of the Canning River, would involve designation of 4,000 acres (6.3 sq mi). An unusual outcrop, the "Flaxman formation," resulting from glacial action moving west from Canada, has no other occurrence in the Brooks Range. The Island also is the site of polar bear denning.

The Sagavanirktok River was selected as the foremost example of a braided stream on the Arctic Coast. Approximately 16,100 acres (25.2 sq mi) would be designated. Kadleroshilik River, 29,500 acres, and Plain, 14,600 acres, (46.1 and 22.8 sq mi respectively) have a distinctive and wide array of permafrost features.

Kadleroshilik Mound (161 acres or .25 sq. mi) is the largest pingo in northern Alaska, rising to an elevation of 200 feet (61 m). It was formed

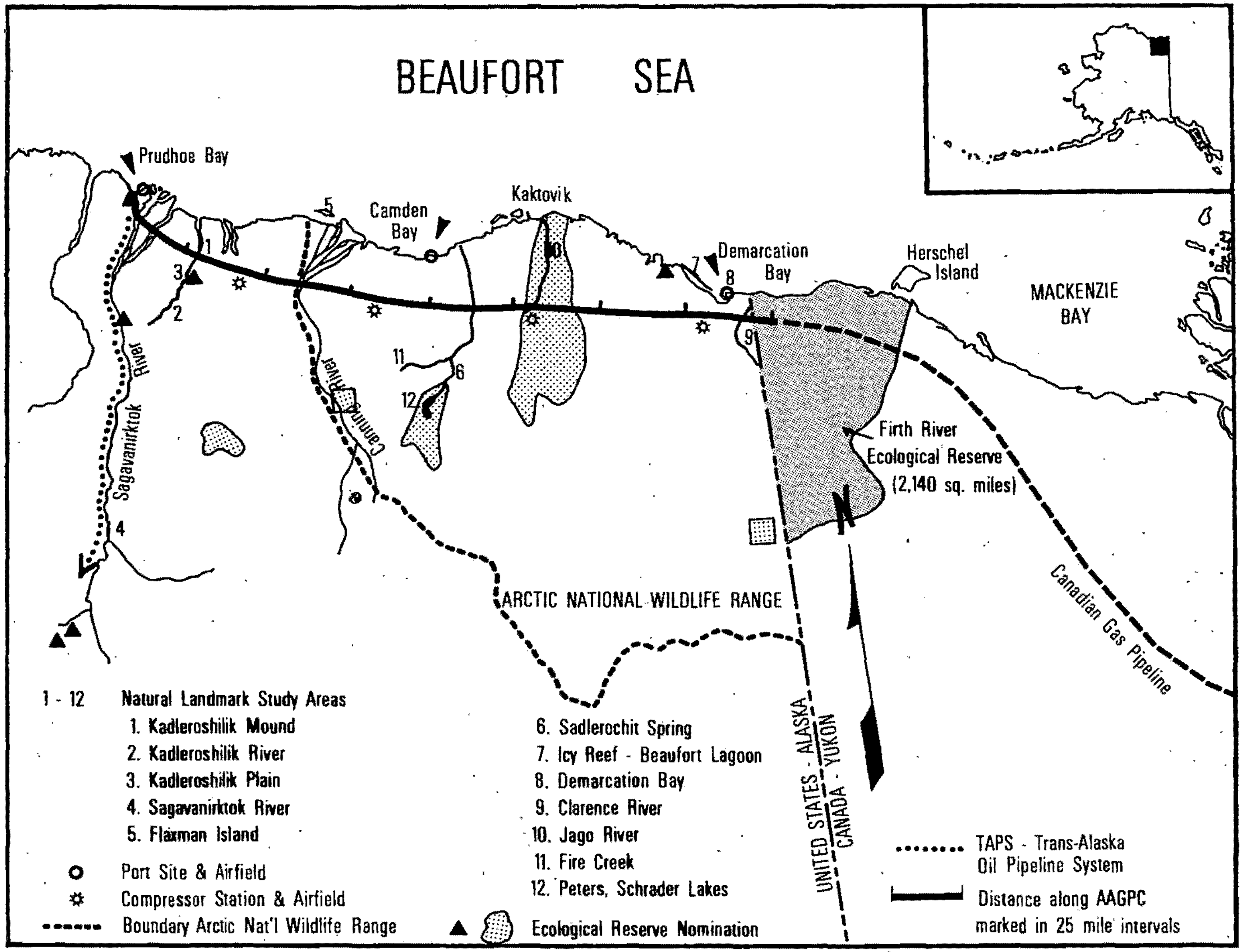


Figure 2.1.1.12-2 Unique areas along the proposed AAGPC pipeline, Alaska

approximately 10,000 years ago through frost action. Because of its size, it has been used by caribou hunters and may have archeological values. It is located near M. P. 29.

The Fire Creek site (400 acres or .6 sq mi) is 15 miles (24.1 km) south of M. P. 105. Highly fossilized bedrock dating from the Mississippian Age outcrops along Fire Creek.

Sadlerochit Spring, 640 acres (1 sq mi), is 6 miles (9.7 km) south of M. P. 113. This large spring maintains a temperature of almost 50°F (10° C) throughout the year. Distinctive plant and animal communities are associated with the spring.

The Jago River is identified for its evidence of glaciation. Size is 26,300 acres (41.1 sq mi) as compared to the 400,000 acres (625 sq mi) for the INF nomination discussed previously in this section.

Clarence Plain (39,000 acres or 61 sq mi) is an excellent example of an Arctic Coast flood plain and has many permafrost features.

Demarcation Bay (18,200 acres or 28.4 sq mi) presents good examples of offshore bars and islands along the Arctic Coast.

Icy Reef (10,600 acres or 16.6 sq mi) presents good examples of offshore bars and islands with important bird nesting and abundant marine fauna.

Adjoining the existing Arctic National Wildlife Range in Canada is an 2,140-square mile Firth River area proposed for establishment as an Ecological Reserve under the International Biological Program as part of Canada's participation (Scotter et al., 1971 in EPB, 1974). The Firth River area was selected because of its importance as a representative segment of the British Mountains with foothill and coastal plain tundra, migration and calving of the Porcupine Caribou Herd, northernmost expansion of white spruce, spawning and overwintering areas for arctic char, grizzly bear and Dall sheep habitat, and archeological sites. This area is part of the larger Arctic International Wildlife Range proposed by the Arctic International Wildlife Range Society in 1971 (Figure 2.1.1.12-3).

2.1.1.13 Esthetic and Recreational Values

The area of the Arctic Coastal Plain and Arctic Foothills associated with the proposed AAGPC pipeline system is one of both sameness and contrasts.

Within the perspective of west to east along the proposed route, the landscape primarily is flat, with unlimited horizons to the Canning River at the western boundary of the Arctic National Wildlife Range (M.P. 00 to M.P. 61). After the first 61 miles (98.2 km), the terrain becomes more rolling and a transition from land dotted with lakes and ponds to gently rolling uplands is completed.

The general trend of the landform is rising elevations from west to east and then a gradual decline as the route approaches the United States-Canada border. The route reaches its highest elevation, (825 feet or 251.5 m above sea level), near M.P. 85 and M.P. 92. The ridges encountered along the route slope northward to the sea. Ridgetops afford vast vistas to the north and the Beaufort Sea and to the south the massive flanks of the Brooks Range.

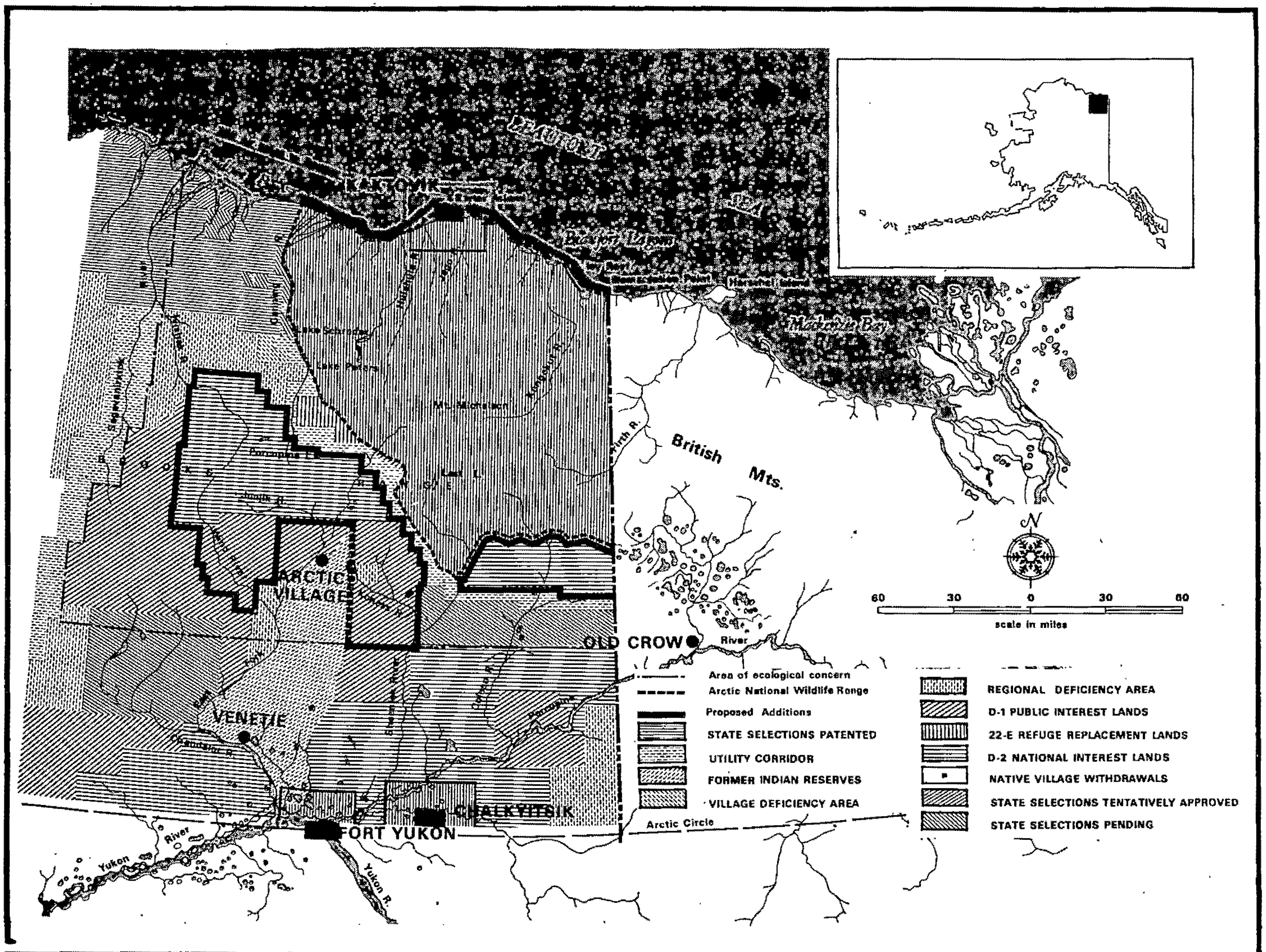


Figure 2.1.1.12-3 Arctic national wildlife range proposal

Green dominates land areas during the summer while water reflects the blue to leaden sky. Reds, yellows, and browns of frosted plants prevail in the fall. Higher elevations of the Brooks Range typically are barren of vegetation. Therefore, grays and buffs with occasional outcrops of reds form a backdrop to the treeless tundra of the plain and foothills. Low sun angles heighten greens and reds and cause shadow accentuation to the microrelief of local topography. During the almost seven months when the landscape is snow-covered, white blends everything together. Basically the only limitation to visibility is climatic in nature (2.1.1.1), as terrain and vegetation combine to produce almost unlimited vistas.

The Resource Planning Team of the Joint Federal-State Land use Planning Commission for Alaska (1974a) noted that the area associated with the proposed AAGPC pipeline system has an exceptional diversity of mountain and isolation which are "...above average for scenic and primitive ratings when considered on a statewide basis."

Figure 2.1.1.13-1, based upon data distributed by the Joint Federal-State Land Use Planning Commission for Alaska (RPT, 1974a), shows that all of the Sagavanirktok River, pingos in the lower Kadleroshilik River area, and Franklin Bluff have good to high value for natural features (geological, botanical, zoological).

All land associated with the proposed AAGPC pipeline system within the Arctic National Wildlife Range have good to high quality primitive, or wilderness, value.

Within the coastal portions of the Arctic National Wildlife Range, the northern flanks of the Brooks Range are within 12 to 40 miles of the Beaufort Sea. Accordingly, the natural continuum of arctic ecosystems from the sea coast to the crest of the Brooks Range is compressed into the smallest distance in Alaska.

In 1971, the entire Arctic National Wildlife Range was studied by the Fish and Wildlife Service to determine if the area was suitable for inclusion in the National Wilderness Preservation System. Preliminary findings indicate there are high wilderness values. Wilderness preservation is one of the specific objectives for establishment of the Arctic National Wildlife Range, and on December 18, 1973, the Secretary of the Interior recommended that the existing Range, together with adjacent areas south of the proposed AAGPC pipeline system, be established as the Arctic National Wildlife Refuge and that within years the enlarged area be studied for its suitability for inclusion in the Wilderness System. An act of Congress is required to include areas in the Wilderness System (APG, 1974).

There are no developed recreation sites or areas within the area associated with the proposed AAGPC pipeline system.

Except for visitors to the Prudhoe Bay Field at Deadhorse, probably fewer than 100 persons a year seek recreation in the area. Namtvedt et al. (1974) concluded that few people seek recreation along the Alaskan Arctic Coast because of the area's remoteness, high cost of transportation, lack of information on what to see and what can be done, high cost of lodging, difficult and limited access, harsh climate, and mosquitoes.

The level of present recreation activities in the area associated with the proposed AAGPC pipeline system are unknown, but assumed to include fishing, hunting, winter sports (cross-country skiing), water sports (canoeing and kayaking), sightseeing, photography, nature study, and hiking.

According to Namtvedt et al. (1974), outdoor recreational activities have a great potential for future development, especially if improved

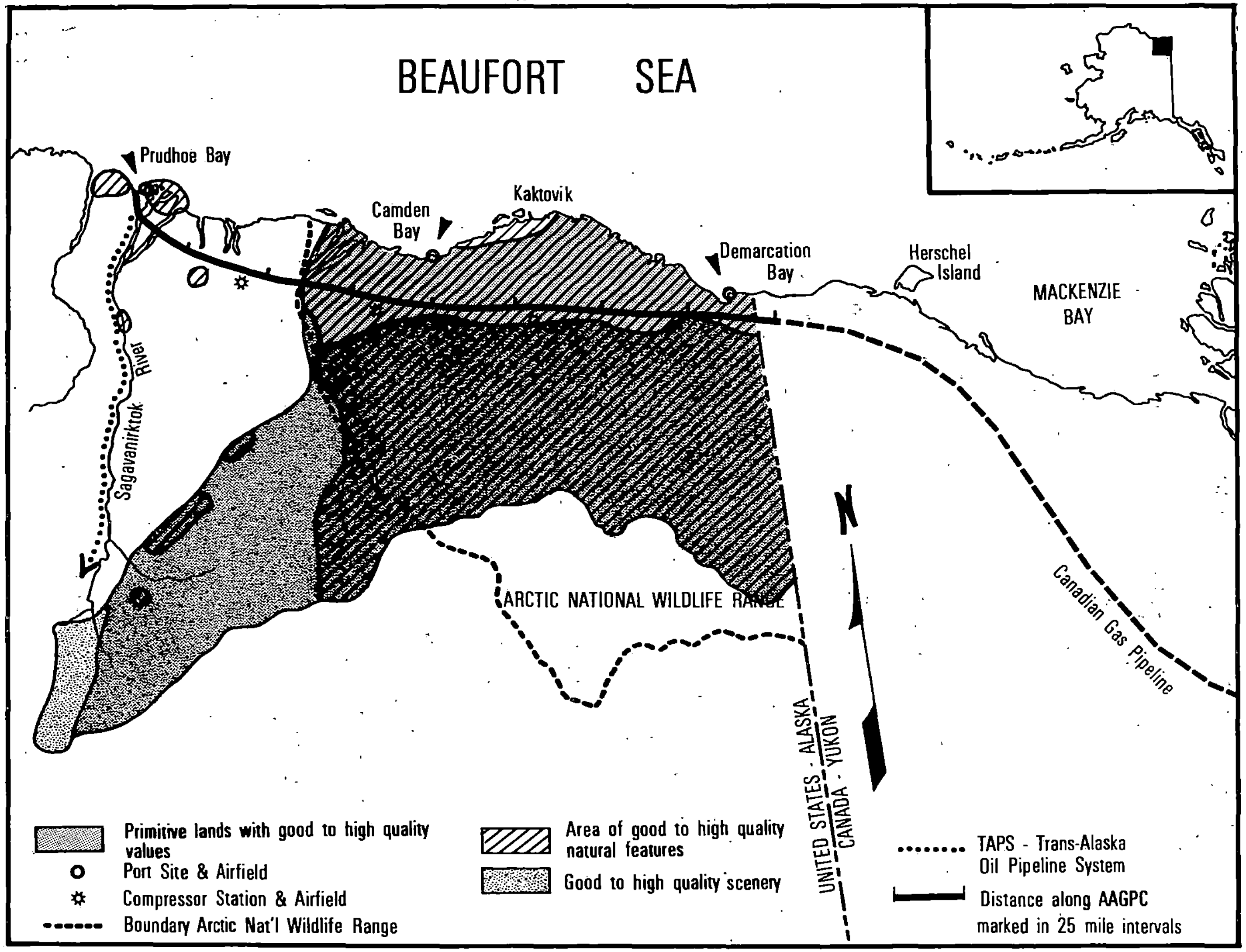


Figure 2.1.1.13-1 Areas having high values for wilderness, scenery, or natural use

transportation means are developed as a result of increased oil activity in the area. The proposed road system would provide access to an area previously inaccessible to the outdoor enthusiast. Activities such as camping and hiking undoubtedly will become popular. This influx of campers and hikers will be concentrated during the summer, primarily along the roadway. A system of campgrounds and hiking trails will undoubtedly develop. Strict regulation of off-road activities will be needed to protect the area and assure access for the Natives and their subsistence activities.

2.1.1.14 Air Quality

The closest air quality monitoring to the proposed route has been at Barrow (178 nautical miles north and west of Prudhoe Bay), and Fairbanks (326 nautical miles south of Prudhoe Bay). Only Fairbanks has regular air quality monitoring stations. Records there or at Barrow are not considered applicable to the proposed project area because of distance and their higher level and concentration of human activities.

Approximately 70 percent of the proposed AAGPC pipeline system is to be located in the Arctic National Wildlife Range where a total of 150 people live (Kaktovik) and the single "industry" is military (Barter Island DEW-line site). There are no commercial transportation facilities other than air; hence, there are none of the usual sources of air quality degradation such as auto exhaust emissions or power plants. Because of their small size, the Barter Island DEW-line site and Kaktovik are considered to have no appreciable impact on air quality within the area where the proposed AAGPC pipeline system would be located on the Arctic National Wildlife Range.

Approximately 30 percent of the proposed AAGPC pipeline system including port receiving, the first compressor/chiller station, and the first 62 miles of the pipeline will be located in the Prudhoe Bay oil and gas field (200 square miles). Prudhoe Bay rapidly is undergoing development to support exploration, development, and production of Alaskan oil and gas. Existing facilities include two major gravel surface airfields, modular housing for workers, a topping plant (refinery), port, drilling and production equipment, and associated construction equipment. A gravel road, approximately 400 miles long, between Prudhoe Bay and the existing road network from Fairbanks was constructed during 1974. Contracts have been awarded for construction of three flow stations to separate oil, gas, and water, a gas injection plant to return separated gas to the Prudhoe Bay oil and gas reservoir and a gas conditioning plant. These new facilities will all be located at Prudhoe Bay as part of the trans-Alaska oil pipeline system.

Air quality records have only recently been collected at Prudhoe Bay. Namtvedt et al. (1974) cite a background reading of from 300 to 500 condensation nuclei per cubic centimeter to 20,000 nuclei/cu cm, with highest concentrations generally associated with proximity to industrial facilities.

Characteristic of the winter Arctic climate is a strong temperature inversion above the snow or ice surface resulting from strong radiational cooling (Sater et al., 1971). The average depth of this inversion layer is 3,937 to 4,921 feet (1,200 to 1,500 meters). It is only temporarily or partially cleared by strong winds and it reforms rapidly. The combined presence of temperature inversions and condensation nuclei from industrial facilities associated with petroleum production and transportation may generate serious local ice-fog conditions (Namtvedt et al., 1974).

Prevailing winds in the proposed project area are from the Beaufort Sea toward the Brooks Range. Accordingly, it is unlikely that human activities in the Prudhoe Bay area will affect air quality over the Arctic National Wildlife Range to the east.

The Clean Air Amendment of 1970 established categories for assessing the severity of air pollution within given regions, as follows:

Priority I. Portions of the region are in violation of the primary Ambient Air Quality Standard.

Priority II. Pollutant levels within the region are in excess of secondary standards. but less than primary standards.

Priority III. Pollutant levels are below secondary standards.

Alaska has adopted the National Ambient Air Quality Standards as the Alaska State Standards (Table 2.1.1.14-1).

As discussed above, there have been no air measurements involving the air pollutants of concern (Table 2.1.1.14-1) anywhere in the region of the proposed route. However, ambient air quality is considered to be good, because of the general absence of human activity. Activities at Prudhoe Bay have been increasing, undoubtedly with some deterioration of air quality, but this has not been quantified.

2.1.1.15 Environmental Noise

The proposed pipeline route is through essentially undeveloped wilderness areas (except at its conception point: Prudhoe Bay). The background sound level was measured at 20 to 30 dB on a linear scale near Arctic Village (Klein, 1973) and for the purposes of this study the midpoint of this range (i.e. 25 dB) is selected as the typical ambient sound level presently existing along the proposed pipeline route.

Higher background sound levels of 50 to 64 dB (C-weighted) have been measured near rivers in wilderness areas of Alaska (McCourt et al., 1974). Other natural sounds which may cause temporarily higher sound levels are wind, animal footsteps and vocalizations, thunder, and rockslides (McCourt et al., 1974). Occasional aircraft can also be expected to add momentarily to the ambient level. Therefore, the majority of the various routes can be characterized as being very quiet except for occasional natural sounds.

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Table 2.1.1.14-1 **State of Alaska and National Ambient Air Quality Standards**

	Primary standard* µg/m³	Primary standard* ppm	Secondary standard† µg/m³	Secondary standard† ppm
Sulfur oxides -				
annual arithmetic mean	80	0.030	60	0.021
24-hour concentration	365††	0.137	260††	0.091††
3-hour maximum	1,300			
Particulate matter -				
annual geometric mean	75		60	
24-hour concentration	260††		150††	
Carbon monoxide -				
8-hour concentration (mg)	10††		Same as primary	
1-hour concentration	40††			
Photochemical oxidants -				
1-hour concentration	160††	0.08††	Same as primary	
Hydrocarbons -				
(corrected for methane)	160††	0.24††	Same as primary	
3-hour concentration (6-9am)				
Nitrogen oxides -				
annual arithmetic mean	100	0.053	Same as primary	

*Primary standards: Maximum permissible concentration to protect human health.
†Secondary standards: Maximum permissible concentration to protect plants and wildlife.
††Not to be exceeded more than once a year.
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3 ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

3.1 ARCTIC GAS PIPELINE PROJECT

3.1.1 Alaska Arctic Pipeline

Introduction and Summary of Impacts

There are major engineering, location, and construction variables associated with the proposed AAGPC (Alaskan Arctic Gas Pipeline Co.) pipeline system in Alaska.

A chilled, buried, high-pressure, large-diameter natural gas pipeline of the type proposed by the Applicant has no precedent. There is no reservoir of practical experience, therefore, from which to evaluate theoretical design features proposed by AAGPC.

Laboratory and full-scale field tests by the Applicant are currently being conducted to determine effects of frost-heaving on the pipe and substantial data have been developed. Until practical applications have been made, however, questions remain. In other cases, the available data are not complete. For example, the Applicant does not have data for subsurface soils between M.P. 130 and 175, along the proposed pipeline route. Because of the extreme variability of soil type, temperature, and ice (moisture) content, the available data are not adequate to demonstrate that a thorough analysis has been made of pipeline integrity. Further field exploration will be necessary to perfect the engineering design.

The Applicant proposes to use the most current engineering design principles and to comply with the existing applicable codes. Arctic conditions create problems that require advancement of pipeline technology. It appears that Part 192, Title 49 of the Code of Federal Regulations does not embrace criteria for pipeline design for the Arctic.

New types of equipment will need to be developed for construction, operation, and maintenance for the Arctic. For instance, in case of pipeline failure during the thaw season, the type of air-cushion vehicles proposed by the Applicant to transport equipment and supplies during the summer is in the prototype stage of development.

Many elements of location and criteria for engineering design for the proposed AAGPC pipeline system are to be developed as part of the final design cycle and are not available now. As an example of how initial plans change with experience and collection of additional site specific data, the trans-Alaska Oil Pipeline System was planned and designed as a "buried" pipeline system. Yet, today, almost 400 miles or 655 km (approximately one-half of the total pipeline) are being built above ground to maintain pipeline integrity.

The following is a summary of the major impacts expected if the AAGPC gas transmission system is constructed as proposed:

Permafrost--The entire proposed AAGPC pipeline system in Alaska is in an area of continuous permafrost except at certain river crossings. Any alteration of the thermal regime can trigger environmental changes, including soil erosion, disruption of drainage systems, stream and land pollution, and vegetation destruction, which in turn can affect operation and maintenance of the pipeline system and construction if it exceeds one season. Pipeline impacts from permafrost destruction could include disruption of construction schedules, damage to the system with accompanying need for repair, delay in repairs and increased operation costs.

Water Withdrawals--The proposed construction of a snow pad and snow roads will require large amounts of snow and water. Water also is needed for camp use, hydrostatic testing, and the ditch flooding proposed to stabilize the trench and backfill in ice-rich areas. Neither snow nor water is abundant in the Arctic, and from January through April, surface water usually is locked up as ice. If snowfall were reduced during the 3-year proposed construction period, enough water may not be available for construction activities. If sufficient water is not available, construction would be delayed or a gravel road and work pad would need to be constructed. A substantial increase in gravel requirements and a gravel pad would create a whole new set of impacts.

Frost Bulb Formation--The frost bulb which will develop around the chilled, buried pipe will obstruct subsurface movement of water and also will affect surface flow. Important long-range impacts on water quality could result, along with threats to vegetation and pipeline safety.

Stream Crossings--Impacts are likely to occur at stream crossings for the following reasons:

a) At certain stream crossings, the pipe will pass through areas of intermittent frozen and unfrozen soil, and differential settlement of the pipe could result.

b) The chilled pipeline will induce earlier streambed freezing, later breakup, and blockage of subsurface stream flows.

c) Development of a frost bulb in stream crossings could result in ice dams that could induce changes in stream profiles and channels.

Vegetation--Vegetation will be destroyed or altered by site changes such as those affecting soil moisture, surface drainage, soil temperature, nutrient availability, microrelief and depth of the active thaw layer.

Wildlife--Major impacts of construction, operation, and maintenance of the proposed AAGPC pipeline include the following:

a) The number of caribou could be reduced substantially below historic population levels. Calef (1974) concluded that if controls on all aspects of the project are not enforced, the herd may decline as much as 90 percent in 5 to 10 years because of the combined impacts from the following: direct mortality, disturbance, physical barriers, and habitat destruction. The long-term possibility that a major international resource could be lost as a result of gas pipeline and related oil and gas developmental activities cannot be ignored.

b) Musk oxen have been re-introduced in the project area only recently, and disturbances could cause the small herd's extirpation.

c) Combined impacts of a gas pipeline and related oil and gas developmental activities will have most serious environmental impacts on the Beaufort Sea polar bear population including disturbance to denning, reduced productivity, and disturbance to the food chain supporting polar bears.

d) Entire fish populations in a drainage could be destroyed by impacts resulting from: water withdrawal from critical overwintering areas; accidental spills of fuels, lubricants, and methanol; and degradation of water quality.

e) The Arctic Coastal Plain is considered a critical link in the life history of snow geese. The entire fall staging population of snow geese could be adversely affected by project-related disturbances.

Wilderness--Construction of the proposed AAGPC system will destroy wilderness values of a portion of the Arctic National Wildlife Range, a unique natural continuum of arctic ecosystems. Construction of the system will also eliminate the possibility of coastal portions of the Range being included in the National Wilderness Preservation System.

Subsistence--Impacts resulting from pipeline activity that affect the distribution and abundance of waterfowl, game, and fish will, in turn, adversely affect persons who depend on these resources for subsistence and cultural heritage. Particularly serious would be any impacts that limit the availability of the Porcupine Caribou Herd, on which residents of Kaktovik, Arctic Village, and northwestern Canada (mainly Old Crow) depend. Change in subsistence would affect not only the economic situation of persons affected but would also impose a change in their lifestyle.

A detailed discussion of these impacts and others follows.

3.1.1.1 Climate

Impact on Climate

The proposed construction, operation, or repair of the AAGPC pipeline system will have little, if any, impact on climate. The proposed system will not affect regional temperatures, winds, precipitation, or the amount and location of ice in the Beaufort Sea. Available information suggests there will be micrometeorological changes resulting from compressor station emissions (see 3.1.1.14, Air Quality).

Impact of Climate on the Proposed AAGPC Pipeline System

Climatic conditions of the arctic environment in which the proposed AAGPC pipeline system will be constructed, operated, and repaired can have severe adverse impacts on the pipeline system.

Cold winter temperatures, in combination with strong winds, produce wind-chill factors which approach and sometimes exceed -100°F, making working conditions hazardous for people constructing, operating, and repairing the proposed pipeline system during winter months. Long-term darkness as well as the cold winter temperatures will also affect the construction personnel.

Adverse weather conditions include at least 90 days annually in which fog can restrict or prevent ship and aircraft movements throughout the area where the proposed pipeline system would be located. There are 118 days annually at Barter Island when visibility (exclusive of darkness) is less than 1 mile. These same conditions are expected to exist at both the proposed Demarcation and Camden Bay port areas.

The proposed AAGPC pipeline system will be built, operated, and repaired without a permanent road network. Accordingly, very heavy reliance is placed upon movement of men and supplies by air and sea. Although major Alaskan air lines have demonstrated in excess of 95 percent reliability in North Slope arctic operations, adverse weather will affect reliable air and sea movements, and can cause delay of construction, operation, or repair procedures until weather permits air and sea movements. Alternative transportation modes would require surface vehicles which can cause serious damage to the environment as the proposed system does not plan facilities to handle large aircraft such as the C-135. (See 3.1.1.16, Pipeline System Repairs.) Delay in construction, operation, or repair will cause serious adverse social and economic impacts since the Prudhoe Bay gas would be unavailable for use in domestic markets. Adverse weather conditions could also restrict emergency transportation of injured or ill workers, even though the Applicant plans to use IFR-equipped helicopters and fixed-wing Otter aircraft during this period.

The Applicant proposes to substitute a snow pad over the right-of-way in lieu of the usual workbed. Snow roads are also proposed for the construction road infra-structure used to transport men, supplies, material, and equipment from the port sites of Prudhoe, Camden, and Demarcation Bays to the maintenance camps, along the right-of-way and to haul gravel and sand from borrow pits. Approximately 195 miles of right-of-way (90 feet wide) and 200 miles of infra-structure (30 feet wide) are required.

Snow roads would be prepared by building up thin layers of snow, consolidated layer by layer with water. Snow for the roads and right-of-way along the proposed route in Alaska would be derived from natural ground cover, by controlled drifting using snow fences and snow harvested from frozen lakes and rivers.

In addition, the Applicant recognizes that early winter natural snow may be insufficient to provide the roads and right-of-way required to support an October through May construction schedule. He proposed to initiate early winter construction with roads and right-of-way initially constructed of manufactured snow and of early season snow packs formed by drift fences. High production snow making equipment was scheduled for testing in 1975 (winter).

From tests performed in Inuvik, it appears that roads with a Rammsonde hardness of 450 or greater could withstand heavy equipment traffic provided ice capping on bends and slopes, as well as repair and maintenance, was continually provided. Repair was accomplished by laying a mixture of sawdust or chips and freezing it into place by application of water. But, the Applicant states that this repair method would not be used along the North Slope.

The use of snow roads for heavy traffic during the month of May may be marginal. The report of the Muskeg Research Institute on the use of lumber roads in Richards Island during spring thaw led to the conclusion that the traffic halt is a combination of exposed tundra, thickness of snow, etc., but that as a guide, air temperature of 10° to 20°F with bright sunlight and light winds appears to be the limit. Air temperatures in the northern coastal zone in May are between a maximum of 28.4°F and a minimum of 16.8°F and it may not be possible to traffic heavy vehicles in May without local destruction of the tundra.

Maximum snow depths rarely exceed 15 inches and in many places are considerably less. Vegetation often protrudes through the natural snow cover. Accordingly, large volumes of snow would be required to construct snow roads and pads of sufficient thickness and strength to protect the vegetation from damage.

The Applicant examined the effect of a snow road upon the underlying vegetation in the Inuvik tests. The effect on the vegetation, as determined after the spring thaw, appeared negligible; however, the site selected for the tests did not represent windswept tundra. Additional information on the survival of arctic vegetation under snow roads indicates that for roads built according to the best practice, the organic mat (peat) may be compressed, that the thaw may increase in the first year, and plant recovery may be slow. Single or multiple passes of heavy equipment (such as the Caterpillar D-9 tractor) over 11 to 19 inches of unprepared snow surface show that low density hoarfrost compresses above the vegetation, flattens and breaks standing (dead or alive) vascular and cryptogamic vegetation and that although thaw depth may not be affected, biomass and plant productivity are adversely affected.

It is noted that construction of roads and right-of-way pads of manufactured snow, the construction of roads and right-of-way pads from natural or drifted snow cover, and the repair and maintenance of the snow roads and right-of-way pads during the October through May construction period all would require water, but in differing amounts. In addition, water would be required for camp use, hydrostatic testing and for ditch flooding, a mitigating measure proposed to stabilize the trench and backfill in extreme ice rich areas (see Section 3.1.1.5). The water requirements (estimated) for a light snowfall year are 5,319,000 barrels, or 686 acre-feet.

Climate severely limits the availability of water during the proposed winter construction periods by completely freezing lakes and streams. In normal years, appreciable amounts of surface water are locked up as ice from January through April. It appears likely, therefore, that the large amounts of water needed to construct ice roads would not be available if there were any appreciable reduction of snowfall during the 3-year period needed to build the pipeline system.

In addition to the water availability issue, there is the question of hauling water to the road and pad sites. Typical equipment used to transport water for road construction is a six-wheel drive tank truck, with a capacity of 3,700 gallons (880 barrels) and weighing 65,000 pounds. The use of such equipment to support snow road construction from October through December would require that it exist in a low ground pressure configuration, be equipped with suitable water extraction and application equipment, and be insulated or heated to preclude in situ freezing of the water load.

Movement of ice in the Beaufort Sea is unpredictable. The maximum time to move shipping past Barter Island is approximately 90 days. With late breakup and an early freeze, the period would be shortened to approximately 45 days (see Table 2.1.1.1-5). The Applicant proposes to move construction materials and supplies during two consecutive summers by ship between the Mackenzie River and port sites in Alaska at Prudhoe, Camden, and Demarcation Bays. It is possible (as in the summer of 1975 near Pt. Barrow) that ice might not move sufficiently offshore to permit ship passage along the Beaufort Sea Coast and fall storms may move the polar icepack back to shore at a very early date. The impact of sea ice severely limiting shipping during two consecutive summers would cause a 1-year delay in the operation of the proposed AAGPC pipeline system, since the large volumes of materials and supplies could not be moved easily by alternative methods (such as air) and still meet the stringent winter construction schedule proposed by the Applicant.

3.1.1.2 Topography

Impact of the Proposed AAGPC Pipeline and Related Facilities on Topography

The proposed AAGPC pipeline project will require excavation of at least 3.1 million cubic yards of borrow materials for construction purposes. Most of the identified borrow areas are located in active or fossil flood plains crossed by the route or adjacent to facility locations. The Applicant proposes to construct a berm around each borrow pit to prevent siltation. The physical dimensions of the berm have not been specified; however, the pits will be reformed by grading, contcuring, reseeding, and applying fertilizer. The impact from excavation of borrow materials and from berm pit construction on topography and landscape will be insignificant because the Applicant proposes to obtain necessary sand and gravel materials from many different sites not connected to each other and will take mitigating measures. For additional evaluation of borrow sites see 3.1.1.5, Water Resources.

The proposed AAGPC pipeline construction method will result in a mound of material over the buried pipeline. The Applicant states that "...height of the backfill mound will be variable, depending on material and ice content, for the first couple of years. As settlement and thaw consolidation above the pipe take place, the height of the mound will be reduced to near grade level." The ditch mound will form a linear alteration in the existing surface configuration. The Applicant has considered the possibility that the pipeline may remain inactive for 1 or more years. Berm erosion, due to ponding and surface drainage, and berm side channeling to approximately 8 feet could occur during this inactive period. Since the berm is a mitigating measure, it must be replaced to the extent of the erosion and side channeling. This increase in berm width may be visible for more than the first couple of years. The impact of the ditch mound and/or channel in the right-of-way on existing topography/landscape is considered to be excessive even in view of the rapidly industrializing area between Prudhoe Bay and the Arctic National Wildlife Range associated with the exploration and development activities occurring to develop the oil and gas fields.

The Arctic National Wildlife Range (M.P. 60 to 195) has not been intruded upon by man to create any adverse impacts on the topography and landscape. Therefore, even a slight mound and/or channel scar along the proposed AAGPC route is considered a significant impact on the pristine wilderness characteristic of the Arctic National Wildlife Range.

Microrelief is important in the development of surface drainage and vegetation. Accordingly, the ditch mound may have important secondary impacts on water distribution and vegetation. (See 3.1.1.5, Water Resources, and 3.1.1.6, Vegetation.) The Applicant proposes specific measures to be taken to minimize interference with natural drainage patterns until revegetation is effective and in addition, the Applicant presents specifications for a revegetation plan which anticipates site-specific revegetation activities as late as the spring following construction.

The Applicant estimates that explosives will be required to excavate approximately 25 percent (48 miles) of the total pipeline trench, and this will take 850 tons of explosives. The Applicant further states that the technique for using explosives to excavate a pipeline ditch in frozen soils has not been developed. The location of sites where blasting would take place will not be known until final engineering studies are completed. Blasting in frozen soils would not have a major impact on topography or landscape along the proposed AAGPC route if it does not involve areas where blasting would cause landslides or other catastrophic changes in the existing topography or landscape. The Applicant has not indicated if any blasting will be necessary to excavate borrow pits.

In summary, the overall impact of the proposed AAGPC pipeline project will produce a significant topographic modification through the establishment of a low, linear ditch mound which may be up to 16 feet wide. The greatest impact on topography will be in the Arctic National Wildlife Range where there is little evidence of human activity. Blasting to excavate the pipeline ditch is considered minor in terms of topographic impact.

3.1.1.3 Geology

Impact on Bedrock and Mineral Resources

Except for approximately 10 miles (5 percent of the proposed AAGPC pipeline route), bedrock is covered by a mantle of at least 10 feet of unconsolidated materials. The 10 miles where bedrock is exposed at the surface or covered with less than 10 feet of unconsolidated materials are primarily located between Mile Posts 81 and 111. Excavation of the pipeline ditch through that area is not expected to have a significant impact on bedrock.

Construction and operation of the proposed AAGPC pipeline system will have an impact on mineral resources of the area in that additional development of prospective oil and gas reserves (Section 2.1.1.3) will be encouraged. (See 3.1.1.9, Economic Factors, and 3.1.1.11, Land Use, for additional discussion of mineral developments.)

The Applicant states a need for approximately 3.1 million cubic yards of gravel to construct the proposed project. As stated above, occurrence of bedrock along the route is very minimal, thereby precluding availability of a quarry site to produce gravel within a reasonable distance. No overall estimate of the amount, quality, and location of gravel in the vicinity of the proposed AAGPC route has been accomplished.

The impact caused by development of gravel (borrow) pits would mostly be limited to visual disturbance, drainage disruption, and possible loss of big game habitat. Because the borrow sites proposed by the applicant are in floodplains, the visual disturbances and drainage disruption should be self-healing. Therefore, the impact of gravel extraction is considered minor.

Some changes in the geologic environment will be caused by the transportation and redistribution of borrow materials but these are considered minor. The most important impact will be the expenditure of an essentially irreplaceable natural resource. This is especially sensitive when no estimate of the total amount, quality, and location of gravel in the vicinity of the AAGPC route is available.

Impact of Permafrost on the Proposed AAGPC Pipeline System

One of the most critical factors to be considered is how the proposed AAGPC pipeline project will cause local changes in permafrost and, in turn, how permafrost will affect the project.

The proposed AAGPC project is located in a region underlain by continuous permafrost. Figure 3.1.1.3-1 shows the relationship of permafrost and bedrock along the proposed route. The vast majority of the permafrost associated with the proposed AAGPC pipeline route contains significant reaches of ice-rich soils.

Eventually, the proposed AAGPC pipeline will result in creation of more permafrost in areas not now frozen, such as at major river crossings, and in reduction of the active layer. The direct impact of creating "more" permafrost is minor. There are, however, major secondary impacts on surface and subsurface drainage which in turn will affect permafrost (see 3.1.1.5, Water Resources).

All disturbances in permafrost areas will 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 permafrost area is involved, subsidence, slumping, gullying, and establishment of new drainage patterns occur. Once initiated, permafrost degradation is difficult to arrest until a new heat balance is achieved. In the Arctic, disturbed areas are slow to regain a natural organic insulation because of the short growing season.

Soil temperatures along the right-of-way at the pipeline burial depth (centerline--approximate) range from 16°F (April) to 33°F (October). A temperature of 33°F produces melting.

Gas temperature along the right-of-way can range from 33° to -3°F, depending upon inlet temperature and the pipewall temperature. These ranges are associated with a flow rate of 2.25 bcf/d.

The Applicant notes that depending upon the burial depth of the pipe, temperature of the gas, and temperature and ice content of the adjacent permafrost, the depth of the active layer will be reduced. Figure 3.1.1.3-2 shows that anticipated change in the depth of the active layer over the pipeline will be as much as 1.5 feet (0.46 m) with a gas temperature of 12° F (-11.1° C).

Buried pipewall temperature will lie between the soil temperature and the gas temperature, i.e., between 33° and -3°F.

Should the pipeline not become operational during the first summer following winter construction, the Applicant has stated that mound subsidence (2 feet), side channeling along the berm, and increased penetration depth of the active layer (to 5 feet) are expected to occur during the dormant pipeline period.

However, the Applicant's analytical model fails to consider ponding, waterflow along the ditch, and assumes ideal construction procedures, i.e., the organic mat along the right-of-way remaining undisturbed during the construction period even though (limited) grading and surface cuts will occur.

Of particular concern is active layer penetration below the pipe and excessive berm erosion due to ponding and side channeling. Penetration of the active layer below the pipe will introduce buoyant forces and freeze-back of a water-saturated trench will introduce frost heave forces.

The production of "unexpected" bucyant forces could lead to berm cracking. This could be a contributing factor to "excessive" berm erosion caused by ponding and waterflow along the ditch. Excessive berm erosion

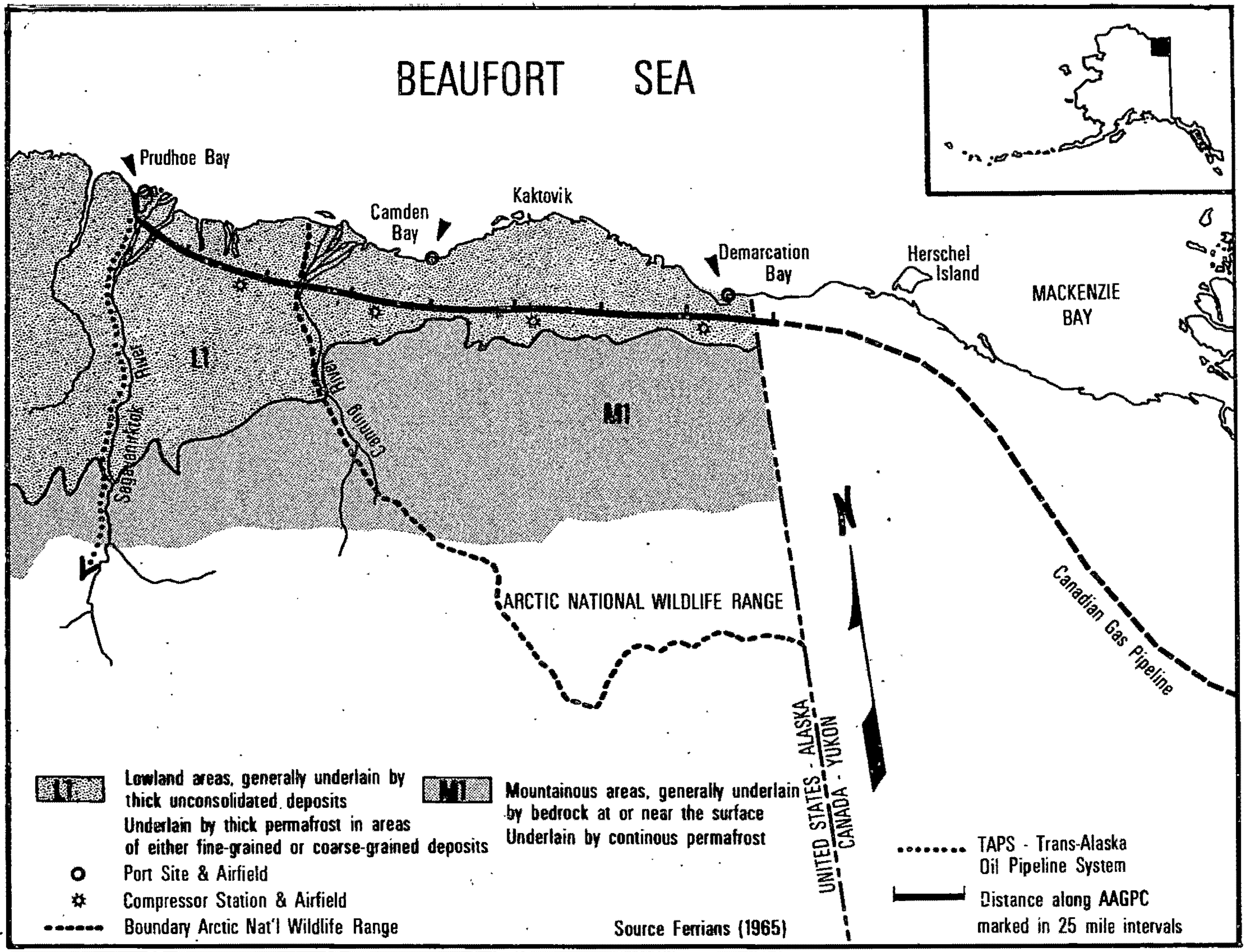


Figure 3.1.1.3-1 Permafrost bedrock relationships along the proposed AAGPC pipeline system, Alaska

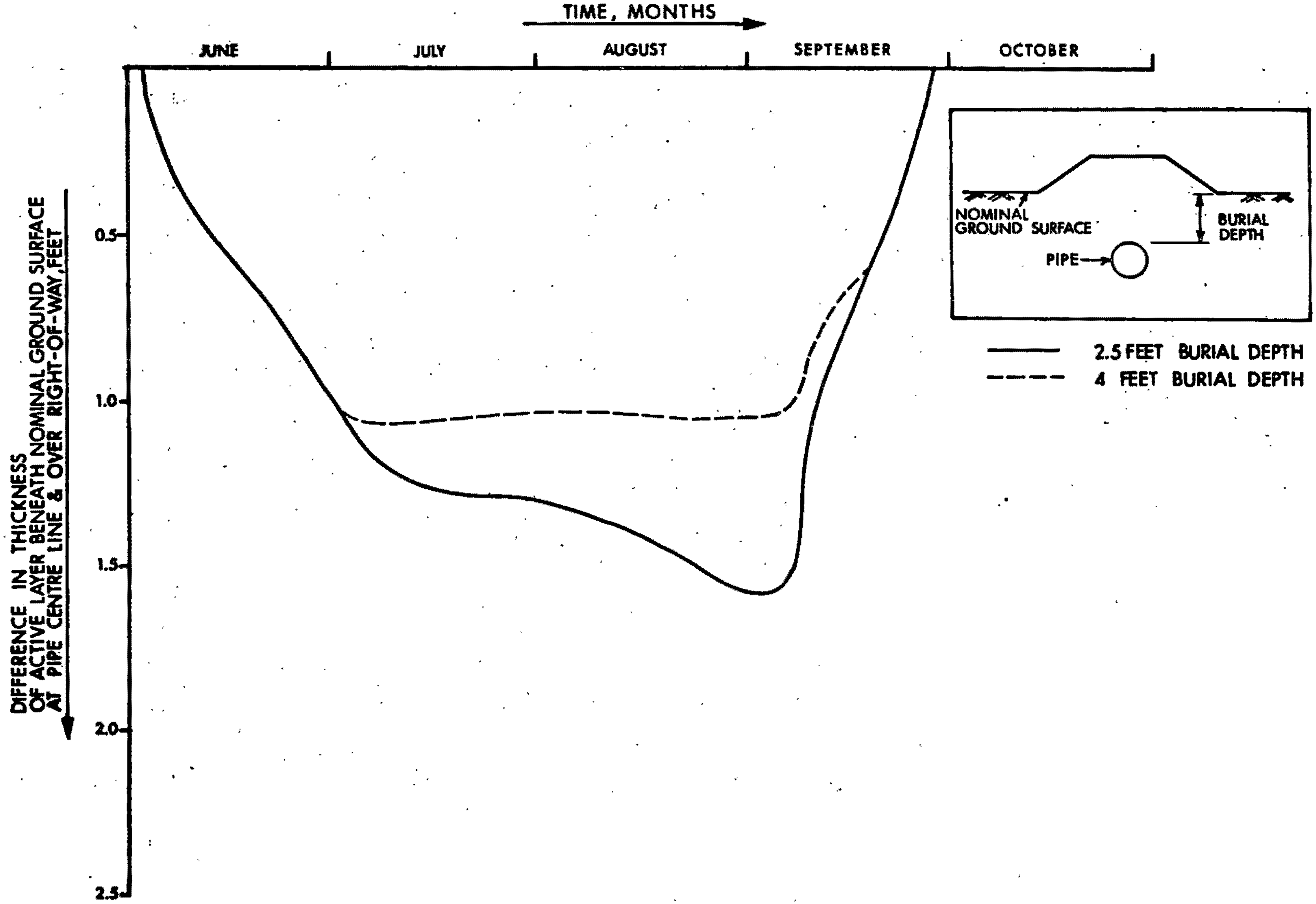


Figure 3.1.1.3-2 Difference in the depth of the active layers caused by the chilled, buried pipeline

will compromise a primary measure proposed by the Applicant to mitigate the effects of buoyant and frost heave forces.

This erosion also leads to siltation and eventually pollution of land and water. The impact on the pipeline by permafrost is considered significant because if not controlled, it could contribute to pipeline failure, and will lead to pollution of streams and land, degradation of water quality and it could initiate repair actions which could in turn compound permafrost degradation.

The Applicant recognizes that the ditch bottom may be irregular when excavation is in frozen materials and proposes to use a bedding of processed spoil or borrow material where the bottom is rough or uneven. However, the composition and characteristics of this bedding material have not been described nor has the degree of unevenness that will require bedding been specified.

The Applicant estimates that in unfrozen muskeg or peatland the pipe will settle as much as 12 inches (30.5 cm) during hydrostatic testing. Settlement is caused by the weight of the methanol-water test fluid compressing the bedding, backfill, and trench bottom. In permafrost, the Applicant states there will be no settlement of the pipe during hydrostatic testing. However, bedding and backfill compression will occur and some settlement is expected.

In Alaska, soil may range from frozen to unfrozen soil and back again at a selected river crossing. During hydrostatic testing, differential settlement could occur in this transition zone. Although the Applicant has included differential settlement in definition of design criteria, differential settlement associated with differential compaction of the bedding, backfill, and trench bottom through such a transition zone has not been considered.

The integrity of a pipeline traversing this transition zone could be compromised by local pipe deflections and the development of an overstress condition during hydrostatic testing.

Since the pipeline is buried during hydrotest, leakage will cause a rapid low thaw. The Applicant recognizes this and proposes to replace fine-grained thawed soil (described as a viscous slurry) with gravel backfill to within 1 foot of the surface. However, the Applicant does not discuss the influence of a test medium leak upon the sides and bottom of the trench, or upon the characteristics and effectiveness of the bedding material.

The methanol solution saturated material will be spread in borrow areas or other approved sites, where it will stabilize as the methanol evaporates. However, the Applicant has not discussed the time period for stabilization and the impact of this upon borrow pit vegetation.

The Applicant states that although some methanol backfill will remain around and over the pipe, it will consolidate under the weight of the granular backfill and the concentration will gradually diminish. He further states that this material may not freeze back initially, but it will be at temperature below the freezing point of water. Thus, the adjacent soil beyond the area affected will freeze back and the unfrozen portion will not significantly inhibit the formation of the frost bulb.

Differential formation rate of the frost bulb may lead to differential loading of the pipeline. This potential loading has not been discussed by the Applicant.

The Applicant states that in the event of a leak, the location of the leak will be visually detected by persons walking the trench. The effectiveness of this method in arctic winter conditions has yet to be determined.

In summary, the continuous permafrost and its extreme variability from location to location create special problems for the construction, operation, and repair of the proposed AAGPC pipeline. The Applicant is keenly aware of problems created by construction in permafrost and has conducted extensive testing in Alaska and Canada to develop new and specialized engineering techniques for burying the proposed, high-pressure, chilled gas pipeline in permafrost areas. These studies and tests are still under way.

Impact of Frost Heave on the Proposed AAGPC Pipeline System

Frost heave is caused by differences in volume between frozen and unfrozen water and buildup of segregated ice or ice lenses. Frost heave, or expansion of the soil materials through ice lenses, is possible where frost-susceptible soils, water, and freezing temperatures exist. The proposed buried, chilled AAGPC pipeline system will cause pore water (ground 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, the AAGPC pipeline system will provide the freezing temperature and the backfilled pipeline ditch will provide localized conditions favorable to frost heave.

Except at river and stream crossings, the proposed pipeline is to be buried below the depth of the active layer and therefore, should pose no special problems unless construction activities cause the active layer to deepen beyond that normally encountered (see Section 3.1.1.3).

The buried pipeline will not be in permafrost at major stream and river crossings such as the Canning and Sagavanirktok Rivers because the active layer under these rivers is below the depth of expected pipe burial. Information currently available does not show conclusively that frost susceptible deposits do not occur at such locations. Therefore, a frost heave condition could exist. This is of special concern since the Prudhoe Bay tests conducted by the Applicant on a buried pipeline do not represent "worst case" frost heave situations. Test results at Prudhoe Bay did show bending moments that were 20 percent of the yield moment at pipe anchors as a result of frost heave. These moments are considered to be significant in terms of potential frost heave problems along the proposed AAGPC pipeline system.

In the event frost heave occurs, it is probable that the buried pipeline would be subjected to differential stresses 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. Frost heave could occur at thaw lakes, beaded drainages, possible taliks, stream and river crossings, and any areas with frost susceptible soils, which may thaw during summer or prolonged shutdown and refreeze; all of which could cause pipe stress conditions. Thus the amount of allowable flex in the pipeline system will be restricted by short segments anchored in permafrost on either side of the frost heaving reaches.

Information supplied by the Applicant does not identify either the range or tolerance in allowable pipe stress relating to pipe deformation. The Applicant states that the reversal of water flow caused by the differential temperatures between the operating (chilled) pipeline system and the adjacent permafrost, (that is, the pipeline will be colder than the permafrost in summer and warmer in winter which will tend to cause water to migrate toward the pipe in summer and away from the pipe in winter) will prevent significant ice buildup around the pipe. It is important to note, however, that because permafrost temperatures vary and operating temperature of the pipeline system is independent of permafrost temperatures, the hoped-for results may not occur. The temperature of the system ranges from 25° to 5° F (3.8° to -15° C) during initial operation phases. Thus, there are almost certainly one or more reaches of the system where the temperatures lateral to the pipeline will be colder than the adjacent ground in both summer and winter and will always be colder than at some unknown depth beneath the pipe.

The permeability of cold permafrost is low (10^{-9} cm/s) which indicates that water migration to the frost front is extremely low. The amount of unfrozen water in cold permafrost is low (estimated to be approximately 5 percent); therefore, ice-lensing should be insignificant. However, the potential for frost heave from water migration does exist primarily at or near thaw lakes, beaded drainages, and wherever unfrozen lenses of soil are encountered. Frost heaving will cause the pipeline to be displaced upward, thereby greatly increasing stresses on the pipeline system with increased risk to keeping the proposed high-pressure, buried pipeline system operational.

Prediction of frost heave is a very difficult problem. The applicant is conducting laboratory and full scale field testing to determine predictability of frost heave and cause and effect on pipe integrity. Preliminary data indicate that frost heave impacts on the pipeline buried in cold permafrost will be insignificant. However, where the pipeline surfaces at valve sites, future compression station sites, river crossings, and thaw sites, there is a departure from permafrost to thaw areas which creates problems with frost heave that need to be addressed. This condition is considered to be critical in terms of demonstrating the design adequacy of the frozen bury mode. Impact could be significant in that it could cause disruption of gas delivery from Prudhoe Bay. Frost heave is likely to occur when the active layer is thawed which could create a significant surface impact should there be a need for summer repairs. (See Section 3.1.1.16, Nonwinter Repairs.)

Impact on Slope Stability

In permafrost regions, slope stability is very sensitive to the amount of water in the soil.

Information submitted by the Applicant indicates that approximately 90 percent of the slopes traversed by the proposed pipeline route are less than 3°. Except for those cases involving disturbance of the permafrost regime, slopes of less than 3° tend to be stable regardless of the character of the underlying material. The remaining 10 percent involve at least 56 places where slopes range from 3° to 9°+. Most of these are associated with stream crossings and locally may approach 20°. These areas would be susceptible to slope failure which, if deep-seated, could displace, damage, or break the proposed pipeline. This is not true if liquefaction of the thawed active layer occurs.

Thawing of permafrost because of construction or maintenance activities could result in slope failure, especially where fine-grained, ice-rich soils are encountered. As melting of interstitial ice (thaw consolidation) takes place, the volume of the thawing soil profile is reduced and if water is generated at a rate exceeding the discharge rate of the soil materials, the total soil mass may behave like liquid. Typically, the active layer (soil or rock material thawed annually) is close to or at saturation because percolation is limited in depth by the top of the permafrost layer. The closeness of the permafrost to the surface and melting ice help keep the soil supersaturated and included rock fragments damp as the active layer deepens. The collection of moisture could increase slope load and decrease soil strength. If saturation causes elevated pore-water pressures, liquefaction leading to slope instability could result. Brown (1969) reports 50 percent of the total annual thaw occurs within 3 weeks of the onset of the thaw season and that in some summers, 100 percent of the annual thaw depth has been attained by the first 2 weeks in August. Accordingly, thaw consolidation must be considered as an annual event which takes place rapidly and, therefore, slope instability could occur throughout the operating life of the proposed pipeline system. This would be most probable during the early summer, necessitating repair work when the surface is thawed.

The proposed AAGPC pipeline route is in hilly terrain between Mile Posts 60 and 115. Similiar but more moderate terrain exists between Mile Posts 115 and 155.

Solifluction (shallow, downslope movement of water-saturated unfrozen sediments over a surface of frozen material) is probably the most frequent evidence of slope instability on the Arctic Coastal Plain and Arctic Foothills. It differs from other forms of slope instability, such as creep and rockslides, in that entire sheets or lobes of unconsolidated sediment move. It is a condition caused by the impermeability of permafrost and low evaporation rate. Solifluction occurs in the active layer and is limited to periods of thaw. Downslope movements may be so rapid that a structure resting upon the area of movement either will be subjected to large earth pressures or will move passively downslope.

Shallow, downslope movement of soil and vegetation such as solifluction probably would not directly affect the proposed pipeline system since the pipe is expected to be buried below the shallow depth at which solifluction usually occurs. Solifluction could redirect surface drainage, accelerate erosion, and thaw permafrost which in turn would threaten pipeline integrity. The impacts of slope instability conditions are considered important to the pipeline system since slope failure would require repair and stabilization at a time when the surface was thawed and most susceptible to damage by vehicles used in repair activities.

The proposed AAGPC pipeline project will require excavation and backfill of a ditch running essentially at right angles to the prevailing northward slope of the terrain and intersecting approximately 120 streams and rivers where water flows at least seasonally. Fine-grained ice-rich permafrost areas are extremely sensitive to disturbance. Intersection and potential capture of surface and subsurface drainage along the pipeline ditch could increase moisture availability locally and slope stability would be threatened. The impact of the proposed AAGPC pipeline on slope stability could be significant. Although impacts would be local, their proximity to water courses (where terrain is steepest) could have major secondary impacts on water quality from increased siltation. A tertiary effect resulting from slope instability would be to upset the heat balance controlling the underlying permafrost. (See discussions under 3.1.1.3 Permafrost, and 3.1.1.5, Water Resources.)

It is probable that construction of the proposed AAGPC pipeline project will increase the occurrence of skin flows where the surface vegetation is disturbed. The impacts of skin flows would be local and are considered minor since the flows generally are shallow. Secondary impacts from new skin flows could be major in that the heat balance controlling permafrost would be disrupted. Because this type movement is shallow it probably will not affect pipeline integrity unless surface drainage is redirected. Impacts from skin flow are considered to be similar to those from solifluction in that summer repair work could produce major impacts from surface equipment movement over the thawed surface.

Deep-seated creep may occur in permafrost slopes where the underlying permafrost becomes warmer but does not thaw. In such an event, thick deposits of materials may move downslope. There are no known areas along the Alaskan portion of the proposed AAGPC pipeline route where deep-seated creep has occurred; however, construction of the proposed pipeline ditch may provide local conditions favorable to deep-seated creep. The area of concern is the slope-pipeline interaction, since deep-seated creep can cause movement of the proposed pipeline system. The impact of deep-seated creep causing pipeline failure would be of major significance and adverse since the system could not deliver natural gas. Impact to the local environment would be similar to that described for solifluction and skin flows in that summer repairs would be required. These could have major secondary impacts on fishery or wildlife species present at the time of repair.

The Department's geotechnical analysis has identified three broad examples where slope stability becomes an important element in the selection of final design criteria for the proposed AAGPC pipeline project. These involved evaluation of a slope in the Arctic Foothills paralleled by the pipeline route, a low-angle slope intersected by the pipeline route at a 45° angle, and an alluvial fan slope crossed at a perpendicular angle by the pipeline route.

In the Arctic Foothills, the selected slope is 4.5° to 5° and is located approximately 4 miles east of the Katakturuk River (M.P. 86.5). The proposed AAGPC pipeline runs parallel to the slope. It crosses ice-rich silty and organic soils probably overlying old morainal deposits of till. The slope is located in smoothly rounded silt-mantled sloping regions composed of thick (up to 50 feet) eolian (silt) and colluvial (organic silt) deposits with many inclusions of ice. The moisture content for samples recovered below the active layer varied from 40 to 90 percent. The actual moisture content may be significantly greater. Thawing of these soils will result in a great loss of volume and the releasing of large quantities of water. Concentration of surface and subsurface water flow will induce thermal degradation and rapid erosion of the soil and enhance the formation of icings in water.

The removal of the organic mat during pipeline construction will upset the heat equilibrium of the slope. With unchilled pipe, the thaw depth will increase and excess pore pressure may be generated during the thaw of fine-grained soils. As a result, the effective shear strength of the soil is reduced with probable initiation of skin flows. The skin flow may cause a vertical movement of the pipe and, depending on the magnitude of the mass movement, pipe stresses may be substantial. This vertical movement of the pipe will be further aggravated by reduction of the negative buoyancy of the pipe because of excess water in the pipe trench. The slope flow may vary from inches per year to feet per year, depending on the soil condition and the disturbance introduced by pipeline construction.

The second slope reviewed lies approximately 4 miles west of the Egaksrak River (M.P. 162). It is a low-angle slope (0.5° to 2°) and was selected because the pipeline direction is 45° to the slope. The slope is a part of an alluvial fan, underlain by deep silty to clean and gravel sands. The bottom of the slope merges with the fossil flood plain with less than 5 feet of ice-rich silty to fine sand top stratum. Mass movement which could occur would cause vertical and lateral displacement of the pipe, although the lower angle of the slope and thaw stable material would mitigate this movement; therefore, it is considered insignificant.

The third type of slope evaluated is in an area characterized by gently rolling terrain cut by broad, very gently sloping flood plains and alluvial fans which become the predominant features east of the Aichilik River at M. P. 150. (The proposed pipeline route is perpendicular to an alluvial fan.) The slope is located approximately 4 miles east of the Turner River (M. P. 184) near the Canadian border. The soils in the flood plains and alluvial fans are composed primarily of gravels although the subsurface soil data derived from the Applicant's soil borings indicate the presence of isolated pockets of ice-rich, fine-grained soil. Silty surficial deposits, generally less than 5 feet thick, are commonly associated with the alluvial fans and the "fossil" flood plains. A thin active layer consists of inorganic and clayey silts with low plasticity. Soil moisture content varies from low in coarse-grained soils to 100 percent in fine-grained soil. The general characteristics of the terrain are similar to those of the previous slope (alluvial fans with low gradients, 0.5° to 2°). Erosion is not expected to be a problem in these gravels except at river crossings or where subjected to flooding. Thawing can, however, initiate problems. Because of a lower specific heat and a greater thermal conductivity, gravel will thaw faster and to greater depths than will fine-grained soil under similar circumstances. Differential settlement between the coarse-grained and fine-grained deposits can be large enough to be a problem and the loss of fines through piping could accentuate problems or cause siltation. While no massive ice was observed in the drill holes, it is well to remember that massive ice (wedges) has been observed in gravels in the Arctic.

Depending upon final location, size, and depth of the excavation, removal of at least 3.1 million cubic yards of borrow materials for construction purposes could result in undercutting natural slopes. Oversteepened pit walls could result in local slumping. Excavation could also initiate local permafrost degradation which in turn enhances thaw consolidation. The impact of borrow material sites on slope stability, however, is considered minor. Borrow excavation may have major secondary impacts on water quality and/or pipeline safety. Data supplied by the Applicant are not adequate to identify properly whether such impacts will occur and if so, their degree or location.

Impact of Earthquakes on the Proposed AAGPC Pipeline System

The design of a structure to resist serious motions must consider the earthquake intensity, the structural parameters governing its response, and the permissible allowable levels of response, such as stress or strain and deflection for the particular earthquake hazard selected. The Applicant selected the Design Maximum Earthquake (earthquake return period of 100 to 200 years) as his design criteria. In a 1973 study, Stevens and Milne conclude that along the proposed route the strain energy release has been equivalent to one earthquake of magnitude 5 or less on the Richter scale per occurrence per 100 years. This numerical value is related to the total energy in elastic waves released by the earthquake. The total energy may be determined for any earthquake when the magnitude is known.

The Applicant has assumed in his earthquake studies and from studies on the trans-Alaska oil pipeline that a maximum probable earthquake of magnitude 5.5 on the Richter scale was assigned to the area of Prudhoe Bay south to 67° N and that similar conditions occur east of Prudhoe Bay on the proposed route to the Canadian border. Using the above earthquake magnitude of 5.5 for design criteria, the pipeline system, in the event of an earthquake of 5.5 or less, will be able to continue operation. Therefore, earthquakes are not expected to have a serious impact.

A strain release map for eastern Alaska has been prepared by Stevens and Milne (1973) using earthquake records of 1899-1970, Figure 2.1.1.3-7. The numerical value of the strain energy released by earthquakes that have occurred in an area over a period of time can be assumed to indicate the past and probable future earthquake activity in that area. At the present time there are no known active faults along the pipeline route. In the unlikely event that an earthquake greater than the design magnitude occurs, it is assumed that failure of the system would occur. The impact to the environment would result when repair activities are initiated as discussed in Section 3.1.1.16 and gas is released into the atmosphere as discussed in Section 3.1.1.14.

The proposed AAGPC pipeline system is not expected to induce or increase earthquake activity.

3.1.1.4 Soils

Impact on Soils

The soil related impacts that will occur as a result of implementation of the proposed action are discussed in this section. Although quantifications, because of the lack of detailed information, are not always possible, the relative impacts anticipated and the ranges of effects to be expected are discussed.

Of all the natural physical resources affected by the project the disturbance of the soil will create the most significant impacts. Development of soils in the Arctic is very weak or shallow and varies extremely within short distances. There is a distinct difference between the depth of soil development and the depth of unconsolidated materials or the regolith. A developed soil is a reflection of the environment. It is reflected in the modification of the surface materials by weathering and leaching as compared to the relative raw geologic material from which the soils are developing. Also the thickness of the organic mat is a reflection of the stability of the surface and has a definite effect on soil development and depth of the permafrost layer.

The disturbance of the existing soil profile will interfere with the natural processes of the functional ecosystems through which the pipeline passes. Disturbance of the soil will have a changing effect on the natural plant communities. The changes caused by soil disturbance to vegetation will have indirect effects on wildlife dependent on the original plant composition. The exposure of soil by removal of the vegetation will allow erosion from wind and water. In natural areas soil disturbances will cause adverse effects to topographic features and changes to natural plant communities will result in esthetic degradation. There will be no disruption of agriculture as there is none in the area.

The Applicant conducted a reconnaissance soil testing program along the proposed AAGPC pipeline route in Alaska. The Applicant has drilled a total of 55 test holes along the proposed AAGPC pipeline route, but these are deemed insufficient to make more than generalized observations because of extreme variability from site to site.

Generalized data prepared by the Applicant indicate glacial deposits comprise 37.9 percent of the proposed pipeline route, while alluvial deposits are 29.0 percent. Marine deposits make up 20.1 percent and diverse deposits are 10.2 percent. Lacustrine deposits comprise 2.7 percent. Although these percentages could change as final subsurface engineering studies are completed, the relationships are considered typical.

The proposed AAGPC pipeline project will require excavation of a ditch approximately 195 miles long across the Alaskan Arctic Slope. Materials excavated from the ditch will be placed on a packed snow pad alongside the ditch until the pipe has been laid in place. At that time this spoil material would be used as backfill to cover the pipe. The process of excavation, storage, and replacement will result in considerable mixing of the soil. The impact of mixing the soil during the excavation and backfilling procedures proposed by the Applicant is considered minor since most soil will be replaced in the pipeline ditch where operation of this pipeline will create new conditions for plant growth. These secondary impacts may affect the success of the Applicant's proposed revegetation over the pipeline. The extent of this impact is unknown (see 3.1.1.6, Vegetation).

It is probable that all spoil stored along the open ditch will not be removed during the backfilling process. The impact of leaving soil on top of the native plants will result in secondary effects on soil temperature (darker earth will absorb more heat, potentially upsetting the natural heat balance), and on plants which will be smothered.

The Applicant has indicated that as much as 700,000 cubic yards of selective backfill material will be used to replace ice-rich soil excavated from the pipeline ditch. It has been tentatively proposed that excess spoil will be disposed of in the borrow sites (generally located in active flood plains) used to obtain the new backfill material. These excavated ice-rich soil materials could lower water quality if they thaw and reach rivers, streams, lakes, or estuarine areas as mud or, subsequently, as a source of dust to smother adjacent plants.

The Applicant plans to use 47,000 tons of fuel and lubricants during construction of the proposed AAGPC pipeline project. It is probable that spills of fuels and lubricants will occur and that all spills cannot be completely removed before contaminating soil. Unknown, but substantial, quantities of fuel and lubricants will be stored at the three port sites, four future compressor station sites, field operating headquaters, and at local mobile construction sites. Subsequently, the fuels and lubricants will be redistributed during the construction, operation, and repair phases of the proposed AAGPC pipeline project. The potential for small, chronic spills at these locations is considered high. Assuming that Federal and State standards for storage of fuels and lubricants will be followed, the expected impact of soil contamination by fuel and lubricant spillage at ports, compressor sites, headquarters and local mobile construction sites is considered moderate.

Thawed soils under arctic conditions are considerably more depleted chemically as a result of sustained leaching (Brcwn, 1969). Nutrient availability in arctic soils appears to be related to soil temperature but is adequate to permit growth of arctic plants. Bliss (1971) has shown that nutrient levels decrease as soil temperature lowers. The proposed AAGPC pipeline system will cause a frost bulb to develop around the buried, chilled pipeline, reduce the active layer by as much as 1.5 feet, and correspondingly reduce soil temperatures. The impact of the proposed chilled pipeline on reduced soil nutrient availability may have important secondary impacts on vegetation (see 3.1.1.6, Vegetation).

3.1.1.5 Water Resources

Impact on Water Quality

The proposed AAGPC pipeline project will require the presence of large numbers of construction workers at Prudhoe, Camden, and Demarcation Bays and at the four future compressor station sites. The Applicant proposes to comply with State and Federal standards for sanitary sewage control; therefore, the impact of temporary concentrations of people should have little effect on existing water qualities. The Applicant states that if sewage lagoons are used, all effluents will receive secondary treatment and be discharged so that they will be carried off during spring flooding. The details of how such an operation would be implemented are not available. Accordingly, the impact of human sewage on water quality, especially from the aspect of dissolved oxygen levels or addition of nutrients, is unknown. Bacteria survive for extended periods under arctic conditions. Any accidental discharge of waste materials into water could have long-lasting effects since it would be possible for humans to ingest live pathogenic organisms if they drank untreated surface water. This could be a major adverse impact on human health since water for human consumption in the proposed project area tends to be used "as is," or without treatment.

The Applicant states that 700,000 cubic yards of borrow material may be required for selective backfill in the pipeline ditch. The Applicant proposes to dispose of the excess 700,000 cubic yards of ice-rich materials at the same borrow sites where the substitute materials were excavated. The Applicant plans to construct a berm around the borrow pits to preclude siltation. Borrow sites used as disposal sites for ice-rich spoil may increase siltation locally when flowing water is present. The location or amounts of excess spoil to be disposed of in such sites are unknown. The impact of lowered water quality from excess spoil melting and turning to mud and reaching water is speculative. There could be major adverse effects on water quality since silt-laden waters would be present at a time when the water normally is clear. This will detract from its appearance esthetically and may harm aquatic life. All identified borrow sites are associated with active flood plains. It is possible that some excess spoil would be flushed downstream at a time when waters were already silty. The impact, if any, of adding silt to an arctic stream that is in a normal silty condition is unknown.

Gravel extraction from active flood plains will increase siltation. The Applicant proposes to extract gravel from active flood plains during the summer and early winter. Highest water flows in rivers and streams of the project area commonly are associated with frontal storms during summer and early fall. The construction of such a berm is likely to insure that gravel pits will not be flooded by high waters as were the gravel removal operations in the Sagavanirktok River during the summer of 1973. The impact on water quality of additional silt being added to water at a time when it is normally silty is unknown.

Construction of the proposed AAGPC pipeline will result in substantial surface alteration for the entire 195-mile (313.8-km) long, 120-foot (36.6-m) wide right-of-way. Within the 120-foot (36.6-m) width, a ditch will be excavated, spoil stored, and a snow-ice working pad and road constructed (Figure 1.1.1.6-1). Each action has significant potential to expose soil to erosion by water which, in turn, can result in a significant lowering of water quality by addition of silt. The possibility of decreased water quality through erosion will continue until the Applicant's proposed revegetation program becomes successful, permafrost stabilizes, and the frost bulb stabilizes so that long-term surface and subsurface drainage patterns and slope stability can become re-established. This may take many years. Accordingly, the construction of the pipeline will produce significant impact on water quality through increased siltation. Increased siltation will be most pronounced during periods of low flow when surface waters normally would be clear. Rain or snow melt will not be necessary to transport silt-laden water to streams, rivers, or lakes since thaw consolidation (melting of ice within the soil) will provide the water. Increased siltation could pose serious secondary impacts to aquatic life through smothering or destruction of habitat. These impacts may extend into the marine estuaries of the Beaufort Sea where reduced light penetration as a result of silt-laden waters could have significant long-term impacts on marine life by reducing the growth potential of bottom fauna and micro-organisms important in the marine food-chain.

The proposed AAGPC pipeline project will require large volumes of water during construction phases (see Table 3.1.1.5-1) of the completed pipeline. The water would be needed during the November-April winter construction period. The Applicant states that the majority of the lakes in the vicinity of the pipeline right-of-way are shallow, do not appear to contain fish populations and probably freeze solid at some time during the winter. After December, water sources will be scarce. The impact of lowering water quality by increasing mineral content cannot be evaluated since the location of water sources is unknown. There may be harmful effects, however, to any overwintering aquatic life at the source of water withdrawal. Similarly, there may be secondary impacts on vegetation, as late-winter sources of water are likely to be highly mineralized, and these minerals would be concentrated along the snow road where water will be used to form an ice cap. Highly mineralized water probably will require treatment before being used for human consumption.

The Applicant will be using 47,000 tons of fuel and lubricant during construction of the proposed AAGPC pipeline project. In addition, the Applicant proposes to use 6,000 tons of methanol for pipeline testing purposes.

The probability for major spills of fuels, lubricants, or toxic materials at storage sites and during water transportation along the Alaskan Arctic Coast cannot be discounted. Should a major spill occur, there would be long-term adverse impacts on water quality. Because adverse weather and ice conditions can hamper remedial actions, it is probable that adverse water quality conditions would be serious. The extent of lowered water quality in the marine-estuarine ecosystem along the Alaskan Beaufort Sea Coast would depend upon the following: (1) the type of fuel, lubricant, or toxic material spilled; (2) amount spilled; (3) season; (4) location; and (5) success of remedial action. Under worst case conditions, it would be possible to destroy a major segment of the oldsquaw and eider duck populations (see Wildlife, 3.1.1.7).

Repeated small accidental spills of fuels and lubricants may be as serious a water quality problem as a single large spill. Spills have potentially greater impact at the three port sites and during water transportation, since control measures will be difficult. Petroleum products entering the subsurface drainage system may recur in several successive thaw seasons until the active layer is flushed out. Impact on water quality cannot be determined but the threat remains from accidental spills.

Methanol (wood alcohol) is very toxic to humans; as little ingested as 3 oz. (10 ml) has caused death, and smaller amounts have caused permanent blindness. Aquatic animals and vegetation appear to be relatively tolerant to methanol when it is diluted to less than 1 percent solution with water. The Applicant has stated that research is under way to determine the effect

Table 3.1.1.5-1 Construction water requirements (estimated)

	Construction Spread		
	D	A	B
Road and Pad Requirements			
Manufactured (miles)	20	41	32
Normal (miles)	110	101	104
Total (miles)	130	142	136
Water Requirements			
1. Manufactures (bbls)	530,000	971,000	782,000
Normal (bbls)	790,000	720,000	740,000
Subtotal (bbls)	1,320,000	1,691,000	1,522,000
2. Ditch Flooding (bbls)	69,000	69,000	69,000
3. Camp (bbls)	210,000	210,000	210,000
4. Hydrostatic Testing (bbls)	40,000	40,000	40,000
Subtotal (bbls)	1,639,000	2,010,000	1,680,000
TOTAL (bbls)		5,329,000	

of stronger concentrations of methanol upon vegetation. These studies may or may not show the concentrations to be harmful. Since a 26 percent concentration of water and methanol will be used as the hydrotest agent, leaks in the ditch will produce localized concentrations within the ditch excavation which may enter the subsurface water flow during the thaw period and pose a threat to water quality. Impact can be serious if dilution of the methanol-wood mixture does not meet human, animal, and vegetation safety standards.

Repair of the proposed AAGPC pipeline will cause lowering of water quality. Repair during winter months would produce impacts on water quality similar to those described above for construction. Repairs undertaken during the period between the start of thaw and freezeup could cause primary impact on water quality by increasing turbidity and through accelerated erosion as vegetation is compacted by repair equipment and permafrost is exposed as the buried pipe is excavated at a time when there is abundant surface water (3.1.1.16, Pipeline System Repairs). There also is a chance for spill of fuels, lubricants, or methanol during repairs. The impacts of reduced water quality from repair operations would depend upon time of year, repair location, how far equipment must be moved, and the type of soil and water conditions encountered during transport and repair procedures.

Impact on Ground Water

Ground water conditions along the proposed AAGPC pipeline project are highly variable, primarily reflecting permafrost influence. Subsurface water flows tend to follow terrain, flowing from higher elevations to lower points as influenced by local topography and microrelief.

Unfrozen ground water may be found beneath large rivers and deep lakes that do not freeze completely during the winter.

Construction of the AAGPC pipeline in Alaska will involve movement of heavy equipment and supplies along the right-of-way and between proposed port sites at Camden and Demarcation Bays. Vehicular traffic will be on snow/ice roads. Traffic on snow roads will compact the vegetation mat and soil, reduce the insulating properties of surficial materials, and increase the depth of the active layer. The increased depth of thaw will cause subsurface water to concentrate in a linear depression. Concentrated water will enhance thaw consolidation (melting) and accelerate deeper thawing of the permafrost. The impact of the heavy equipment and supply surface movements on subsurface drainage may be significant in that the thermal balance would be disrupted along the 250 miles (402.3 km) of snow/ice roads (Figure 3.1.1.5-1). The extent of this impact is unknown, but once initiated, it would be difficult to control. Haugen and Brown (1971) noted that effects of surface layer compaction do not appear for a number of years.

Except at river crossings and prospectively at deeper or recently drained lakes, the pipeline ditch will be excavated completely through the active layer into the underlying permafrost. This notch into the permafrost will be refilled with spoil removed from the ditch and possibly selected borrow materials, a 48-inch diameter pipe, and excavated materials. The pipeline is to be operated at temperatures below freezing and a bulb of frozen materials (frost bulb) will develop around the pipe. Until the frost bulb develops, as in the case of pipe inoperative for 1 or more years, the excavation will become a natural trap and redirect subsurface water flow. As water concentrates in the ditch, it will enhance consolidation of ditch backfill.

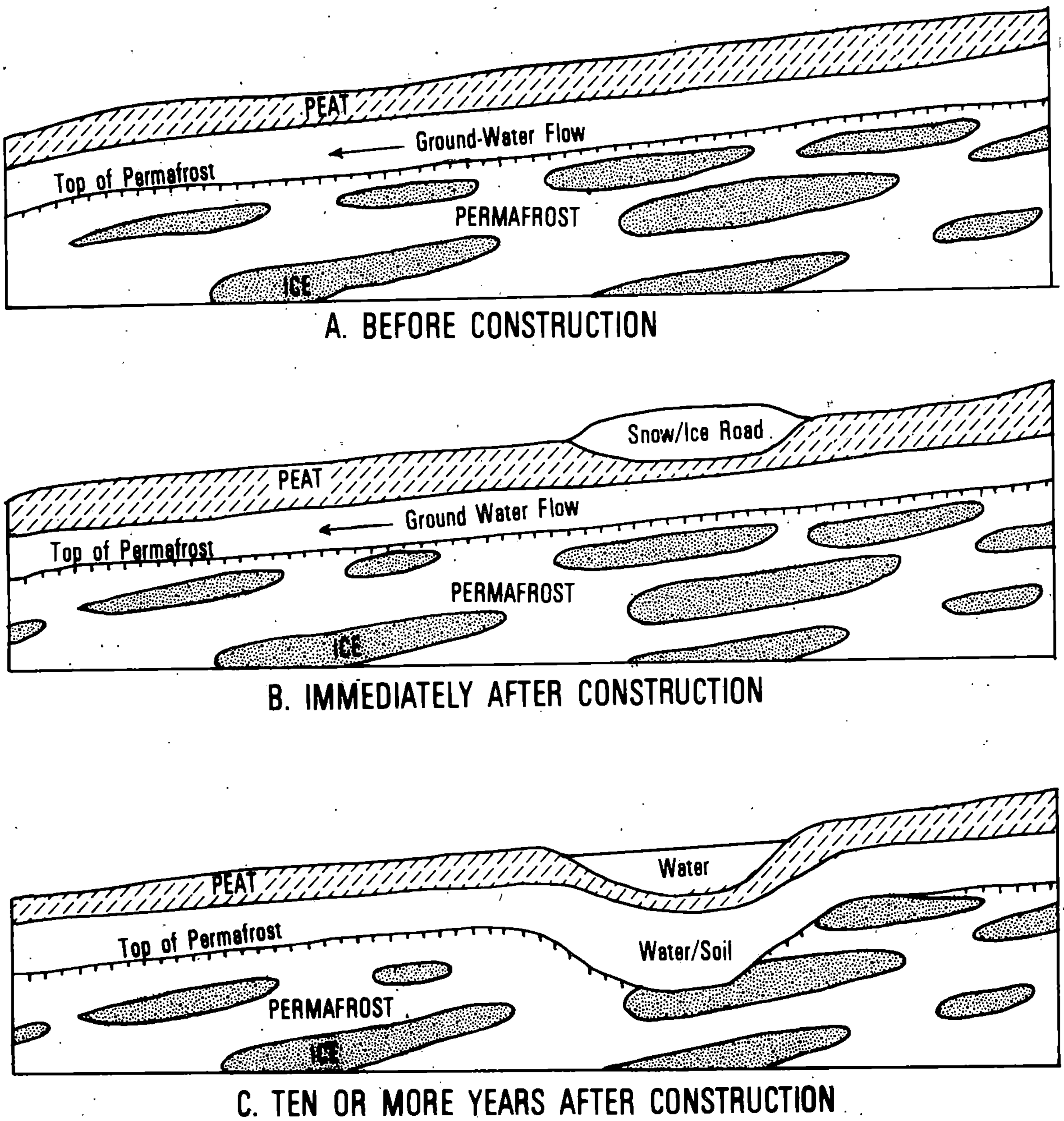


Figure 3.1.1.5-1 Schematic drawing of late summer conditions showing long-term impact of snow/ice road construction on permafrost and subsurface drainage

The impact of the ditch excavation intercepting, concentrating, and redirecting subsurface water flows is major in that thaw consolidation could increase the probability of slope instability.

Operation of the proposed chilled gas pipeline will produce a frost bulb around the pipe which will extend up to 25 feet (7.6 m) laterally from the pipe, up to 36 feet (11 m) below the pipe, and reduce the thickness of the active layer up tc 1.5 feet above the pipe. The influence of this frost bulb will depend upon the temperature of the pipeline, soil type and moisture content, and temperature of the adjacent permafrost. The development of a frost bulb will make a dam to subsurface movement of water. Subsurface water flows will be concentrated and ponded on the upslope side of the frost bulb which will accelerate thawing of the adjacent permafrost. The impact of the frost bulb on subsurface water movement will be significant in that complete blockage is probable. This will have important, long-range impacts on water quality and secondary impacts on vegetation and on pipeline safety.

Figure 3.1.1.5-2 illustrates the formation of the frost bulb dam on the upslope side of the buried, chilled pipeline.

Operation of the buried, chilled pipeline may force subsurface water to the surface in the winter at stream crossings, causing formation of ice (Figure 3.1.1.5-3). The impact of ground water being forced to the surface by the frost bulb and subsequent icing could have significant secondary effects of smothering vegetation or forming a surface ice dam which redirects surface drainage patterns.

The frost bulb formation in fine-grained saturated silty soil may induce formation of ground ice (Figure 3.1.1.5-4). The impact of the formation of ground ice could be a serious threat to pipeline safety as frost heaving of the pipe might take place.

In the event repair of the proposed AAGPC pipeline is required during the summer using conventional heavy equipment, there would be immediate, significant impact on subsurface water drainage. Surface movement of equipment and supplies across a thawed tundra surface will cause compaction and concentration of water almost instantaneously. The resulting immediate change to subsurface drainage would be similar to that shown in Figure 3.1.1.5-1. Wintertime repairs would be similar to those described for construction.

Impact of the Proposed AAGPC Chilled Pipeline on Streams and Rivers

Ice carried by rivers and streams during spring breakup becomes an active erosion agent when blocks of ice gouge riverbanks or, if tilted on edge, scour the streambed. The formation of ice dams as ice becomes grounded can cause water levels to rise, and once the water is over the top of the normal banks, new river or stream channels may be formed. Both conditions pose serious engineering and environmental problems.

The Applicant proposes to bury and operate a chilled gas pipeline in all drainages intersected in Alaska. The chilled pipeline in the streambed will (1) induce earlier freezing of the ice to the bed, (2) cause later breakup of ice which is "locked" to the riverbed, and (3) result in blockage of subsurface flows in the bed of the stream.

The Applicant has not provided specific engineering information on how each of the approximately 120 streams in Alaska would be crossed. In

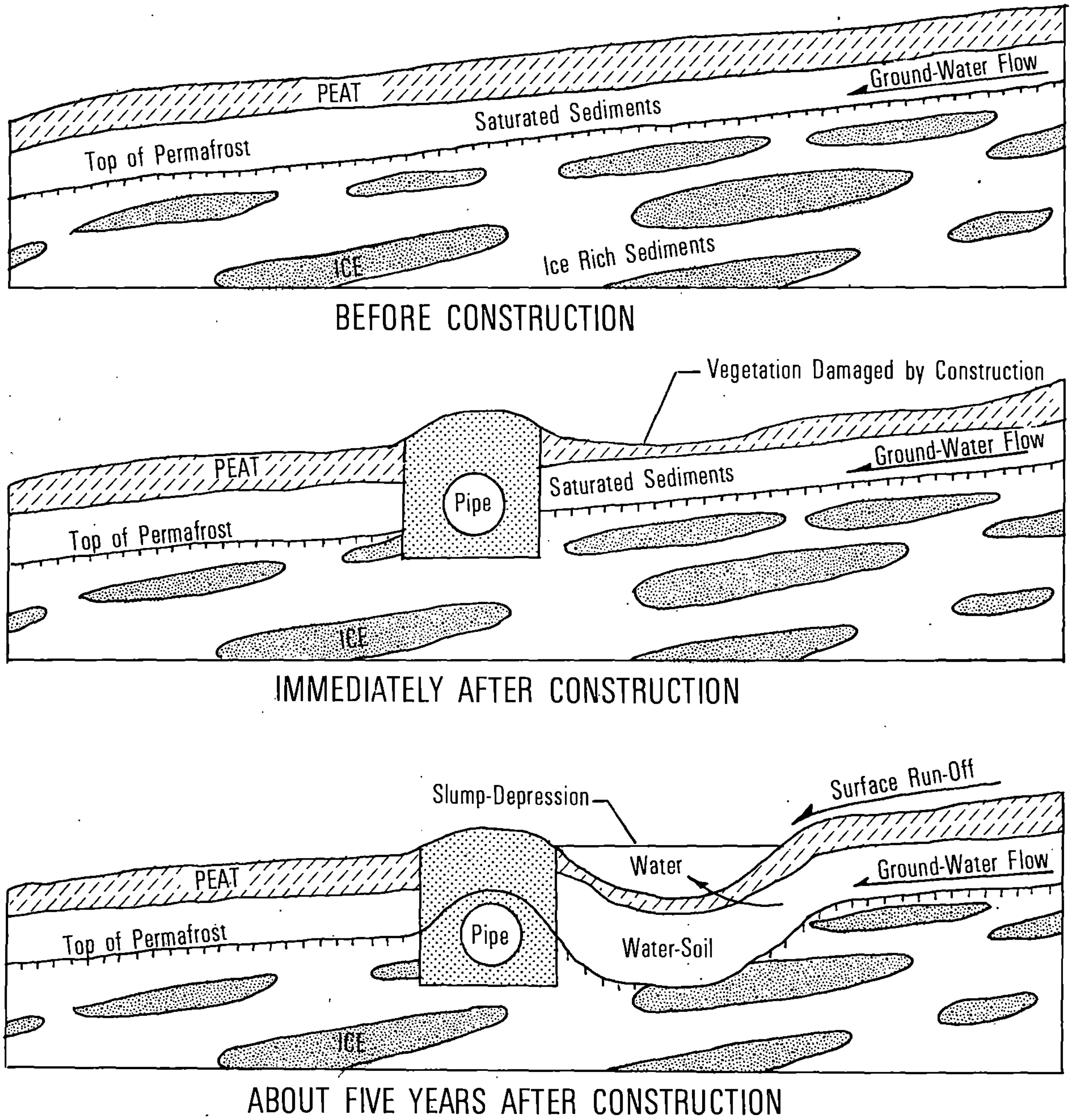


Figure 3.1.1.5-2 Schematic drawing of late summer conditions showing thermokarst development along chilled, buried pipeline

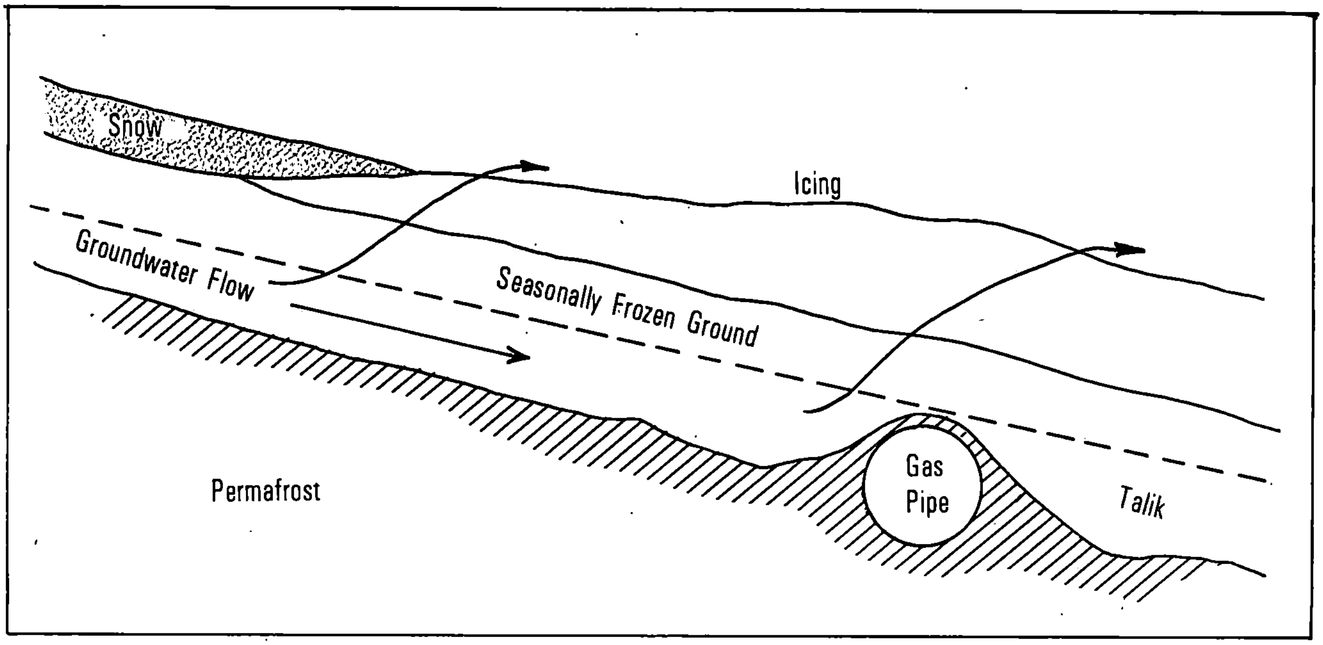


Figure 3.1.1.5-3 The effect of a cold pipeline will initiate new ground icing in areas where surficial sediments are water saturated and permeable and where there are unfrozen zones below the active layer

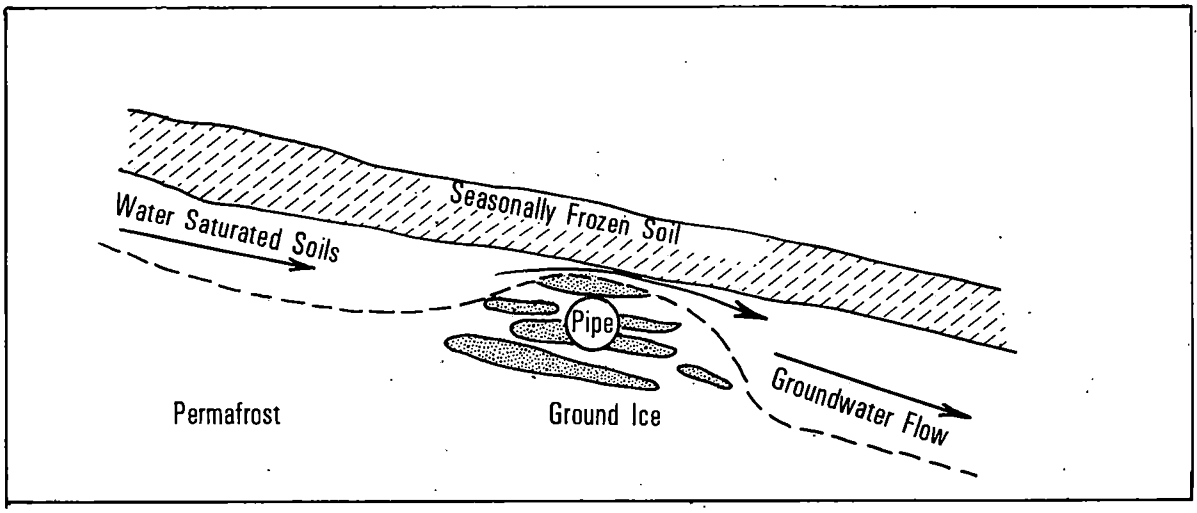


Figure 3.1.1.5-4 Ground ice may develop in vicinity of pipeline in areas underlain by fine-grained, silty soils where saturated unfrozen (surficial) materials overlie the pipeline

general, the proposal is that the stream crossings are to be made at an unspecified depth to avoid bottom scour.

Scour depth in a typical braided river may be up to 13 feet (4 m) for a single channel river (Blench, 1969), but local summer channeling may be as much as 30 feet (9.1 m) below normal streambed elevation.

The Applicant states that detailed engineering data such as depth of scour will not be available until after the project has been approved. The Applicant further states that parallel pipelines may be constructed at some stream crossings so that the pipeline frost bulb can be controlled by alternating the flow of chilled gas through the two pipelines or that the pipeline could be insulated to minimize frost bulb growth. The Applicant has not stated where and under what conditions double crossings would be constructed or insulation provided.

The impact of the creation of a frost bulb by operation of a chilled natural gas pipeline in the bed of approximately 120 streams and rivers flowing northward across the Alaskan Arctic Slope can have major impacts on the existing natural hydrologic regime. The frost bulb will block the flow of water in the streambed to a depth of as much as 20 feet (6.1 m). Blockage of unfrozen water in the streambed, or of free water directly under the ice, would force water to the surface and enhance formation of aufeis (floodplain ice) which in turn would increase the potential for the formation of ice dams during breakup. A portion of the streambed downstream from the pipeline would be dewatered. This could affect fish concentrated in overwintering areas and survival of fish eggs deposited in gravel downstream from the crossing by depriving them of a water (and thus oxygen) source (Figure 3.1.1.5-5). The extent of downstream spawning areas, if any, is not known. Available information suggests, however, that most spawning areas are upstream from potential crossings (see Section 3.1.1.7, Wildlife).

Development of a frost bulb in stream and river crossings will cause an ice anchor up to 20 feet (6.1 m) in width across the entire stream. The result will be an ice dam which will cause repeated bank overflow at the same location and in the long run will be conducive to the formation of new, permanent channels in braided stream sections and meander cutoffs in meandered streams. Ice scour of the bank and bed downstream from a potential crossing would be enhanced as ice dams would tend to form in the same place on a yearly basis. The impact of increased, repeated ice scouring could result in a change in river gradient and riverbed load which would tend to continue until the stream profile reached a new equilibrium. Accelerated bank erosion, in turn, could have serious secondary impacts on slope stability where slopes are undercut.

Development of a frost bulb in the bed of a river or stream will also produce an erosion-resistant ridge of ice-encased material across the stream. Water flowing over this new obstruction will tend to create bottom currents which may scour indentations in the streambeds on the downstream sides of the ice bulb. The depth of the downstream cavity would be related to the velocity of streamflow and size of the bed materials. The frost bulb and bottom configuration will create new habitat for fish and aquatic invertebrates, and at the same time, potentially create an upstream movement hazard where increased stream velocities result over the pipe. The overall impact is considered likely to be minor. A major secondary impact may result as a threat to pipeline safety since the downstream cavity in combination with a 20-foot (6.1 m) wide ice dam might make conditions favorable to downstream movement of the buried pipeline. The extent of this secondary impact, if any, cannot be properly assessed until an engineering analysis has been conducted for each crossing.

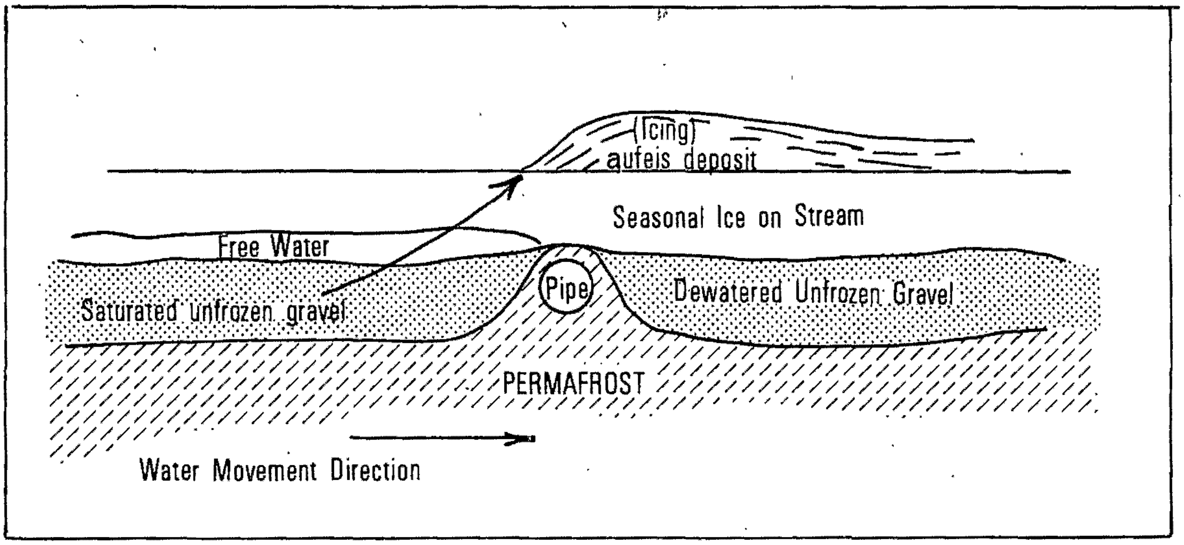


Figure 3.1.1.5-5 Potential development of aufeis and dewatering of streambed downstream of a buried, chilled pipeline

Large volumes of water will be required for construction and maintenance of snow/ice roads and for testing of the pipeline. The Applicant proposes to withdraw needed water from selected lakes and streams. Since most lakes and streams freeze completely, it is questionable whether adequate water can be found without going to upstream spring sites. These upstream spring areas provide critical overwinter habitat necessary for survival of fish. Withdrawal of water from these sources will have significant adverse effects on fish populations and distribution throughout the project area. There may be important impacts on survival of fish and/or fish eggs downstream from the source of water withdrawal, should water supplies necessary to life be unavailable or depleted.

Impact of Borrow Material Excavation on River and Stream Hydrology

Borrow sites for up to 3.1 million cubic yards of sand and gravel would be located in the active flood plains of the Sagavanirktok, Kadleroshilik, Canning, Tamayariak, Sadlerochit, Jago, Aichilik, and Kongakut Rivers, Marsh Creek, and several unnamed streams. It is probable that borrow materials for the Demarcation Bay port will come from the deltas of the Turner River or Clarence Creek. Marsh Creek will be the source of materials for the Camden Bay port area. Borrow operations are proposed to be conducted in the summer and early winter.

The Applicant proposes to excavate gravel within the flood plain, but not in a watered channel. As indicated, shift of water throughout the flood plain will eventually result in the excavation being in the water course. River gradients in the Arctic Coastal Plain and Arctic Foothills are in a shifting equilibrium wherein the stream profile depends upon the amount and velocity of water in the stream, streambed material size, and the degree and frequency of scouring. The impact of excavation of gravel to depths in excess of 10 feet (3.1 m) on stream and river hydrology will be locally significant. These excavations are well in excess of the normal shallow water depth [less than 2 feet (0.6 m)]. The river or stream profile, therefore, will start to readjust by refilling the excavation during high water cycles. The refilling materials would come from the bed of the stream on the upstream side of the excavation. Thus, there will be gradual upstream migration of the deeper water until the stream profile has reached its new point of equilibrium. The impact of this new profile could be significant to the overall hydrology, as stream flows might be sufficiently concentrated to reduce the braided character of the flood plain. Impacts of a new stream profile would be similar, but larger than those described for the frost bulb created around the buried chilled pipeline. The extent of this impact, if any, cannot be evaluated until data on the precise location and excavation depths of borrow sites are available. A secondary impact from a new stream profile resulting from excavation downstream from pipeline crossings could be to increase the scour depth and the possibility of pipeline failure through undercutting of the streambed. This would be most critical at the potential crossings of the Kadleroshilik, Sadlerochit, Jago, Aichilik, and Kongakut Rivers where the gradient ranges from 31 to 41 feet per mile.

In summary, the impact of the chilled gas pipeline buried in river and streambeds may have significant adverse impacts on water distribution and erosion of the bed and banks. Excavation of borrow from the flood plain will cause local environmental impacts and may threaten pipeline integrity. Brooks et al. (1971) concluded that rivers and larger streams usually are the only sources of thawed gravel.

Impact on Surface Drainage Other Than Rivers and Streams

Construction and operation of the proposed AAGPC pipeline project will provide countless opportunities for cross drainages to be diverted parallel to the pipeline. Principal project features affecting surface drainage patterns include the pipeline ditch, ditch mound, frost bulb around the chilled pipeline, snow/ice roads, and snow/ice work pad.

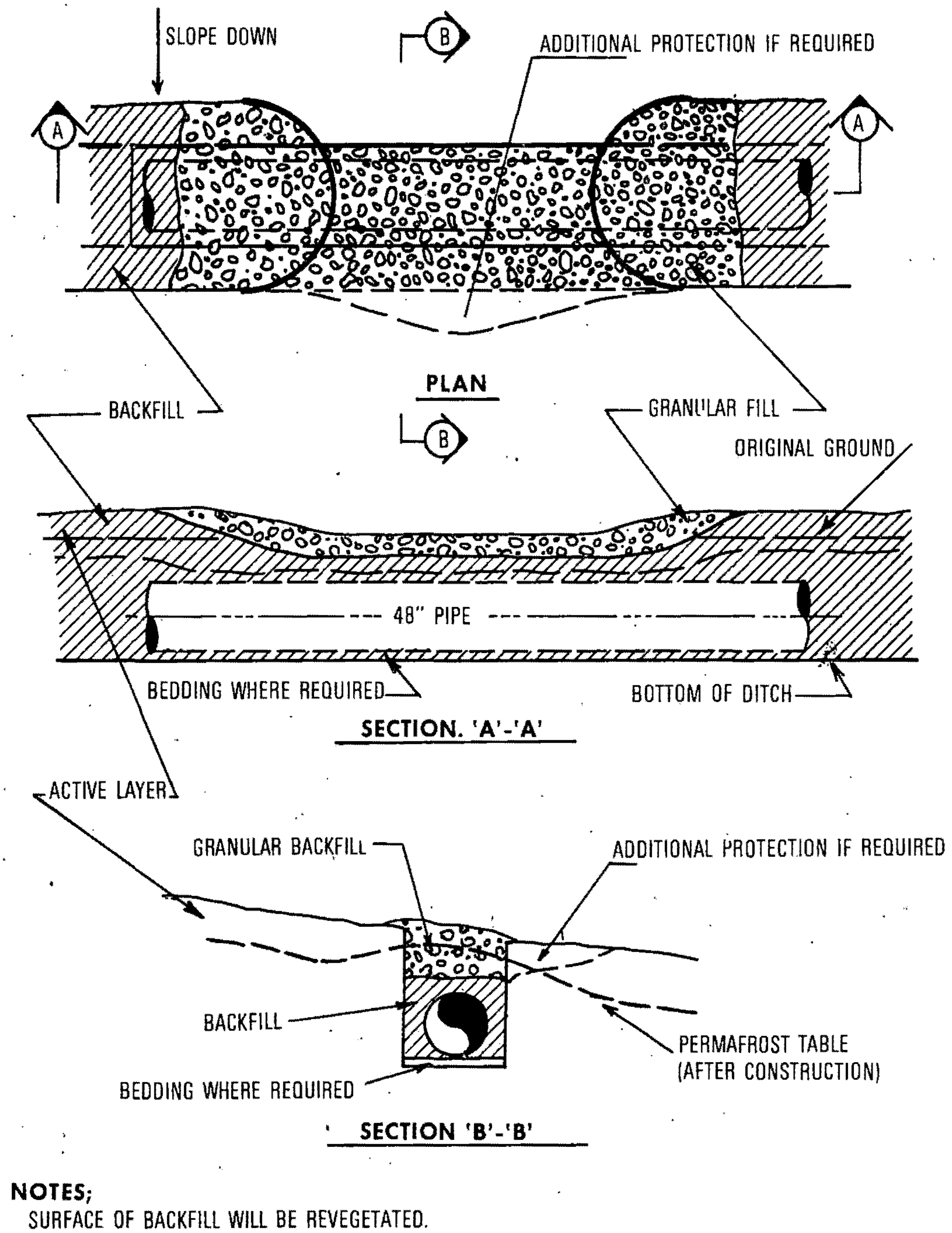
Surface waters will be ponded or interrupted by the ditch and its berm. Surface waters will tend to concentrate on the upslope side of the buried pipeline. The Applicant proposes to construct and maintain breaks in the ditch mound with selected borrow materials to permit surface water drainage (Figure 3.1.1.5-6). The frost bulb resulting from the operation of the chilled buried pipeline may cause icings to develop in these breaks or snow drifts may reduce surface drainage across the ditch as berm height is approximately equal to the height of drift fences proposed to bank snow for road and pad construction.

The impact of the proposed 195-mile (313.8 km) AAGPC pipeline, ditch, mound, and frost bulb on diversion of small drainage systems would not become evident until several years after construction. The effects of diversion and capture of surface drainage would be to concentrate undefined drainages into small streams and potentially small streams into larger streams. Alteration in the surface drainage will create new areas of wet and dry condition. Secondary impacts of concentrating or redirecting surface drainage would result in increased local water quantities and velocities. These concentrated drainages will cause both thermal and surface erosion. The changes would tend to be irreversible and are not quantifiable at this time.

Detailed information indicating the location of ditch mound breaks and the specific type of construction cannot be determined until final engineering criteria and designs have been developed by the Applicant. Final location of mound breaks will be made in the field during and after backfilling the ditch. The Applicant also states that the height of the ditch mound will not stabilize for a period of several years after the pipeline system is operational.

Construction of the proposed AAPGC pipeline system is planned to be accomplished with the aid of snow/ice roads along the entire right-of-way. Access to and from borrow sites to the right-of-way and construction areas will also be by snow/ice roads. Excess spoil from the ditch excavation will be placed upon packed snow. Snow/ice roads will be used to transport equipment and supplies from the proposed Camden and Demarcation port sites to the right-of-way. These snow/ice roads will be approximately 15 and 7 miles (24 and 11.3 km) long, respectively. Both will be reconstructed and used during at least two winter seasons. These two snow/ice roads will also probably be rebuilt and used when the four compressor stations are constructed in Alaska (2 to 5 years after initial operation of the pipeline system).

Snow/ice roads will melt more slowly than adjacent areas, temporarily blocking surface drainage during the construction phases of the proposed AAGPC pipeline project. Snow/ice roads in some instances will be on the upslope side of the pipeline ditch; in others, on the downslope side. Placement of snow/ice roads will be determined by the direction of movement of pipelaying equipment, with construction spreads working in both directions along the right-of-way from construction camps. The impact of a snow/ice road on the upslope side of the ditch impounding, concentrating, and redirecting surface drainage away from the newly excavated ditch will be beneficial to pipeline safety because the possibility of thaw consolidation



Source: AAGPC DRAINAGE AND EROSION CONTROL BACKFILL MOUND BREAK

Figure 3.1.1.5-6 Drainage and erosion control by breaks in backfill ditch mound would be reduced. The impact of downslope snow/ice roads could be significant and adverse to pipeline safety since surface water would tend to be directed to the ditch prior to the formation of frost bulb. Water in the newly excavated ditch would cause thaw consolidation and loss of shear strength, and would increase the possibility for differential settlement of the buried pipeline.

Construction and use of snow/ice roads from the Camden and Demarcation Bay port areas to the proposed pipeline right-of-way will cause compaction of the tundra vegetation mat and underlying soil. The extent of compaction is unknown but generally should be modest to slight. The degrees of compaction will depend upon type of construction equipment, period of use, and types of vegetation and soil. Since these two connecting snow/ice roads will be used at least 3 years, the extent of compaction will also depend on whether the same location is used each time. Compaction of the surface will provide depressions where surface water will start to flow. Increased flow will enhance erosion and could result in the formation of new drainage patterns. Battelle (1973) noted that present methods for constructing snow and ice roads may not apply to conditions over rough terrain (polygons) or where snow cover is shallow as it is over much of the Arctic Coastal Plain. Studies at Prudhoe Bay Test Facility showed that vehicular movements on snow roads produced a visible impact on the tundra surface which lasts for more than one summer. The impact of snow/ice roads between port sites and the right-of-way is unknown, but could be severe.

The Applicant proposes to obtain snow for construction of snow/ice roads with the aid of snow fences. The number and location of snow fences have not been identified; however, repeated use of equipment used to collect snow for transportation to the snow/ice road site will cause compaction of the surface vegetation mat and underlying soil. The extent of compaction, if any, would be a function of the type of vehicles used to mine and transport the snow, type of vegetation, type of soil, and periods of use. The impact of snow mining on surface drainage is expected to be similar to that of snow/ice roads.

Construction of airfields, future compressor station sites, port sites, and repeater communication sites is considered likely to have local impacts on surface drainage patterns, because of their relatively small size. Although exact sites for these facilities are not known at this time, it appears that any impacts would be slight since site locations avoid major rivers or streams.

In summary, the 195-mile (313.8-km) long pipeline, ditch, mound, frost bulb, ice roads, and spoil piles will affect surface drainage patterns. Impacts associated with the pipeline, ditch, frost bulb, and mound will be long term and will result in wet conditions on upslope sides and dry conditions on downslope sides. Impacts from ice roads will be temporary, but can pose serious threat to pipeline safety whenever surface drainage is concentrated at the newly excavated ditch. Compaction, resulting from use of snow/ice roads for several winters from Camden and Demarcation Bay port sites to the right-of-way, may produce serious long-term shifts of surface drainage patterns. Airfield, future compressor station, port, repeater communication sites are considered to have no significant impact on surface drainage patterns.

Impact of Water Availability on the Proposed AAGPC Pipeline System

The Applicant has indicated a general need for as much as 168.9 million gallons of water during the single winter construction season when the pipeline is placed in the ground. The Applicant has not conducted specific studies on where this amount of water would be obtained. No water is available after December except at springs or at the few large lakes which do not freeze completely to the bottom. Except for the first 40 to 50 miles of the proposed route, there is not an abundance of lakes associated with construction areas.

In the segment used by the Applicant to indicate water needs (M.P. 65 to 130, Table 3.1.1.5-1) there are no large lakes except at the beginning and end of the 65-mile segment. Since the water requirements are for approximately one-third of the proposed AAGPC pipeline system, the 56.3 million gallons have been increased by threefold as an estimate of the total water requirements of 168.9 million gallons of water for the major construction period of November through April.

As winter progresses, available unfrozen water tends to have increasing amounts of minerals and salts due to the freezing of water. By late winter, unfrozen water supplies may have excess amounts of salts. Similarly, ground water within or beneath permafrost has concentrated amounts of dissolved solids.

Each of the four compressor stations will have emergency living facilities to accommodate 30 people. Except for serving as emergency shelter on an as-needed basis, the quarters will serve day to day maintenance people and the infrequently visiting compressor overhaul crews. The Applicant has no plans for compressor stations in Alaska until a later time. But in Canada a 48,000-gallon water storage tank, housed in a heated building, is planned at each living quarters site.

In Canada, water requirements for these personnel at compressor stations will total 57,600 gallons per year. This will necessitate replenishing the water in the storage tank approximately every eight months (Northern Engineering Services Ltd., 1973).

Future compressor stations are to be located in areas where there will be difficult water supply problems in late winter. It is probable that surface water will not be available at these sites between November and April and little if any possibility of an unfrozen supply of ground water. Previous studies indicate the energy cost to obtain water by melting snow or ice is extremely high and probably prohibitive.

3.1.1.6 Vegetation

Floristic studies have dominated the large volume of literature concerning arctic plants, and it is only within the last 10 years that studies have begun to contribute much insight into detailed characteristics of tundra vegetation. No local work has been done on aquatic plant communities.

Impact of the Proposed Construction Activities on Tundra Vegetation

The severest direct impact of the construction of permanent roads, airfields, compressor stations, communications sites, wharves, borrow pits, and other structures will be a permanent loss of those areas and the plants uprooted, cut off, or buried on the 900 acres affected. Since virtually all of these acres will be overlaid with gravel embankment and in use during the operation phases of the proposed project, there will be little chance of restoring plant production on them. The loss is, therefore, irreversible.

The loss of net annual primary production from those acres, while locally significant, will be insignificant in relation to that available along the Arctic Slope.

Excavation of the proposed pipeline ditch will destroy plants and the insulating mat of living and dead vegetative material along 195 miles of pipeline route from Prudhoe Bay east to Canada. The ditch will transect an undetermined number of plant communities and result in the loss of individual mosses, lichens, sedges, grasses, herbs, and shrubs from at least the 640 acres excavated, and probably cause a loss of much of the plant cover on the 2,850 acres of adjacent work pad area where plants will be broken and mashed by machinery or covered by excavated dirt.

Ditching and backfilling will leave the pipeline mound devoid of living plant cover. Removal of the insulating plant cover and exposure of bare soil along the pipeline route will induce local changes in the microclimate and initiate a series of impacts on the soil leading to various forms of soil instability and erosion discussed in Sections 3.1.1.3 Geology, 3.1.1.4 Soils, and 3.1.1.5 Water Resources and Figure 3.1.1.6-1. Stabilization of bare soil surfaces will be necessary to prevent a further loss of vegetation on unstable sites, and in some cases mechanical stabilization measures (or structures) may be required before revegetation of the disturbed sites can be affected.

Restoration of a plant cover to all disturbed areas is important for one or more of the following reasons: 1) control soil erosion; 2) restore natural thermal energy budget of soils and prevent permafrost degradation; 3) diminish the esthetic impact of a 195-mile long scar; and/or 4) restore a measure of primary production to the perturbed tundra ecosystem.

The Applicant proposes to initially revegetate the pipeline berm by applying a mixture of grass seeds in the spring following winter construction. These efforts are likely to result in differential success at various locations along the route due to variations in gross site characteristics and microsite differences between the top and the side slopes of the mound.

The seeding and growing of grasses on disturbed sites in the arctic region of North America is now in an experimental stage with very little experience available to predict proper methods or their likelihood of success (see 4.1.1.6). Evidence to date indicates, however, that certain exotic varieties of grasses can be expected to germinate and grow more successfully than the native grasses tested, at least during the first 2 or 3 years. The native grasses will gradually dominate the site as the percent of plant cover increases, but plant succession proceeds very slowly in the Arctic and it may be 50 years or more before the vegetation on the pipeline mound resembles that in the adjacent undisturbed communities. Therefore, the pipeline will be a discordant element in the tundra vegetation for many years and will show up as a long, straight line with a color and texture different from the surrounding landscape (Section 3.1.1.13, Esthetic Resources).

Applications of grass seed and fertilizer at various spots along the pipeline will probably be necessary each year as the backfilled ditch slumps, settles, consolidates, erodes, and eventually stabilizes. This process of maintenance seeding will interject aircraft and human activity along the route each spring at the time when migrating waterfowl and caribou may be returning to their nesting and calving grounds (section 3.1.1.7, Wildlife).

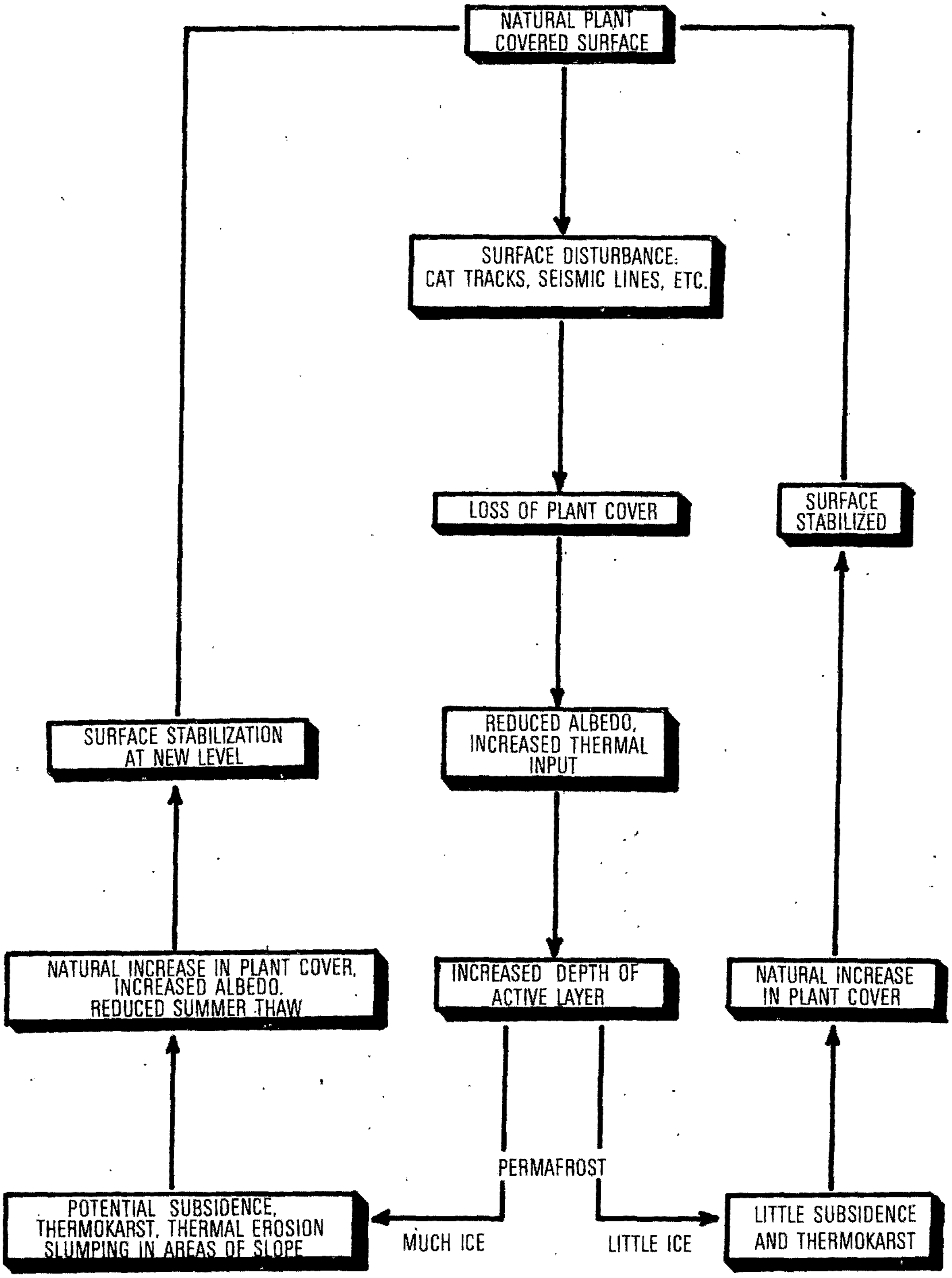


Figure 3.1.1.6-1 Schematic diagram of plant community response to disturbance in permafrost areas with ice content

As part of the transportation system necessary for the movement of pipe and heavy material, the Applicant proposes to build some 250 miles of temporary snow and ice roads which will receive heavy use during the winter and some lesser mileage of temporary winter trails which will be used for only one or two round trips each. Some 300 acres will be occupied by these roads, but snow will be gathered from many hundreds of additional acres to build up the snow and ice road surface.

Surface vehicle travel during the winter causes much less disturbance of the tundra soils and vegetation than at other times of the year. But even in the winter, varying amounts of damage will occur. The extent of damage will depend on the depth of snow cover, microrelief of the site, vegetation type involved, amount of soil moisture, and depth of organic layer. When the interactions of these variables are added to those of vehicle ground pressure and number of trips, it is evident that selection of road route will be important in determining the ultimate effects on vegetation.

Snow collection activities will uproot or break off many plants, especially where the snow cover is shallow and where the microrelief consists of tussocks or hummocks. Snow collection and general construction clearing within river flood plains may result in damage or destruction of riparian willow shrubs. Willows sprout readily, so such damage will have little long-term effect on the riparian communities, but a short-term loss of such shrubs could have a severe local adverse impact on moose confined to those river valleys during the winter (See 3.1.1.7, Wildlife).

Some 47,000 tons of fuels and lubricants will be used by the many vehicles engaged in pipeline construction. It is very probable that some of this petroleum will be spilled at both fixed installations and along the pipeline route. Such accidental spills constitute a potential local adverse impact which not only would kill the plants in contact with the spill, but could also contaminate the soil and result in a long-term change in the plant community on that site.

Methanol (methyl alcohol), which will be used as an antifreeze in gas pipeline testing and as a dehydrating agent, may be spilled during hydrostatic testing of the installed line. While the effects of dilute solutions of methanol have been tested on very few of the plant species, preliminary studies in Canada at the Inuvik Test Area (Northwest Territories) have shown that a diluted water and methanol solution during winter does not detectably affect shrub-tundra vegetation.

It is not known whether the tests at Inuvik are applicable to any or all of the Alaskan Arctic Slope traversed by the proposed AAGPC pipeline system since the vegetation and soil conditions at the test site are considerably different from those in Alaska. The effects of full-strength methanol being spilled are not known.

There is a possibility that during construction the pipeline may remain inactive (not refrigerated) for 1 or more years. If this were to take place, there would be mound subsidence, channeling along the berm, excessive berm erosion with siltation and burying of vegetation, and an increase in the active layer with a resultant disturbed area triple that of the original trench width (see 3.1.1.2 and 3.1.1.3).

The major vegetative impacts would involve an increased difficulty and delay of establishing a vegetative cover. In essence, these impacts are an increase in area and extent of vegetative impacts previously discussed. The mechanisms and cause and effect of the impacts are also the same.

Impact of the Proposed Pipeline Operation on Tundra Vegetation

The pipeline and ditch will be constructed during the winter when the tundra is frozen and plants are dormant, but the structures built during the winter will remain to modify the physical environment at other seasons of the year. It is these long-term effects of the pipeline presence (and operation) which will have indirect but long-term effects on the vegetation of the Arctic Slope. Site changes will include changes in soil moisture, surface drainage, soil temperature, nutrient availabilty, microrelief, and the depth of the active thaw layer.

The proposed pipeline will cross 120 active streams and numerous small intermittent streams and unmarked surface drainages and, therefore, will change the normal pattern of drainage along the 195-mile route in Alaska. The chilled buried pipeline and the backfill mound or depression over it will, at various places, impound, impede, and divert the normal flow of surface and subsurface water despite the use of granular fills and cross drains (ditch crossings) to allow its passage (3.1.1.5, Water Resources).

Where water is impounded, vegetation will be drowned and eventually the present plant communities will be replaced by pond, marsh, and wetland communities to the south of the pipeline.

Wetland communities downslope which are deprived of their normal water supply will be replaced gradually as the plant species better adapted to drier sites become established. The downslope changes may be slower than the upslope changes, but the ultimate results will be the same--i.e., replacement of the present natural vegetation by a new mosaic of communities.

Lower soil moisture in the pipeline berm and changes in microrelief will create another set of conditions alien to the present plant communities and will probably result in new sets of communities growing along the north slope, crest, and south slope of the pipeline mound. These various changes in plant species occurrence and community juxtaposition will radically modify the landscape through which the pipe passes and make its location easily visible to the knowledgeable observer. These changes in habitat may cause further secondary impacts on the invertebrate, mammal, and bird species dependent on the present plant communities.

There may be some potential impacts from spills of petroleum products and other chemicals during operation of the pipeline, but their effects should be local and insignificant with respect to both terrestrial and aquatic vegetation. Fertilizers applied as an aid in revegetating disturbed terrestrial areas, however, may become pollutants if introduced in sufficent quantities into watercourses.

Lichens are very sensitive to sulfur dioxide and suffer reduced growth or death in its presence. Throughout the world, large areas around industrial plants that emit high concentrations of sulfur dioxide have become denuded of lichens (Klein, 1971). The *Cladonia* group of fruticose lichens is one of the most abundant in many of the plant communities along the proposed route and is considered to be one of the most sensitive. Long exposures to 0.05 ppm sulfur dioxide are considered damaging to *Cladonia* (Schofield and Hamilton, 1970), and exposures to concentrations of 0.03 ppm, between 0.03 and 0.006 ppm, and below 0.002 ppm of sulfur dioxide caused acute, chronic, and no injury respectively to epiphytic lichens and mosses (LeBlanc and Rao, 1973).

According to data from the Applicant, the gas exhaust of turbine engines at proposed compressor stations would consist of about 220 ppm nitrogen oxides, 1 ppm sulfur oxides (Applicant estimates ground level concentration of SO_2 will be less than 0.0008 ppm), 10 ppm carbon monoxide, 5 ppm unburned hydrocarbons, and 7,200 gal/hr of water vapor. Sulfur dioxide emissions in sufficient concentration on the ground can kill lichens and the area affected would depend on the local meteorological conditions. Loss of these lichens, a winter food of caribou, may have an adverse impact on the caribou which winter on the Arctic Coastal Plain. Modification of plant communities through loss of Cladonia, and possibly other plant species, will negate the value of those communities as research natural areas or ecological reserves.

The huge volume of hot water vapor emitted from each compressor station may influence growth rates and species composition of plant communities within the vicinity of the station. The exact effects are unknown, but would probably be of little consequence to the regional vegetation.

Impact of the Proposed Pipeline Maintenance and Emergency Repair on Tundra Vegetation

Emergencies will require pipeline repairs during the summer when the ground is not completely frozen. It is during the period when the root zone is thawed that all plant communities are most susceptible to disturbance, and repair and maintenance activities at that time have the greatest potential for adverse impacts on tundra vegetation.

The Applicant proposes to stockpile pipe, repair equipment, and other materials at the compressor station sites, which will be about 50 miles apart along the pipeline. In an emergency some of the equipment can be flown to the break by helicopter, but heavy equipment will have to be moved over land by low ground-pressure and air-cushion vehicles. Since no permanent roads will be available, this travel will be cross-country along the pipeline right-of-way. Since a station can supply the needed equipment, about 25 miles of terrain must be crossed.

Overland summer travel across all wet communities (wet sedge meadows, bogs, etc.) will kill plants and disturb the peat layer. Wet meadows, which can support vehicle traffic in winter much better than can the upland low shrub-heath type, are susceptible to damage by even one pass of a light, tracked vehicle in summer. Repeated passes churn the peat and expose the mineral soil with a resultant increase of 80 to 100 percent in thaw depth.

Cottongrass tussock vegetation is better able to withstand a few passes of low ground-pressure vehicles but repeated travel will scuff off the tops of hummocks, exposing mineral soil and increasing the depth of the active thaw layer. Recovery of cottongrass tussock communities depends on the severity of disturbance, and exposure of mineral soil leads to colonization by many of the same species which establish themselves in low shrub-heath communities. This change in vegetation would be noticeable for many years until site conditions again permit communities similar to those in the adjacent undisturbed vegetation.

Low shrub-heath vegetation is less severely damaged by summer vehicle traffic but, as with other vegetation types, the degree of disturbance depends on vehicle weight (and ground pressure), track design, soil moisture, proximity of frost to ground surface, and the number of vehicle passes across the surface. See Table 3.1.1.6-1 for a summary of impacts caused by cross-country travel by all-terrain vehicles in summer and winter.

Impact on Unique or Threatened Plants and Communities

The National Herbarium of the Smithsonian Institution has compiled a list of endangered plant species which includes 35 species found in Alaska. Only one of these, Thlaspi arcticum, a member of the mustard family, occurs on the Arctic Slope and Hulten (1968) lists it as being very rare with only single specimens collected.

Construction of the proposed pipeline system through the restricted range of this endangered species could modify or destroy its habitat and thus lead to its extinction.

A dwarf willow species, Salix reptans, which was previously known only as a native of Eurasia, was collected by the Applicant's consultants while sampling vegetation about 3 miles (5 km) from the proposed pipeline route (Hettinger et al., 1973). These field crews also described two botanically unique stands on the fossil flood plains of the Canning and Sagavanirktok Rivers about 0.6 mile (1 km) from the pipeline route. Impacts of the proposed pipeline system on this dwarf willow and the two plant communities would be negligible if the system were constructed precisely on the proposed alinement. However, if the alinement were to be shifted and thus destroy these unique stands, science would lose the opportunity to study the lost communities and be poorer because of the loss.

The dwarf willow or unusual plant communities on the Canning and Sagavanirktok Rivers have not been specifically suggested for inclusion in ecological reserves or research natural areas, but several such reserves (Viereck and Zasada, 1972) have been proposed within the area to be affected by the AAGPC pipeline and others have been proposed as Natural Landmarks (Section 2.1.1.12, Unique Areas). The proposed natural gas pipeline system intersects the only remaining largely undisturbed continuum of arctic ecosystems and vegetation types from the Arctic Ocean to the interior of Alaska.

Impact of Abandonment of the Proposed AAGPC Pipeline on the Tundra Vegetation

The Applicant believes that additional supplies of natural gas will continue to be found and moved to market through the proposed AAGPC system. This process of continuing discovery, development, and depletion of new gas reservoirs may span a period of 50 years or more (AAGPC, 1974c).

The methods chosen after that time for salvage or abandonment of the steel pipe will impose a new series of impacts on the Arctic Slope environment. This will lead to changes in ground water drainage, soil moisture, and soil temperature with shifts in plant community species composition as significant as those resulting from the initial construction. A wider ditch than that of initial construction will be required to free the pipe from the permafrost. With the pipe removed, there may not be enough excavated material left to backfill the ditch, and millions of cubic yards of borrow material would be required to level the resulting trench. Exposure of the new excavation without a chilled pipeline to maintain low soil temperatures would result in a period of soil instability, thaw consolidation, and erosion. This would require a concurrent revegetation program to heal the wounds opened by the new excavation and to establish new plant communities different from those found on the operating pipeline berm.

Table 3.1.1.6-1 Impacts on various types of tundra vegetation anticipated from summer and winter use of low ground-pressure-vehicles (track and air-bag vehicles)

Characteristic Microsites (Arranged in order along the typical moisture gradient from dry to wet)	Characteristic Species (Modified from Brown, et al., 1974)	Summer Impact (Assume maximum thaw) (Modified from Burt 1970)*	Winter Impact (Assume middle of winter)
A. Dry, good surface drainage, relatively early and deep thaw, little or no snow cover in winter.			
Tops of high-centered polygons, small ridges and high creek bluffs.	1--Dryas integrifolia and crust lichens. Several other cushion dicotyledons and frutcose lichens.	In steep areas tracks and/or air-bags may lose traction, slip and cut or break vegetation. Loss of traction or turning may also cause gouging or rearrangement of soil surface. Passage of vehicle may cause compaction of soil, local dewatering and result in track depressions susceptible to subsequent erosion during snow melt or rain run-off. If vegetation or soil disruption is extensive, a change in albedo may occur and allow deeper thaw. Decomposition of standing dead may be accelerated by flattening vegetation and bringing it in contact with soil microbes. Soft sediments in center of frost boils may be displaced and cover vegetation around the rim of the boil. Bird nests and young may be destroyed and fox dens disturbed or collapsed.	Where little or no snow cover exists tracks may cut tops of vegetation and may cut divots from the frozen vegetation. Low pressure air-bags may crush frozen vegetation or break it, particularly the more brittle erect growing species.
Pingos	10--Diverse vegetation with Dryas integrifolia, Oxytropis nigrescens and Carex rupestris. Several lichens and mosses.		
Dry polygon rims, and well-drained areas.	2--Dryas integrifolia and Cetraria spp. Several other frutcose lichens and sedges. Few or no crustose lichens.		
Frost boils	8--Saxifraga oppositifolia and Salix reticulata often with Juncus Biglumis and several lichens.		
B. Moist, saturated conditions early in season, relief allows surface drainage of water from snow and ground ice melt.			
Slumping river bluffs, areas of erosion and/or solifluction.	11--Diverse vegetation with Salix rotundifolia, Chrysanthemum integrifolium and Oxyria digyna.	The least serious impacts will probably be associated with travel on moist tundra. Some ground compaction will occur. Flattening of vegetation will help to accelerate decomposition of standing dead. Tracks may cut vegetation or lift parts of vegetative mat. Polygon rims may be compacted or breached causing changes in drainage patterns. Traffic across river banks may seriously affect vegetation mat, cause mechanical erosion and lead to permafrost degradation. New drainage patterns may develop on river banks. Bird nests and young may be disturbed or destroyed along with small rodents.	Providing a reasonable snow cover exists no direct impacts are anticipated. Compaction of the snow will delay spring melt and cause a lag in active layer thaw and spring growth. This will probably not be serious if the same routes are not used repeatedly winter after winter. Thin snow cover or development of depth hoar may allow tracked and air-bag vehicles to break or cut vegetation during ice crystal repacking. Compacted snow along the track may interfere with lemming movements under the snow and surface drainage during spring break up.
Snowbanks.	9--Cassiope tetragona and Salix rotundifolia.		
Polygon rims and flat areas that are not continually wet.	3--Carex aquatilis and/or Eriophorum augustifollum and Dryas integrifolia Several other sedges and dwarf willows Very few or no lichens.		As with moist tundra above.

Table 3.1.1.6-1 Continued

C. Wet, areas subject to excess water during most of snow-free season, poor drainage due to absence of relief.			
Stream and lake banks.	13--Salix lanata and Carex aquatilis. Shrubby willows with a Type 12. understory.	Saturated soils particularly susceptible to compaction. Passage of both track and air-bag vehicles flatten vegetation and expose standing dead to increased rates of decomposition. Flattening of leaves and possible reorientation of rooting mechanisms may lead to permanent submergence and eventual decomposition. Compaction causes water ponding in long troughs created by vehicle track. This and change in albedo due to flattening of vegetation may be sufficient, with time, to begin development of extended thaw lake. Tracked vehicle disturb substrate and churn soil (depending on vehicle speed). Squeezing occurs in front of the air-bag and suction behind it. Moss and plant litter displaced and deposited at sides of vehicle path by hydraulic action. Considerable albedo change may be associated with displaced moss. Compaction may lead to changes in surface drainage and subsequent changes in terrain as a function of permafrost degradation or aggradation.	
Centers of many low-centered polygons, troughs and poorly drained areas, such as pond margins.	4--Carex aquatilis and/or Eriophorum angustifolium and Drepanocladus spp., usually with Pedicularis sudetica. No lichens.		
Stream banks.	12--Carex aquatilis and Dupontia fischeri with Saxifraga hirculus and other dicotyledons.		
Very wet areas where there is shallow standing water throughout the summer. Wet polygon troughs and pond margins.	5--Carex aquatilis and Scorpidium scorpiodes. No lichens.		
D. Emergent, Standing water			
Standing water of moderate depth (30-100 cm), Lake margins or thermokarst pits.	6--Carex Aquatilis and/or Arctophila fulva. No mosses or lichens.	Summer travel will create considerable bottom disruption. Plants uprooted and stems broken. Wave generated by vehicle may disrupt plants adjacent to path of vehicle.	No major winter impact anticipated. Water frozen to bottom. During early winter and late spring travel over ice which is not frozen to bottom may cause ice movement and breaking of plants and disruption of bottom sediments.

* Summer travel on the tundra with low ground-pressure vehicles, G. R. Burt, 1971, Institute of Arctic Environmental Engineering, University of Alaska.

Source of Table - from Namtvedt et al. 1974

Impact on Wildfire

Recent fire history cannot be used to indicate the probability of when fires will occur because the area has had neither natural nor man-caused fire problems. A 4,000-acre lightning-caused fire did occur in terrain and conditions similar to those encountered along the proposed pipeline.

The introduction of people and equipment into the project area will increase the potential for wildfire resulting from activities related to the construction, operation, maintenance, and repair. Vegetation zones crossed by the proposed pipeline route are subject to wildfire; however, each differs in its ability to sustain fire (Table 3.1.1.6-2).

The potential for man-caused fires is highest during the months of July and August and also increases as activities move from the wet coastal tundra to moist tundra and the high brush zones.

It is likely that the number of fires will increase due to the project, but due to the low rate of spread and the availability of a local work force for suppression, the total impact will be light and localized.

3.1.1.7 Wildlife

Impact on Wildlife

The proposed AAGPC pipeline system would have a variety of impacts on wildlife found north of the Brooks Range in Alaska. Primary impacts of pipeline construction and operation are the immediate effects of the operation of aircraft, heavy equipment, earth moving, and structure placement which destroy habitat and kill animals or affect their behavior. Secondary and tertiary impacts on wildlife are those resulting from primary impacts on other resources or increased human activity in the area.

Either primary or secondary impacts of construction and operation may have direct or indirect effects on a particular animal. Direct effects are those acting directly on individual animals and can result in immediate death or change in behavior. Indirect effects are those which modify the habitat or change a food source in such a way that population dynamics may be altered.

Mammals

Arctic animals are particularly vulnerable to human disturbance because of their high visibility in the short tundra vegetation. Many wildlife species found in the Arctic are unique to that region and provide a focus of interest for the newcomer to the North. This curiosity value results in considerable harassment and disturbance by persons who have the freedom of movement provided by aircraft and overland vehicles. Species such as the grizzly and polar bears, wolf, and musk ox are most detrimentally affected by aircraft harassment because their uniqueness and low density increase the likelihood that individual animals will be repeatedly hazed by persons attempting to photograph and observe them closely.

Caribou

The proposed pipeline will cross the spring calving range of the Porcupine Caribou Herd and have both direct and indirect effects on the caribou population and its habitat. The Porcupine Caribou Herd is an

Table 3.1.1.6-2 Effects of fire on various vegetation types occurring along the proposed AAGPC pipeline system

Vegetative type	Percent by type	Rate of spread	Resistance to control
Wet Tundra	20	Low	Low
Moist Tundra	65	Medium	Medium
High Brush	15	Low	High

international resource shared with Canada and an important source of food and hides for people living in rural Alaska and Canada.

The primary impacts of pipeline construction and operation will be the reduction of caribou habitat by the 3,600 acres to be occupied by permanent roads, airfields, compressor stations, communications sites, borrow pits, and other structures and the impact of these facilities on caribou behavior. The actual loss of forage plants can be considered minor in relation to the range now available, but the presence of roads, structures, vehicles, compressor noise, and people would make a much larger, unknown area unattractive and unavailable to caribou. Spilled fuel and other pollutants would have severe site-specific effects on caribou forage plants, and sulfur dioxide exhaust emissions from compressor stations and campsites would have local detrimental effects on lichens utilized by caribou.

Emergency summer pipeline repair and maintenance activities would increase the amount of caribou range disturbed and/or destroyed. The impacts of summer repair and maintenance on caribou will be major if disturbances occur where the caribou are calving or if caribou are shifted from their traditional calving range (Figure 2.1.1.7-2).

The most detrimental impacts of the proposed AAGPC pipeline will be those affecting caribou behavior and population dynamics rather than habitat.

Winter construction activities would have little direct effect on individual caribou since few caribou remain in the area during the winter, but the structures built during the winter will remain to influence animal behavior at other times of the year and, indirectly, the Porcupine Herd population.

Unless their placement and removal are synchronized with caribou movements, snow fences proposed to collect snow for temporary roads would become temporary barriers to seasonal caribou movement north to the calving grounds in May and/or south toward the mountains in September during the 2 or 3 years snow fences would be used. The pipeline berm, road, and airfield embankments would remain as permanent features of the landscape and potential threats to free movement of caribou, musk oxen, and moose.

The pipeline trench could become a death trap to animals falling into the open trench during winter construction or becoming mired in swampy sections resulting from ditch failure and subsidence in the summer. The first possibility is remote and will have negligible impact on the caribou population. The second possibility is more likely to happen because in summer adult caribou and newborn calves are more abundant in areas near the pipeline and their frequency of contact with the pipeline will be much higher. Scientists from Battelle (1973 b, Vol. IV, p. 90) at the Prudhoe Bay test site observed that caribou generally avoided pools of water and slumping in a partially filled ditch along its entire length. Such conditions could deflect caribou movement around sections of slumped ditch as the animals travel to and from the calving grounds.

One hundred sixty-two miles of the proposed AAGPC pipeline traverse the traditional calving grounds just south of Barter Island between the Canning and Kongakut Rivers, and the modified terrain within the pipeline construction zone may present barriers which could block access to a part of the calving area. The calving grounds of the Porcupine Herd are crossed by the proposed pipeline route and caribou would have to cross it twice each year on their journey to and from the traditional calving/post calving areas each spring and summer. The proposed pipeline crosses at least 160 miles of commonly used migration paths. They would also come in close contact with the port sites at Camden and Demarcation Bays and the access areas between the ports and the pipeline route.

Construction activities conducted between May and October will have greater direct effects on caribou than will the winter construction activities. The Applicant proposes to concentrate summer activities at the two wharf sites, initially, but the four future compressor stations will also be built during summer seasons. Gravel will be excavated and stockpiled during the summer and early winter. Human activities at those sites will disturb caribou in the vicinity and prevent their use of a zone several hundred yards wide around each installation.

Caribou calving and large post-calving aggregations occur in the vicinity of Camden Bay and will be affected by activities associated with construction and operation of the wharf and stockpile sites, permanent roads, airfield, and the shipping activities. This impact will continue through the construction and operation phases as long as each site is in use. Since the Camden Bay wharf site and three of the compressor station/airfield sites are within the traditional caribou calving ground, they will have a continuing detrimental effect on calving activity.

Increased access to a herd and increased human activity have historically had adverse impacts on caribou herds wherever they are found. There is no reason to expect the activities associated with the proposed AAGPC pipeline project will have any less impact. The caribou is essentially a wilderness animal that depends largely on climax vegetation for its food and requires very large undisturbed areas for its seasonal movements. It is also a herd animal adapted to constant movement during the year; such movements prevent overuse of the available forage and always bring the caribou back to a traditional calving area.

Disruptions of the normal movement and behavior patterns of the Porcupine Caribou Herd can cause the herd to abandon part, or all, of the traditional calving ground with possible catastrophic effects on the population and serious secondary impacts on the wolves and humans who depend on caribou for their subsistence. While the animals in a caribou herd may move great distances by slightly different routes each year, and the herd may winter in unpredictable locations within the traditional range, they invariably return to the same traditional calving grounds each spring. The Porcupine Herd may not be as successful in calving elsewhere and maintaining its present numbers if the calving area north of the proposed pipeline is abandoned. The long-term possibility that a major international resource could be lost as a result of gas pipeline and future oil and gas developmental activities cannot be ignored.

Population reduction would cause serious adverse secondary impacts on subsistence hunters and sport hunters, golden eagles, and wolves and other carnivores over the entire range of the Porcupine Herd. It would mean loss of a source of protein from the diets of subsistence hunters at Kaktovik, Arctic Village, and in Canada.

Even if they continue to use their traditional calving grounds, the caribou will be subjected to harassment and shooting because greater numbers of people will have easier access along the pipeline route.

Both fixed-wing and helicopter aircraft disturb caribou at all seasons. Caribou generally do not flee from aircraft flown above 500 feet, although they may still experience physiological fright reactions (Calef, 1974). The Applicant has indicated that aircraft overflights will be restricted to 2,000 feet in the critical areas. Aircraft disturbance would be experienced year-around and would be concentrated at the 6 airstrips and 14 helicopter landing pads. Disturbance during the summer by low-flying aircraft will affect a greater number of animals, but the harassment of the few caribou present in winter can have severe direct impacts on individual animals. In midwinter, when daily energy balance of a caribou is precarious, harassment by aircraft or snowmachines can cause the animal to expend more energy than it can acquire from the available forage, thus placing the animal in a negative energy balance. Repeated disturbance will lead to death of that individual animal.

In the summer, disturbance by aircraft will be most critical during the calving period of late May and early June. Harassment by low-flying aircraft at that time may interfere with the normal interaction of the cow and calf and cause the pair to move before the calf is dry or has nursed properly. In the extreme case, cows will abandon calves which then have little chance of survival.

In summary, it is expected that the operation and repair of the system can have serious impacts on the Porcupine Caribou Herd by shifting them away from a traditional calving area north of the pipeline route. This in turn could lead to long-term reduction of the herd size. It is possible that deflection of caribou caused by the proposed AAGPC pipeline will be large enough to reduce the number of caribou substantially below historic population levels (Table 2.1.1.7-1). Calef (1974) concluded that if controls on all aspects of the project are not enforced, the herd may decline as much as 90 percent in 5 to 10 years because of the combined effects of disturbance, physical barriers, habitat destruction, and direct mortality.

Winter construction activity would not have major impacts on most of the Porcupine Caribou Herd, since the herd is generally located elsewhere during the period for which construction is planned. The berm over the ditch could cause caribou to be deflected away from a traditional calving area.

Moose

During the winter the moose concentrate in willow thickets along the major streams, where they browse the buds and twigs of willow. Each borrow pit, road, pipeline, or other facility which crosses a stream or encroaches on the riparian willow thickets will reduce the amount of winter food available to moose. Studies by the Applicant have found that most available willow sources occur south of 69°45'N and moose are uncommon north of this line in winter. The proposed route generally runs north of this latitude. Some moose habitat will be lost as a result of the proposed pipeline but this loss is not expected to have a severe adverse impact on the moose population.

Winter construction activities may disturb moose and displace them from the river valleys. Winter range is a limiting factor to moose survival and this disturbance and displacement may adversely affect the individual's energy balance and result in death.

Arctic slope moose populations will be subject to increased harvest by those hunters who have gained familiarity with moose locations through association with the project.

Overall, the construction, operation, and repair of the proposed AAGPC pipeline system may have a significant impact on the moose population in the area. The number of moose will be reduced by an unknown amount.

Arctic Fox

Fox denning areas are known to occur along the proposed pipeline route but the number of these areas that would be affected are unknown. Low ridges, hills, and river banks and terraces with well-drained soils that may be favored for pipeline and road routing or for borrow sites have the easily excavated soils required by arctic foxes for their dens. Appropriation of such sites for construction purposes will reduce the sites available to foxes. In years of low lemming populations, this may have little effect, but during a lemming high, the reduced number of den sites available would prevent the fox population from increasing to the historic high levels. This lower abundance of arctic foxes would have a secondary impact on the Eskimo trapper who will find fewer foxes in his traps and thus, fewer dollars in his pockets.

Grizzly Bear

The grizzly bear, wherever found, is an indicator of a wilderness environment and is not tolerant of encroachment on its territory by human structures and activities.

The grizzly is a wanderer, traveling circuitous routes during the summer and sometimes returning to the same den in the fall. The dens are frequently located on steep slopes above rivers in soils that are well drained, have a deep active layer, and are easy to excavate. The choice of borrow pit sites can potentially diminish the grizzly bear habitat by reducing the diversity of den sites available. Studies by the Applicant indicate denning normally takes place south of the proposed AAGPC pipeline system.

Since grizzlies enter their dens in early October and do not emerge until May, they are out of sight and not exposed to human contact or harassment during the winter. The winter pipeline construction activities, therefore, should have little direct effect on these bears as long as denning sites are not disturbed.

Grizzly bears emerge from their dens in May and proceed to the river valleys in search of carrion, roots, and new green plants. At this time, while there is still snow on the ground, the bears are highly visible even at a distance and their tracks in the snow are distinctive. They are most vulnerable to airborne harassment and shooting at this time and can be run to near exhaustion and easily shot from the air or ground. A decline in the grizzly bear population is an inevitable consequence of pipeline operation and maintenance activities across their Arctic Slope range. This arises from the bears' reaction to human presence, human attitudes toward such powerful predators, and the value of the hide on the illicit market.

Even if the possession of firearms by construction workers is forbidden, hunting pressure is likely to increase because of other people coming to inspect, monitor, photograph, or publicize the project. People who would not normally go to the great expense of a special hunting trip may make use of such opportunities to take hunting holidays in the Arctic. Desirability of bagging a grizzly bear adds to this likelihood.

Bears, wolves, and wolverines are inclined to investigate foreign materials and often damage them by chewing and clawing. Plastics are particularly attractive to them. Bears also frequently damage wooden buildings and by clawing and biting can tear thin sheet metal, such as aluminum roofing and siding, to gain entrance to buildings. Because of these proclivities, bears could damage buildings at remote communications, block valve, and compressor station sites. This could require elimination of the offending animals and, if damage became extensive, would result in a significant reduction of the grizzly bear population along the pipeline route.

Improper disposal of garbage attracts carnivores which tend to become dependent on the artificial food source and to lose some of their fear of man. Grizzly bears, under such conditions, become a hazard to people living or working in the area. This probably will result in the removal of the offending animals. It is expensive and often not practical to capture the offending animals alive and transport them to remote areas; as a result, it is usually necessary to shoot them.

Grizzly bears will be subject to some harassment by aircraft. There are important habitats for these animals in the mountain river valleys of the Brooks Range and therefore if valleys like the Canning River become major air transportation corridors, harassment similar to that expected for Dall sheep will occur.

The overall impact on the barren ground grizzly bear will be a reduction of the population. The number of bears lost will be in direct relation to increased human activity.

Polar Bear

Polar bears inhabit the offshore pack ice; they come ashore to forage along beaches in spring and fall, with some bears wandering a dozen or more miles inland during the spring. Construction and operations activities at the Camden and Demarcation Bay wharves and airfield sites will have an impact on these bears at all seasons of the year for as long as those facilities are in use.

The coastal zone between the Colville River and the Canadian border from a line approximately 25 miles inland to the outer limit of shorefast ice supports a significant amount of denning use for the Beaufort Sea polar bear population. Tagging studies have shown that little interchange occurs between the Beaufort Sea area of Alaska and areas to the east or west. Polar bears within the Beaufort Sea area form a discrete population.

Pregnant polar bears require complete isolation in order to successfully bear young. Construction activities may prevent the bears from denning on land or disturb them enough to prevent successful reproduction.

Denning also occurs on drifting sea ice, and bears that might not come ashore to den because of pipeline disturbance would perhaps den on the drifting ice. Lentfer suggests that bears that den on the sea ice have a less successful reproduction history than those that den on land. Sea ice would provide a less stable platform than land, and denning success on drifting ice might be considerably less than on land. This might be especially true of bears denning on Beaufort Sea ice north of the proposed gas pipeline. Ice in this area drifts west toward Point Barrow, where currents cause it to become highly fractured (Lentfer, pers. comm., 1974). If the polar bears abandon the area due to pipeline activities, the loss would be highly significant in terms of its adverse impacts on the Beaufort Sea polar bear population.

Polar bears are also vulnerable to the effects of oil spilled into the narrow band of open water along the coast through which shipping must reach the proposed wharves at Camden and Demarcation Bays during the brief summer season. Oil spilled in the cold waters would not disperse readily and any

Musk Ox

Some 25 to 35 musk oxen reside in the project area year around in small herds adjacent to the Kavik, Jago, and Sadlerochit Rivers. In the winter they depend on range with thin, soft snow cover or windswept areas. Compaction by snowmachines or other modification of the snow cover by snow fences, road embankments, and pipeline berms may prevent musk oxen from feeding in local areas.

Musk oxen are extremely shy animals and will be disturbed by the presence of people and the noise of operating ground machinery and aircraft. Lent (1971) noted that musk ox groups on Nunivak Island fled, rather than forming their traditional defense formation, when approached on foot or by snowmobile. Their flight distances were roughly comparable to those of caribou under similar conditions. When aircraft approach, musk oxen may be seen fleeing when the plane is several miles away. When they stampede, musk oxen may abandon their young or trample them in panic, thus negating their reproduction efforts. Repeated airplane passes will drive the animals from their preferred habitats and could break up the small herds. Thus, continual airplane traffic associated with either construction or operation and maintenance activities will have adverse effects on the precarious status of this small, reintroduced musk ox population. People are naturally curious and will fly over to "see the musk ox" just once. With enough people taking one such look, in a few years there may be no musk oxen to see.

Dall Sheep

One radio repeater communication site is proposed for installation in the Sadlerochit Mountain foothills and will encroach on sheep winter range. The communication site will contain a radio antenna and a small building which will occupy an insignificant amount of the habitat, but the structures and noise from the enclosed generator will create a disturbance that will make an undetermined zone around the site unattractive and unusable to sheep.

The most serious and direct effect of pipeline construction and operation on this population of Dall sheep will come from aircraft flights to the communications site. Sheep are usually frightened by aircraft. The noise is probably the main reason (Price, 1972), but the presence of the airplane may also play a role. Such disturbances disrupt normal behavior patterns and generate increased physiological stress. The significance of disruption of behavior patterns on the well-being of Dall sheep has not been fully evaluated, but it is known that disturbance immediately following birth can result in a substantial decrease in survival of the newborn young (Pitzman, 1970; Klein, 1973). Geist (1971b) had calculated the impact of physiological stress resulting from sheep and caribou being run by helicopters or other aircraft. A single disturbance in which animals are chased for a 10-minute period results in an approximate 20 percent increase over the normal daily energy expenditure. If repeated hazing occurs, during a short time the net effect can be a significant increase in mortality in the harassed population.

The proposed AAGPC pipeline system could cause the Canning River to become a major air transportation corridor. There is a major population of Dall sheep in the Canning River Valley and accordingly, as a result of this project there may be increasing noise disturbance of that group of sheep that is now relatively isolated. The amount of disturbances would depend upon the frequency, type of aircraft, and flight elevation.

Wolf

Approximately 35 to 40 wolves are found in the area to be affected by the proposed construction, with the number fluctuating seasonally in relation to the presence or absence of caribou, the abundance of lemmings, and hunting/trapping pressures. Construction and operation of the proposed AAGPC pipeline would have adverse primary and secondary impacts on the wolf population and habitat.

The primary impact of construction activities on wolf habitats will be the loss of choice den sites found in those areas that may be chosen as upland borrow sites for road and airfield embankment materials. Wolf dens are usually enlarged former fox dens and are found on hillsides and terrace banks containing well-drained soils, a deep active layer, and soils suitable for digging. The same conditions are sought by road builders choosing borrow sites, and each pit excavated in such a location will reduce the range of den sites available to wolves, arctic foxes, and grizzly bears.

Because digging in permafrost soils is difficult, wolf dens may be used year after year. Any construction or pipeline operation activity within sight or hearing of these established dens would cause their residents to abandon the den and avoid the sites as long as the human presence remains.

The presence of large numbers of humans, particularly highly mobile humans, where few have ventured in the past, will have direct effects on populations of wilderness species such as wolves, grizzly bear, and wolverine. Wolves are vulnerable to hazing by airplanes and snowmobiles and increased hunting, and some individuals may be attracted to edible refuse and become campsite pests.

Wolves can learn to tolerate aircraft, if conditioned to them and not shot at, but where they have been harassed or hunted from aircraft they will run for cover at the first sound (Mech, 1970). In the open tundra of the Arctic Slope wolves can be herded by low-flying aircraft and chased to exhaustion by persons attempting to photograph or observe them closely. Such harassment may result in death of the wolf.

Increased access and increased human presence will intensify hunting pressure and also increase the likelihood of illegal killing of wolves by trophy seekers. Since wolves do not generally migrate out of the area, or hibernate during the winter, they are exposed to harassment and hunting all year and will probably suffer their greatest losses during the three winter seasons in which AAGPC proposes to build the pipeline and ancillary facilities.

In those remaining areas of North America where wolves live near humans, they are extremely shy and elusive; they shun areas of human activity. Where wolves are given some protection from persecution, however, they adapt to the presence of man and his structures. Some individuals learn to feed on edible kitchen refuse where they are not molested and may become nuisances. There are some "tame" wolves that now feed on handouts at some of the Alyeska oil pipeline construction campsites. Such animals constitute a human health and safety hazard since they are rarely actually tamed and may bite unwary persons. The possibility of rabies in any wolf or fox must not be overlooked, and wolves attracted to camps would have to be killed if suspected of being rabid.

marine mammals confined to this narrow strip of open water would be likely to come in contact with the oil. Even small amounts of oil may mat a bear's fur, reduce its insulation value, and lead to death in the arctic cold. An indirect effect of oil spills on polar bears would be the adverse effects on the highly productive plankton and invertebrate organisms which are the basis for the food chain upon which the fish, seals, and ultimately, the bear depend.

Because of the known polar bear activity in the Camden and Demarcation Bay area, construction of port sites as proposed by the Applicant at these two sites could cause a disruption of polar bear maternal denning and result in low reproduction in the Beaufort Sea area. Similar loss of polar bears may occur elsewhere, as maternal denning is known to occur as much as 25 miles inland.

The cumulative effect of disturbances including effects of future seismic activity, exploratory drilling, development drilling and transport of oil and gas along the proposed AAGPC route and adjacent areas would have a detrimental impact on the polar bear 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. 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 of leasing State owned submerged lands in the Beaufort Sea. If the gas pipeline were the only factor to affect the north coast environment it could be argued that effects on polar bears might not be too serious. However, combined impacts of the gas pipeline and other proposed activities will have most serious environmental effects including disturbance to denning polar bears and reduced productivity, and disturbance to the food chain supporting polar bears.

Other Marine Mammals

Any shipping along the Beaufort Sea Coast as proposed by the Applicant would pose threats of oil spillage. Such spills would not readily disperse, and marine mammals occurring in the narrow band of open water would be affected by the pollution of their environment (see Section 2.1.1.7, Wildlife). The shallow waters of this coast, particularly those protected from the sea ice by offshore islands and gravel bars, are highly productive of plankton and invertebrates which constitute the base of the food web upon which the marine mammals depend.

Pollution of the coastal waters with petroleum or other chemicals, therefore, can have both direct and indirect effects on the marine mammals of the Beaufort Sea.

Small Mammals

Construction of the proposed AAGPC pipeline will result in the loss of 3,600 acres of habitat and the deaths of large but unquantifiable numbers of small mammals with restricted home ranges. A reduction in numbers of shrews, voles, lemmings, and squirrels available as prey will then affect the livelihood of foxes, weasels, wolves, wolverine, grizzly bears, owls, and jaegers which may result in a downward adjustment in their populations.

The loss of habitat and population reduction have different implications for each of the small mammal species, but can be considered insignificant in relation to the amount of such habitat and total numbers of small mammals residing on the Arctic Slope of Alaska. Even the loss of this food source to the carnivore populations is likely to have less effect on the bear, wolf, and wolverine than human activities in their territories.

The wolverine, like the grizzly bear and wolf, is essentially a wilderness dweller that does not tolerate close contact with man. Since they do not hibernate, wolverines are exposed year-around to hunting and harassment by man and are likely to suffer from winter construction activities when they are easily visible on the snow. Since these animals are so rare, it seems unlikely that pilots engaged in pipeline work will forego opportunities to give their passengers a closer look at the occasional wolverine, even though this sort of activity is prohibited by the Airborne Hunting Act (16 U.S.C. 742j-1) and U.S.D.I. regulations growing out of it.

Low ridges and hills with well-drained soils that may be favored for pipeline routing, or for borrow sites, are also important as ground squirrel habitat. The squirrels require easily excavated soils with a deep active layer for the construction of their burrow systems. Appropriation of such sites for construction purposes will mean a reduction in the numbers of ground squirrels along the pipeline route. Selection of such sites in place of river bars as a source of construction gravel merely transfers the impact from fish to squirrels, wolves, and bears.

Birds

Potential impacts of the proposed pipeline on bird populations can occur from disturbance, habitat destruction, pollution, and direct mortality. Some of these impacts are unavoidable, but many are avoidable, depending on the location of various facilities, construction practices, and scheduling of activities. Among the major potential impacts which could be avoided are those caused by aircraft and human presence at certain critical times.

The area through which the proposed AAGPC pipeline would pass provides nesting and resting habitat for at least 142 species of birds, only 6 of which overwinter in the area. The many small and large lakes dotting the Arctic Coastal Plain are heavily used by swans, geese, ducks, loons, and shorebirds for nesting and molting. The 3,600 acres, (5.6 sq mi) of land required for the proposed project represent a small fraction of the total bird habitat available, but disturbance of the Alaska coastal barrier beaches, spits, lagoons, estuaries, and offshore islands due to project-related activities (such as wharf construction and pollution) would constitute a major loss of a set of habitats constituting part of a relatively rare coastal ecosystem. These shallow estuarine waters are highly productive and more birds use them than any other habitats during their brief stay in the Arctic. Removal of gravel from the protective offshore islands and spits, or contamination of the beaches and waters along the Beaufort Sea Coast, would adversely modify the qualities which now attract waterfowl.

Birds displaced by habitat or habit modification, while not killed outright, are removed from the breeding population for at least 1 year;

continue through June, during which time the nesting geese are very sensitive to disturbance and harassment. Brood rearing and molting take place in July and August and the flightless birds are susceptible to harassment by low-flying aircraft or other human intrusion, which can have adverse impacts on their energy balance at this time. Increase in body size and weight by juvenile birds and growth of new feathers by adults require large expenditures of energy, so disturbances which interrupt feeding activities will affect adversely the well-being of the birds.

While on the staging grounds, snow geese are very sensitive to noise, aircraft, and human presence. Observations of snow geese response to various human activities cited by Jacobson (1974) indicate that the birds may avoid an area as large as 20 square miles (50 sq km) around an operating oil drill rig and 28 square miles (73 sq km) around an operating natural gas compressor station. Landings and takeoffs at airstrips within the snow goose staging area would probably disturb geese within a zone of 250 square miles around each strip and could cause them to abandon the area. Such disturbance on the fall staging areas could reduce their energy intakes or increase their energy expenditures. If geese leave the staging areas before acquiring sufficient fat reserves, they may be forced to interrupt their normal migration, and face increased exposure to hunting and natural mortality on the southward journey.

Since "there is no practical flight altitude that does not frighten snow geese" (Salter and Davis, 1974) unrestricted airplane traffic from the Canning River to the Mackenzie between mid-August and mid-October could be expected to disturb snow geese on 100 percent of the staging area (Jacobson, 1974).

Until more is known about the long-term reaction of fall staging snow geese to these disturbances, the availability and value of alternate areas, and the adaptability of snow geese to alternate areas, the Arctic Coastal Plain must be considered a critical link in the snow goose life history requiring complete protection (Jacobson, 1974). It is concluded that the entire population of snow geese could be adversely affected if repeated aircraft flights, such as might be expected with a major repair of the pipeline system, were required to cross critical staging habitat areas while geese are present.

Ducks

Large numbers of both fresh-water ducks and sea ducks use this segment of the Arctic Coast during spring, summer, and fall. The proposed AAGPC route is generally far enough removed from the coastline to avoid direct conflicts with sea ducks, but wharf operations, petroleum spills, shipping, and aircraft traffic along the coast from Prudhoe Bay to Camden Bay, Demarcation Bay, and the Mackenzie River are all sources of potential conflicts with the hundreds of thousands of oldsquaw, eider, and scoter that use the coast constantly throughout the summer.

Sea ducks may be unusually susceptible to human intrusion during nesting and molting seasons, while colonial nesters, such as common eider, are known to suffer unusually high egg mortality as a result of disturbance during nesting. Undisturbed female eider rarely leave the nest, but when disturbed, they may leave the eggs uncovered and visible to predators. A 53 percent egg loss due to predation was reported by Gollop, Black, et al. (1974) among eiders nesting at Nunalak Spit. One visitor per month is enough to cause loss of a large percentage of eggs in many colonies of marine birds.

thus, they contribute no offspring. This occurs because they can seldom find suitable substitute breeding habitat that is not already occupied by others of their species. Thus, when habitat is permanently lost, through modification or by behavior responses to such intrusions as aircraft disturbances, the population eventually stabilizes at a lower level.

Migrating waterfowl begin to arrive in mid-May and nest among the many ponds and lakes of the coastal plain. Broods of young appear in July and August. Fall migrations begin in late August, and by October, most of the waterfowl have left the area. Thus, pipeline construction, operation, maintenance, and repair activities which occur between mid-May and October can be expected to affect adversely some or all of the species of waterfowl, shorebirds, and songbirds which gather along the proposed AAGPC pipeline route each summer.

The proposed line traverses approximately 150 miles of sensitive habitat.

Swans

Whistling and trumpeter swan species both require large territories (30 to 80 acres per pair) and are very sensitive to human intrusion during the 4- to 5-month period that they are in residence on the Arctic Coastal Plain. Potential detrimental effects of the proposed AAGPC pipeline project include alteration or destruction of summer nesting grounds, increased disturbance on nesting, molting, or staging areas, and an increased loss of eggs and young to predators. Impacts are especially likely during the two summer construction periods when the ports are built at Camden and Demarcation Bays and pipeline construction materials are transported to these ports and to Prudhoe Bay. Aircraft flying to and from these sites will also disturb swans. The Applicant suggests that these sites might be used as long as 50 years for repair of the proposed AAGPC pipeline and for exploration of other prospective oil and gas basins.

Anderson (1973, in Jacobson 1974) reported a pair of whistling swans at Nuvagapak Point was probably disturbed by air traffic and left the area by the end of June. Molting and nonbreeding swans would not approach within 5 miles of an active drill site in the Mackenzie River Delta although they had used the area previously (Barry and Spencer, 1971, in Jacobson, 1974).

Swans are also known to be susceptible to accidental death from collision with towers and wires. While the occurrence may seem remote, such collisions could occur with the 140- to 280-foot (42 to 85.3 m) high communications towers planned for sites on the Kongakut, Jago, and Sikutaktukvik Rivers. The overall effect of this impact on swans is unknown, but available information suggests there may be a significant loss of swans.

Geese

Canada geese, white-fronted geese, and black brant will be affected differently by pipeline construction and maintenance. The impact of disturbances on a particular species is a function of the type and intensity of disturbance, time of year, location, mobility of the disturbance source, pattern of distribution of the bird, and species sensitivity to disturbance (Jacobson, 1974).

Geese generally are the first waterfowl to arrive, and nesting often begins when the ground is still snow covered. Egg-laying and incubation

The postnuptial molt is also a critical time in the sea ducks' tenure on the Arctic Coast because of the birds' inability to escape predators or harassment. The high energy requirements for feather growth require maximum energy conservation, and disturbances which reduce feeding efficiency, decrease nesting opportunity, or increase energy depletion may contribute to increased mortality (Jacobson, 1974). Continued long-term harassment could cause ducks to abandon critical habitat areas like the offshore islands (Sterling and Dzubin, 1967). Because sea ducks concentrate along the coast and offshore islands along the Beaufort Sea, it is considered very likely that major shipping activities during the two summer work seasons between the Mackenzie River and Prudhoe Bay will disturb these birds. Major disturbances will be focused at the three port locations, Prudhoe, Camden, and Demarcation Bays, but a large number of ships are expected along the Alaskan Coast between Prudhoe Bay and the Alaska-Canada border. The intensity of disturbance is not known, but aircraft movements along the coast as part of the shipping operation will intensify disturbances.

During their annual molt, up to 60,000 oldsquaws may be seen on coastal lagoon waters and sand spits. These birds and the numerous shorebirds that use the gravel bars and estuarine beaches along the Beaufort Sea coast will be highly vulnerable to impacts from spilled petroleum products or other pollutants resulting from shipping, cargo transfer, refueling, and other activities at the Camden and Demarcation Bay sites. Uncontained and unrecovered fuel spills on the ice or in the open coastal water could gather in this open water and render shoreline, island, and sandbar habitat unusable, as well as pose a direct threat to the lives of those waterfowl present. Waters polluted with oil may be the first to become ice-free in the spring, due to rapid absorption of solar energy, and attract early migrants to their deaths. The sheen of oil on ice or snow may also cause birds to mistake it for open water early in the spring.

Peregrine Falcon

The arctic peregrine falcon, an endangered species, nests on the north slope of the Brooks Range. Some of these falcons hunt along the Arctic Coastal Plain during the summer and have been sighted near Demarcation Bay. Winter construction activities will not directly affect these birds. Spring and summer operation and emergency repair activities can disturb birds nesting and raising their young. This would be most pronounced in the river valleys in the Brooks Range to the south (for example, the Canning River) where nesting is known to occur. As with other birds and wildlife, disturbances would be associated with aircraft movements. Displacement of peregrine falcons from hunting areas is not considered a long-term impact, but because of low population numbers of this threatened species of bird, any population loss is significant.

Other Birds

Many other species of birds which occur along the Arctic Slope will be affected by the proposed AAGPC pipeline, but in most instances the impacts will be short-term or insignificant. An exception to this may be the phalaropes, semipalmated sandpipers, and other small shorebirds which depend on the estuarine beaches, gravel bars, and sedgegrass marshes and could suffer the same ill effects from pollution of those areas as described for the sea ducks.

The pipeline embankment and some of the other new structures may become new nesting, resting, or display sites for some songbird species.

Fish

The proposed AAGPC pipeline will cross 120 rivers and streams between Prudhoe Bay and Canada and each of the stream crossings presents a potential adverse impact on the fish and other aquatic organisms residing there. The proposed project will cause conditions affecting fish in several broad categories: increases in suspended particles; reduction in dissolved oxygen; and introduction of pollutants. These project-related effects will all be directly inimical to fish life. 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.

On the Arctic Slope, fresh water fish habitat is severely restricted after freezeup, being limited to those few lakes that are deep enough not to freeze to the bottom, deep river pools, and river reaches fed by springs or ground water. Water withdrawals from these areas for use as ice on snow road construction can have a serious detrimental effect on the habitat and overwintering fish.

If any of the 168.9 million gallons of water required by the Applicant for winter snow/ice road construction were withdrawn from sites occupied by overwintering fish, it would probably result in the immediate death of those fish and very possibly the loss of the populations using that site, since tagging studies suggest that there is very little interchange of adult fish among the Arctic Slope populations.

Other activities requiring water can be responsible for fish kills. For example, construction workers reported (Ward and Craig, 1974) that small fish clogged their water pump at a location approximately 15 miles (24.1 km) south of Deadhorse.

Shallock et al. (1970) have documented some of the concerns with low oxygen levels in arctic rivers, primarily in Alaska. They note that low oxygen levels affect both the available fish food and the fish themselves. Since dissolved oxygen levels are already quite low in most Arctic Slope rivers, any further decreases would be detrimental to these aquatic communities, and some activities proposed by AAGPC along the gas pipeline route could have adverse effects on stream oxygen levels, especially in winter. Organic substances introduced into waters will ultimately be degraded (oxidized) by bacteria and other micro-organisms. The respiration and growth of these bacteria take oxygen from the water, thereby reducing the amount of oxygen available to fish. The most likely source of organic materials along the pipeline route is domestic sewage from the camps along the route and at ancillary facility sites. Another possible source is through the inadvertent introduction of fertilizers into water courses during revegetation efforts along the right-of-way. The fertilizers will likely start a chain of actions stimulating growth of plants and invertebrates which will then increase the biological oxygen demand in the receiving waters.

Spillage, leakage, or disposal of various toxic chemicals during construction, operation, maintenance, or repair of the proposed facilities presents hazards to both fresh water and estuarine fish environments. Chemicals that are toxic to fish and which will be utilized along the pipeline include gasoline, fuel oils, paints, additives, anticorrosive and cleaning agents, and methanol. Methanol (methyl alcohol), which will be used as an antifreeze in gas pipeline testing and as a dehydrating agent, is the only toxic chemical planned for routine release into watercourses. According to McMahon and Cartier (1973) neither char nor grayling fry can tolerate exposure to greater than 1.0 percent methanol for 24 hours and concentrations of over 2.5 percent are lethal in a much shorter time. Eggs of these species, while not killed in a 24 hour exposure to 1.0 percent methanol, were apparently damaged and their development delayed. Methanol concentrations of 0.1 percent were tolerated by 80 percent of the developing eggs tested, although some early hatching may have resulted.

The Applicant will be using a 26 percent mixture of methanol and water for pipeline testing. Initial testing is planned for wintertime and therefore it is unlikely that concentrations exceeding the 1.0-percent level would still remain, since snow and/or ice melting would dilute spills before fish came into the area after spring breakup. However, large quantities of pure methanol will be transferred and stored in the project area when streams and rivers are open and fish are present, and with the possibility of testing after summer repair, methanol pollution in excess of the 1.0-percent level cannot be dismissed as a threat to fish and aquatic life.

Borrowing granular materials (sand and gravel) from streambeds, crossing streams and lakes with the pipeline and roads, and unchecked erosion from upland pipeline, road, and borrow sites all constitute actions which potentially will induce finely divided solids (silts and clays) into the aquatic environment. Winter construction activities in frozen streambeds and banks may be followed by erosion, siltation, and sedimentation when the ground thaws in summer. The effects of siltation and sediment on fish have been studied extensively in temperate areas and those which apply to arctic and subarctic environments were summarized by Doran (1974) for the proposed gas pipeline route up the Mackenzie River Valley.

Increased turbidity from suspended solids reduces the depth of light penetration into watercourses and thereby reduces the productivity of the system, ultimately reducing fish food. This is an important consequence in the lakes, but is of less consequence in streams since much of the food available to stream fish originates outside the stream system (Doran, 1974). Of greater significance to stream fish are the effects of siltation and sediments on the eggs and larvae of many fish which develop in gravel beds and require flowing water carrying oxygen. Siltation interferes with this flow of oxygen and upsets the normal development of fish eggs and larvae. Siltation of gravels may also smother fish foods or induce a change in kinds of benthic food organisms as the substrate changes.

Realizing these problems, Brooks et al. (1971) noted that:

> ...another conspicuous change which must be accepted as a justified and routine development is the disturbance of several rivers where quantities of gravel are being removed directly from their active beds. This is usually the only source of thawed gravel, and natural healing will be rapid. Any harm to fishery resources is apt to be temporary and could perhaps be avoided

completely if enough were known about the fish stocks that could be affected.

Relocation of proposed borrow sites from streams to upland areas usually would have adverse direct and/or indirect effects on one or more species of mammals and would usually leave a long-lasting scar on the landscape.

In summary, three major effects of the proposed AAGPC pipeline project on fish populations are anticipated: water withdrawal; spills of fuels, lubricants, and methanol; and water turbidity. Water withdrawals from critical overwinter areas can destroy entire fish populations in a drainage since multi-age classes of fishlife congregate in such areas. Spills of fuels and lubricants are expected. The impact of accidental spillage is speculative since its effect on fish life would depend upon the amount, type, location, and season of year spillage occurred. Methanol used as a testing agent may cause serious threats to aquatic life if spilled during summer or fall repair operations or during storage in an undiluted condition. Siltation may cause local problems by lowering water quality to the point where fish or fish foods are threatened. The cumulative impact of construction, operation, and repair of the proposed AAGPC pipeline on fish may be severe with the loss or significant reduction of the fish population in major drainages crossed by the system.

Long-Term Secondary Impacts on Mammals, Birds, and Fish

The approval of the proposed pipeline will serve to stimulate extensive exploration in the surrounding area and further development which will result in an ongoing complex of human presence, disturbance, and habitat destruction. Additional gas field development will require development of new feeder lines, additional processing plants, and possibly looping the mainline. Service and support facilities will increase.

Although thresholds are generally unknown, the capacity of many wildlife species to absorb and adjust to increased disturbance becomes diminished with each additional disturbance, and a general reduction in wildlife numbers and diversity can be expected as a result of increased development and disturbance. The eventual disappearance of wilderness-dependent and rare species will follow "mechanical habitation" of the Arctic Coastal Plain.

Impact on Invertebrates

Little is known of the invertebrate life associated with the proposed AAGPC pipeline system. Aquatic insects are assumed to be subject to the same factors affecting fish (water availability; pollution by fuels, lubricants, and toxic substances; and siltation).

Flying insects such as mosquitos, biting flies, and butterflies would probably be unaffected, as the Applicant proposes to use no pesticides.

In some cases habitat for insects will be destroyed, as at borrow sites or excavation of the pipeline ditch (soil mites) but new microlife features such as the ditch mound will be created which will provide shelter for flying insects from prevailing winds.

On balance, the proposed AAGPC pipeline system is expected to have little, if any, impact on invertebrate abundance and species composition or distribution.

3.1.1.8 Ecological Considerations

Impact on Tundra Ecosystems

Complexities of processes and interactions within ecosystems and the general lack of knowledge about the mechanisms of the processes in even a "simple" tundra ecosystem make it difficult to predict the impact of the proposed AAGPC gas pipeline construction and operation on ecosystem functioning. Experience has shown, however, that indirect consequences are potentially more significant than the direct and more obvious ones.

One of the chief impacts will be disturbance of the organic cover protecting tundra soils, which will initiate changes in thermal regime of the soils. Figure 3.1.1.6-1 diagrams the interactions to be expected as a result of disturbance.

Loss of plant cover changes the surface albedo and increases thermal input to the depth of the soil, which increases the active layer. The consequences of this deeper thawing depend on the amount of ice in the thawing permafrost layer.

If there is little or no ice in the permafrost, there will be little surface subsidence and erosion. Due to the increase in surface temperatures, decomposition of dead material may be accelerated briefly, with a similar increase in nutrients. Natural revegetation would occur rapidly and the soil surface would soon stabilize. There may be an increase in primary productivity for several years, which would, in turn, feed an increased number of consumer animals.

Where there is considerable ice in the permafrost, subsidence, thermokarst, and erosion would occur. This soil instability and movement may prevent revegetation for several years and cause secondary impacts in the surrounding area due to changes in microtopography, drainage, etc. Eventually, the area would reach a new equilibrium and be covered by vegetation and the active layer would then decrease in depth.

The Applicant's proposal to fertilize and seed disturbed areas would add scarce phosphorus and other nutrients to the system and permit rapid plant growth for several years. Fertilizer washing off the disturbed areas would also increase plant growth on adjacent terrestrial or aquatic sites. An increase in aquatic plant growth, followed by increased activity of decomposer bacteria, would probably reduce the already low dissolved oxygen levels in the water and have an adverse impact on resident fish. An introduction of organic sewage wastes would initiate a similar chain of events with possible detrimental impacts on overwintering fish.

Each of these effects on annual primary production will have secondary impacts on consumer insects, mammals, birds, and fish, which will range from locally severe to insignificant, depending on the size of the consumers' feeding range. For instance, some lemmings might be deprived of most of their food, while caribou may realize virtually no impact from the loss of plant production on 1,600 to 4,700 acres of disturbed tundra.

Nonetheless, the concept of community integrity must be stressed. When physical and chemical components of the ecosystem are changed, the biological communities respond accordingly. The response is a natural process which occurs constantly on a daily, seasonal, annual, and long-term basis. All communities have a certain resiliency, which allows them to survive constantly changing conditions. Conditions normally change within certain bounds, however, and the ability of arctic ecosystems to absorb unusual stress is unknown.

The tundra ecosystem has fewer species of plants or animals than other ecosystems, which implies less overall stability should any one species be disturbed. Partly for this reason, tundra is often referred to as "fragile," but some scientists suggest that the tundra may more accurately be characterized as "slow to recover from insult." Most agree that the landscape often bears visible evidence of its sensitivity to disturbance, and that vehicle tracks made a decade ago remain etched in the ground as if they were made yesterday.

In general, the area to be disturbed by the proposed AAGPC project is relatively small compared to the remaining undisturbed tundra. Thus, the loss of net annual primary production will be locally significant, but in relation to the total area of tundra of the Arctic Slope, the impact on the ecosystem would be minimal.

Impact on Marine Ecosystems

Annual primary productivity rates for the nearshore areas of the Beaufort Sea appear to be substantially lower than for the Bering Sea (a very productive area) or the Gulf of Alaska. Reduced light for photosynthesis caused by turbidity resulting from river sediment outflows is a chief cause of this lower productivity. Construction activities in stream crossings, gravel excavation from streambeds and bars, and erosion from the pipeline ditch can all act to increase the amount of sediment reaching the Arctic Ocean. Additional suspended sediments may increase the turbidity of marine waters enough to further lower primary productivity. This will be short-term loss unless erosion and sedimentation are not promptly controlled.

Introduction of sewage, fertilizer, or other products, which would appreciably increase the dissolved organic nitrogen in waters at the mouths of rivers would have adverse effects on fish. Biological activity beneath the winter ice cover near river mouths lowers the dissolved oxygen content of those waters and further biological oxygen demand would be at the expense of the oxygen required for survival of the fish.

Spills of oil or other pollutants into coastal waters near the proposed wharves at Demarcation, Camden, and Prudhoe Bays would affect the production of planktonic and benthic organisms which form the base of the food web supporting the endangered whale species and the polar bear. Perturbation of this nearshore marine eccsystem may thus have more widely observed impacts than would disruption of the adjacent terrestrial ecosystem.

3.1.1.9 Economic Factors

Alaskan economic impacts caused by construction, operation, and repair of the proposed AAGPC pipeline system cannot be discretely quantified at this time for several reasons. Foremost is the fact that the economy of the State is now undergoing an unprecedented boom as a result of the construction activities associated with the trans-Alaska oil pipeline system from Prudhoe Bay to Valdez. If peak employment cycles of the oil and gas pipeline projects are separated for several years, it is likely that construction of the proposed AAGPC pipeline will have little, if any, impact on delaying the sharp economic downturn following completion of the oil pipeline.

The following assumptions have been used in the analysis of anticipated impacts on the Alaskan economy as a result of the proposed AAGPC pipeline system:

1. Preparatory construction activities of the proposed AAGPC pipeline system will start in 1976.

2. Construction of the proposed AAGPC pipeline system will not cause a significant number of unemployed, nonresident Alaskan oil pipeline workers to remain in Alaska since the AAGPC segment is the last of a total pipeline system requiring construction.

3. Natural gas from the Prudhoe Bay area will not be available for use in Alaska and, therefore, no associated petrochemical industries will develop in Alaska as a result of the AAGPC pipeline system.

4. Present high national unemployment will be lessened.

Impact on Employment and Income in Alaska

The proposed AAGPC pipeline system will be constructed, operated, and repaired in a region where there are few people. The closest community, Kaktovik, has a population of 150 people (principally Eskimos). Access to most of the project area is difficult and there are no public accommodations. The climate is harsh.

Employment levels in Alaska are changing rapidly in response to construction of the oil pipeline. Although the extent of those impacts is not yet clear, it is evident that major adjustments are taking place.

The proposed route generates little direct employment in Alaska, rising from 77 people in the first year of construction, 1977, to a maximum in 1980 when construction employment reaches 682. The duration of peak employment will not exceed 6 months. AAGPC expects operations to require 39 permanent employees. These direct construction and operation jobs and the income support jobs generated will have a large employment effect throughout Alaska. An econometric model developed by the University of Alaska suggests total employment in the State in 1980 that devolves from construction of this proposed route could be 4,300 people with an additional $41,000,000 gross State product being generated that year (Scott, 1975).

Because of the short duration of jobs during the peak winter construction of the proposed AAGPC pipeline, it would seem that the project would have little impact on permanent employment opportunities in Alaska. There will be, however, significant dislocation of employment as people are attracted to the short-term, but higher paying jobs associated with winter construction in arctic conditions. Furthermore, significant long-term employment could result based upon support activity and the manner in which the State expends the considerable revenues generated.

The Applicant estimates that administrative and construction labor payroll during the 1976 to 1980 construction period will total $116.75 million (Table 3.1.1.9-1).

Personal income from the proposed AAGPC project during the construction phase (1976 to 1980) will create a beneficial impact on the Alaskan economy. The magnitude of this benefit is small in comparison to the amounts of personal income to be generated by construction of the oil pipeline which will have peak employment of 32,500 jobs (direct employment of 13,000; secondary employment of 6,500; and indirect, 13,000). Because of the influx of other population, most of which would find employment in lower paid support jobs, the per capita income of the State would not rise significantly as a result of the gas pipeline construction and might even decline in some parts of the State. While individuals will gain, taken as a

Table 3.1.1.9-1 Estimated administrative and construction labor costs, AAGPC pipeline system (1976-1980) *

Activity	(in thousands of dollars)† 1976	1977	1978	1979	1980
Construction and engineering payroll	$ 210	$ 190	$ 13,250	$ 18,900	$ 56,700
AAGPC payroll benefits	4,900	5,400	5,500	5,800	5,900
Total	$5,110	$5,590	$18,750	$24,700	$62,600

Source: AAGPC, Feb. 5, 1975.
†1974 dollars without escalation to year of expenditure.

whole, people in the State would gain little or nothing in additional personal income.

Total costs to the Alaskan economy also must include greater costs for services because of the large number of people attracted to the State for the oil pipeline. The social and economic costs of the oil pipeline are only now beginning to be reflected and therefore, "goodness" or "badness" depends upon the economic and social values assigned to change or to retention of the Alaskan lifestyle.

The proposed AAGPC pipeline will provide employment which is approximately 20 percent of that caused by the oil pipeline. Few jobs with the gas pipeline will last a year and most will be for less than 6 months. Therefore, the total impact of the proposed AAGPC pipeline system on employment and personal income will be small. Since construction of other larger elements of the total system in the lower 48 states and Canada will be under way for 2 years before the start of the AAGPC segment, the net effect in Alaska should be beneficial in that immigration to Alaska of workers seeking employment would be reduced and workers unemployed because of completion of the oil pipeline would be attracted out of the state as other pipeline jobs become available.

Impact on Unemployment in Alaska

Assuming that necessary approvals are received timely, the proposed AAGPC pipeline system will start employing in 1976 and employment will peak in 1979-1980. This is estimated by the Applicant to be one year after peak unemployment resulting from completion of the oil pipeline construction (Table 3.1.1.9-2).

It is likely that construction of the proposed AAGPC pipeline system will forestall but not reduce the increase in Alaskan unemployment resulting from completion of the trans-Alaskan oil pipeline system. Since unemployed oil pipeline workers will be attracted to construction projects of the proposed natural gas delivery system from Montana to Pennsylvania and California 2 years before the construction of the AAGPC pipeline (the last segment of the system), it is concluded that the total impact on unemployment in Alaska will be beneficial. The Applicant estimates that 85 percent of the direct, secondary, and indirect employment will be current Alaskan residents.

Impact on Unemployment among Alaskan Eskimos, Indians, and Aleuts

Construction of the proposed AAGPC pipeline system is expected to have a significant impact upon unemployment among Alaskan Natives. The Applicant has stated its plan to hire and train Natives and has discussed this with the people of Kaktovik. The oil pipeline construction phases have made a commitment that 20 percent of the total work force would be filled by Alaskan Natives. If this percentage carries across to the AAGPC pipeline project, direct employment would be as follows: 8 in 1977; 27 in 1978; 113 in 1979; and 136 in 1980. Approximately 6,300 Alaskan Natives will have been trained for skilled oil pipeline jobs. Assuming peak employment also includes a 20 percent Eskimo, Indian, and Aleut employment factor, unemployed Alaskan Natives could amount to as many as 5,780 people (20 percent Natives X peak 1976 employment in oil pipeline construction = 6,260. Maximum AAGPC employment of 20 percent Natives X peak 1980 employment = 136).

Table 3.1.1.9-2 Comparison of normal employment and unemployment in Alaska to employment and unemployment from the oil pipeline and the AAGPC pipeline system *

Year	Normal civilian workforce†	Oil Pipeline Jobs††	Normal civilian unemployment	Oil Pipeline unemployment	AAGPC jobs
1970	115,500	-	-	-	-
1976	156,000	+31,300	14,800	$ 5,000	250
1977	163,800	+10,400	15,500	+22,100	1,250
1978	172,000	+ 5,600	16,300	+25,700	6,000
1979	180,600	+ 2,300	17,100	+ 8,100	5,900
1980	189,600	+ 2,300	17,900		1,900

Source: URSA, 1974, p. 48
†Work force without either oil pipeline or proposed AAGPC pipeline projects
††Civilian employment (includes direct, indirect, and secondary jobs).

Impact on Income to the State of Alaska

The price of natural gas in future years is difficult to predict, but it is clear that substantial revenue to the State will be generated from royalties, production taxes, and property taxes. Major uncertainty exists today on the rates used to compute royalties and production taxes; as proposals are pending to deregulate the wellhead price of "new" natural gas such as that at Prudhoe Bay. Also, the State of Alaska is considering establishment of in place tax on oil and gas reserves. All interact to influence revenue to the State.

Based upon an assumption that the wellhead price of natural gas will be 50¢ per Mcf (thousand cubic feet) in 1980 and the Applicant's estimate that 730 bcf (billion cubic feet) of gas will be produced that year, the gas production tax revenue to the state would be $14.6 million. By 1990, similar assumptions suggest that the tax revenue would be $16.6 million (810.0 bcf gas X 50¢). Comparable assumptions (royalty of 12.5 percent of value of production) were used to predict State royalties from gas production at $45.6 million in 1980 and $51.3 million in 1990 (Scott, 1975).

It should be noted that the 1990 State revenue calculations are based upon a delivery of 2.25 tcf/d (trillion cubic feet per day) of natural gas. The Applicant proposes an ultimate capacity for the system of 4.5 tcf/d. If this capacity is reached, the estimated revenues to the State of Alaska from gas production taxes and royalties would double.

There is major uncertainty as to whether 2.25 bcf/d of natural gas can be extracted from the Prudhoe Bay reservoir without damaging the total amount of oil that can be recovered. The State of Alaska is currently (December, 1975) reevaluating the actual rate of production from the oil and gas reservoir and has not made a final determination as to the actual level of production for either oil or gas to be permitted.

In summary, the prospective annual income to the State from royalties and gas production taxes resulting from the proposed AAGPC pipeline system is large [$67.8 million for production of 2.25 bcf/d at 50¢ per MMcf/d (million cubic feet per day) wellhead price]. The impact of this annual income revenue to the State is considered significant since the increase in permanent population due to direct employment from the AAGPC pipeline system is expected to be only 100 to 150 workers. This will maximize net revenue gains, since increased State and local costs to schools, highways, and other public services would remain substantially unchanged.

Impact on Transportation Costs

Assuming that highest priority, other than national defense status, is assigned to the proposed AAGPC pipeline system, movements of workers to and from the project area will cause major usage and expansion of the capabilities of the air transportation system in Alaska. This impact on transportation could be felt during that single construction winter in all rural areas of Alaska dependent upon air transportation for movement of people and goods. In the event of competing uses between transportation needs of the proposed AAGPC project and nonemergency uses, it is assumed that the pipeline will be given priority. The net result will be that rural Alaska will wait or pay higher rates to receive nonemergency goods and supplies. This type of competition for limited transportation capability between the oil pipeline and domestic supplies has been a factor in increased costs to Alaskan consumers. If the project airfields are turned over to the State after the project, it will require the State to hire more personnel for operation and maintenance.

Impact on Present and Future Mineral Resource Exploration and Production

The proposed AAGPC gas pipeline itself, serving as a means of converting gas production to gas sales dollars, will have a major impact in providing incentive to accelerate industry plans for additional petroleum drilling and production.

Wharf facilities to be constructed at Camden and Demarcation Bays, with new airstrips capable of handling large cargo planes, are presently intended to support the construction and operation of the Applicant's proposed gas pipeline. The very presence of these facilities, however, will have an impact by being of vital importance to and serve as ready made staging areas for future petroleum exploration, drilling, and development. The affected areas will include the offshore Beaufort Sea as well as all the Coastal Plain lying between Prudhoe Bay and the Canadian border.

The impacts, which may result in additional and/or increased petroleum exploration and development, will include those from required support, construction, and production activities. Construction and petroleum production supplies, material, equipment, labor, engineering, and management will be required. A network of small-diameter pipelines for gathering crude oil and gas production from individual wells into a centralized station for treatment prior to delivery to a large-diameter sales pipeline is required for every oil and gas field. The further impact of possible discovery of large additional oil and gas reserves will require the study and determination of the need for new large-diameter petroleum transport pipelines in addition to the proposed AAGPC pipeline system. Simultaneous development of outer continental shelf leases could increase the demand for labor and materials as well as transportation facilities.

Impact on Basic Industries in Alaska Other Than Mining and Transportation

Alaskan waters associated with the proposed AAGPC pipeline system are not used for commercial fisheries. Accordingly, the pipeline project will have no impact on this industry in Alaska.

Timber products required for the construction of the proposed AAGPC pipeline system will be transported via barge down the Mackenzie River, in Canada. Alaskan timber resources will not be used for this project because of the distance between their location and the project area. There may be local timber harvest and processing in the Fairbanks area, but any amounts for this project will be small. Accordingly, the proposed AAGPC pipeline project will have little, if any, impact on the forest products industry in Alaska.

The proposed AAGPC pipeline system is intended to be an export system. Hence, gas transported through this system will not be available for use in the State. Accordingly, there will be no impact on existing manufacturing in Alaska.

Agricultural areas are not associated with the proposed project and therefore, the project will not have an impact on existing or potential agricultural areas.

Impact on Revenue to the North Slope Borough

The entire AAGPC pipeline system will be located in the North Slope Borough.

The proposed pipeline system will increase the existing tax base of the new Borough (see 2.1.1.9). The amount of increased revenues is not known since these reflect future rate of assessment and assessed valuation. Taxation powers of the new Borough are still undergoing litigation, but increased revenue from the AAGPC pipeline to the Borough should be substantial. The Applicant intends to employ and house 39 workers in the Prudhoe Bay area. Accordingly, the net result of income received by the Borough in relation to outgo for increased social services, such as schools and police and fire protection, should be beneficial; however, the exact extent is not quantifiable.

Impact on Native-Owned Resources

The North Slope Native Regional Corporation has made tentative selection of the Kemik gas field, and if approved by the State, it would become the royalty owner of this gas. The proposed AAGPC pipeline system will provide an opportunity for transportation of that gas to market and therefore, will have a beneficial impact on the income of the North Slope Native Regional Corporation and on other Regional corporations. The extent of the impact on revenue to the Corporation is unknown but could be substantial.

3.1.1.10 Sociological Factors

Impact on Population

Impacts of 2,400 construction-related workers being spread among the Prudhoe Bay area, four future compressor station sites, Camden and Demarcation port areas, the North Slope Borough, and/or Kaktovik are considered to be short term and minor since workers will be there less than 6 months. It is noted, however, that construction of the proposed system is phased over a 3-year period. Therefore, the population of the Borough would be temporarily increased. Since this would occur after the completion of the trans-Alaska oil pipeline system construction, it is believed that impact on the population of the North Slope Borough will be similar to the current situation and of a continuing nature. There would, however, be important impacts on other existing local activities such as subsistence, since the proposed AAGPC pipeline system radiates eastward away from Prudhoe Bay into an area where there is now little human activity.

The proposed AAGPC pipeline system requires that at least 39 workers be permanently stationed in the Prudhoe Bay area. The Applicant does not plan for families to live at Prudhoe Bay. If dormitories are built by the Applicant and only single people are encouraged to work at the Prudhoe Bay field office, the permanent population of the Prudhoe Bay area would be increased by at least 39 people. The actual number of "permanent" people working at the Applicant's field office during a year would probably be at least double since it is likely that there would be a regular rotation of employees in and out of the Prudhoe Bay area. Should Prudhoe Bay have apartments and/or houses, and families are permitted to come, the permanent population of the Prudhoe Bay area would be greatly increased. Of the total 100 operations and maintenance workers, the Applicant anticipates that many will be current residents of the impact region. The impact resulting from increased population would be reflected in the need for more social services and an increase in basic supplies to the area.

Data now available are not adequate for an analysis of impacts resulting from a large permanent population of workers living at Prudhoe Bay. Major secondary impacts would accrue to both the North Slope Borough and the State in the event of an increased permanent work force living at Prudhoe Bay. These include, but are not limited to, needs for police services and increased public payrolls because of the number of people needed to provide public services in the impacted area.

Another major secondary impact on the population of Alaska may result if unemployed workers from other states are attracted to Alaska with hope of securing jobs on the proposed AAGPC pipeline system. This secondary impact would be of more significance should a large number of workers now employed in the construction of the oil pipeline choose to remain in Alaska, hoping for work on the gas pipeline. The occurrence of this impact is not considered likely because: (1) other elements of the total pipeline system (of which AAGPC will be building only 195 miles) will be under construction in Canada and the lower 48 states for 2 years prior to start of the system in Alaska [see 2.1.2.9 (Canada); 2.1.3.9 (North Border), and 2.1.4.9 and 2.1.5.9 (West Coast)]; and (2) high costs for food and housing in Alaska are not conducive to maintaining a good standard of living for unemployed persons even though unemployment benefits are also high.

Impact on Housing

The Applicant states that "...it may become desirable for Native employees who live in Kaktovik, or wish to live there, to have that [Kaktovik] as a sub-base for maintenance. If so, simple office and warehousing structures would be needed there, and the Applicant would also not wish employees to be in substandard housing..." The Applicant, however, does not propose to develop housing in Kaktovik. Employees would have additional income to invest in new housing.

Should AAGPC construction workers (peak number 2,400 people) bring families to Anchorage or Fairbanks during the 6-month construction period, it may result in increased demand for housing in these two urban areas. The Applicant has indicated that project-induced housing demand will be for 300 units in 1977 and 1,000 units in 1978. Thereafter, AAGPC will create no additional impact and, in fact, the demand would decrease. Accordingly, the overall impact on housing in both Anchorage and Fairbanks is expected to be modest. In the event that high in-migration of people seeking work in Alaska on large construction projects like the AAGPC pipeline is stimulated by high unemployment rates elsewhere and a high proportion of the trans-Alaska oil pipeline workers remain in Alaska, the proposed AAGPC pipeline system would have a major, short-term adverse impact on available housing in both Anchorage and Fairbanks.

Impact on Community Services

The proposed AAGPC pipeline system involves two communities: Kaktovik (pop. 150) and Prudhoe Bay area (est. pop. 1,000).

The proposed AAGPC pipeline system will cause an intense but brief (up to 6 months) impact on community services in the Prudhoe Bay area. Almost all services at Prudhoe Bay are currently provided by industry and as such are considered private. Expected impacts will result from employment of up to 2,400 workers during the third winter construction season after the proposed system is approved. This would be after the period of peak employment of workers building the trans-Alaska oil pipeline system. Accordingly, the impact of the proposed AAGPC pipeline system on community services at Prudhoe Bay is considered minor since needed services would be less than at the present time.

The Applicant does not propose to use community service at Kaktovik as part of the proposed AAGPC pipeline system, unless desired by the local residents. The increased economic opportunities to local residents may result in improved community services.

There may be minor impacts on community services in Fairbanks and Anchorage should families of construction workers move to these two urban areas. Since both areas will have been forced to expand community services in response to the earlier and much larger influx of workers building the trans-Alaska oil pipeline system there should be no major impacts on community services.

Impact of Solid Waste on the Environment

The majcr potential impact of waste disposal will be at the construction camps and along the right-of-way. With regard to solid wastes, the applicant proposes to sometimes utilize the four future compressor station sites and three port sites for the location of up to 50 people as shown in Table 1.1.1.6-1.

These same locations will be used during the peak construction phase as the site for major construction camps (500 to 800 people). It is anticipated that small mobile camps will be located throughout the proposed AAGPC pipeline system during preconstruction, construction, and perhaps during repair procedures. Permanent emergency quarters for up to 30 people will be provided at each future compressor station site during initial operating phases of the proposed system.

It is intended to remove combustible waste by incineration; the resulting ash will then be dumped into "pits" that will be constructed adjacent to the gravel pad. These "pits" will be built by constructing a berm on top of the existing ground cover. The berm will form three sides of the pit and the gravel pad will form the fourth side. The pits will be covered with 24 inches of fill and properly marked as to location and contents prior to the camp being moved.

Small camps will use "single chamber" incinerators that are propane or oil fired. All types of larger camps will use dual chamber incinerators that use the "starved air" process. This type of incinerator acts as a storage unit as the wastes are collected during the day. The applicant expects to handle up to 8 pounds of refuse per capita per day and this appears to be a reasonable figure (Grainge et al., 1973). Thus, the intended system appears to be adequate to handle combustible waste and no adverse impact is expected if the system is properly used. However, the disposal of solid waste in the Arctic requires deliberate and substantial effort. Under the stress of winter conditions, there is a natural human tendency to simply "misplace" things that do not contribute to the specific job. Strong winds will scatter lightweight solid wastes. When solid wastes are scattered across vast expanses, the cost of removing them creates economic questions. The opportunity for distribution of litter throughout a large area is good. Once distributed, the Arctic climate will tend to delay any natural deterioration properties of the particular type of solid wastes. Accordingly, only slight, occasional improper disposal of litter and solid waste will have a cumulative long-range adverse impact on esthetics. This would be most pronounced in the Arctic National Wildlife Range where there is now little evidence of man.

The Applicant proposes to bury non-combustible materials in the same pits as the ash from the combustible materials. These materials will also exist for a long time without severe degradation. Any subsequent exposure of these pits will create an adverse impact. However the alternative action, removal by trucking, may be more damaging to the environment (Grainge et al., 1973). Excess and waste construction material will be removed.

Impact on Transportation

If the transportation facilities the Applicant proposes to build were open to public use, there would be substantial improvement in aircraft transportation since none of the Applicant's proposed aircraft facilities is in an area where facilities now exist. This could result in important adverse secondary impacts in that improved air access could threaten wildlife, subsistence, and wilderness values by allowing opportunity to bring more people to the area and would be a new source of repeated noise (sections 3.1.1.7, Wildlife; 3.1.1.10, Subsistence; and 3.1.1.11, Wilderness).

The improved port facilities AAGPC proposes to build would have a major, beneficial impact on exploration and potential development of the Beaufort Sea offshore petroleum province. Although the Applicant does not intend to use port facilities on a regular basis after construction of the proposed AAGPC pipeline system is completed, development of Camden and Demarcation Bays as major storage and material handling sites for offshore oil and gas exploration would significantly expand adverse impacts on wildlife, especially marine mammals and waterfowl, and on subsistence. (See impact discussions on these subjects for additional discussion.)

The Applicant proposes to construct no permanent roads along the AAGPC pipeline system or between Camden or Demarcation Bay and the pipeline route. The Applicant indicates that it may be necessary to use the newly completed gravel haul road from the Yukon River to Prudhoe Bay to transport some supplies and equipment for pipeline construction.

The amounts and types of supplies are not known and therefore, impacts on the road transportation system cannot be assessed at this time. There could be a need for increased maintenance and repair of the gravel haul road as a result of hauling supplies and equipment.

The proposed AAGPC pipeline system would have no major impact on existing rail capabilities since most supplies would be moved by ship or barge.

See Section 3.1.1.9, Economics, for a discussion of the proposed AAGPC pipeline system impact on transportation costs.

Impact on Subsistence

Construction, operation, and maintenance activities associated with the proposed AAGPC pipeline system will involve movement of people and supplies into an area important to subsistence. For example, the Camden Bay port facilities are located where there are important waterfowl nesting, molting, and staging areas. Supplies and construction materials will be shipped to this port when waterfowl used for subsistence purposes are also in the area. Human activities will, at the least, temporarily disturb waterfowl used by residents of Kaktovik for subsistence. Movement of supplies for 2 years along the coast of the Beaufort Sea between the Mackenzie Delta and Prudhoe Bay similarly may temporarily affect the distribution and abundance of waterfowl because of ship movements and potential pollution from spills of lubricants, fuel, or toxic fluids, such as methanol, needed in construction of the proposed AAGPC pipeline system.

Demarcation Bay is beyond the primary 40-mile subsistence zone from Kaktovik, but activities similar to those at Camden Bay would produce similar results. Aircraft will be used to transport personnel to and from the Camden and Demarcation Bay areas during the two summers that supplies are received. Aircraft will cause significant disturbance to waterfowl and may cause major displacement of naturally occuring historic waterfowl areas. Overall, the impact of the proposed AAGPC pipeline system on the subsistence harvest of 1,200 waterfowl annually by residents of Kaktovik may be short term and severe. In terms of replacement food cost, these waterfowl represent more than $1,700 (APG, 1974). Under worst case conditions, loss could approach the total production for 3 years.

Residents of Kaktovik take five polar bears annually for subsistence purposes. Activities of the Applicant during the winter will cause redistribution of polar bears. Camden Bay is a known polar bear denning site and therefore, sites there will be expected to become unusable during the construction period. Polar bears are often found in the Demarcation Bay area, where there are believed to be polar bear denning sites. Because of food odors, refuse, and human activities, camp areas will attract male bears and nonpregnant female bears. Although there would be an overall gain in the number of polar bears in the vicinity of camps, there would be a net population loss if pregnant females are denied use of known and suspected denning areas. The impact on the subsistence harvest of five polar bears by people living in Kaktovik would, in the short run, be enhancement of harvest opportunities. In the long-term, harvest opportunities may be reduced as a result of loss of denning areas. Such loss would need to be offset by more reliance on purchase of processed meat such as beef, pork, and mutton.

Approximately 100 caribou are taken for subsistence purposes annually by people living in Kaktovik. Hunting takes place on a year around basis. The proposed AAGPC pipeline facilities cross the southern portion of the calving area and the port facilities are located on the south side. Construction activities and receipt of materials at port areas during the summer will cause displacement of caribou on parts of the nearby traditional calving grounds and summer range. Some caribou must cross the proposed pipeline route at least twice annually in the seasonal travel between the calving area and the wintering area (south of the Brooks Range). Aircraft flight between compressor stations and ports are expected to disturb caribou and cause population change and redistribution (see Section 3.1.1.7, Wildlife). The net effect of the proposed AAGPC pipeline system is expected to be fewer caribou within reach of the residents of Kaktovik. This reduced availability of caribou would severely affect the subsistence harvest of the people living in Kaktovik. At Anchorage 1973 prices, this could involve replacement cost of $14,000 for other meat for the village. It should be noted that people living in Canada (principally Old Crow with 400 to 700 caribou harvested annually) and in Alaska (principally Arctic Village with 300 caribou harvested annually) also make considerable subsistence use of the Porcupine Caribou Herd. Accordingly, significant reduction or redistribution of the Porcupine Caribou Herd resulting from the Applicant's activities on a part of the critical calving area would cause an impact on subsistence harvests by rural residents in Canada and Alaska over the entire range of the Porcupine Herd. It is not possible to quantify the total loss to be expected even under worse case conditions.

Residents in Kaktovik annually harvest 30 Dall sheep for subsistence use. A repeater communication site is to be located in the area where a major portion of this harvest is presumed to occur. The Applicant will use helicopters to provide access to this communication site. Noise from helicopters may cause sheep to move further away from Kaktovik, and therefore, may make it more difficult for residents to get Dall sheep.

Two barren-ground grizzly bears are taken annually for subsistence purposes. It is believed that the proposed AAGPC pipeline system will cause sufficient displacement of local grizzlies so that it will be difficult for residents to obtain them for subsistence use. This will require a replacement cost of more than $600.

Subsistence harvest of 105 seals and one walrus by people at Kaktovik is presumed to occur throughout the year on an opportunity basis. If these marine mammals are displaced by shipping activities, subsistence harvest may be more difficult. Marine mammals now harvested have a subsistence food-cash value of $27,600 annually.

The proposed AAGPC pipeline system is expected to have no major impact on subsistence use of furbearers and small mammals.

The people of Kaktovik harvest between 6,000 and 15,500 pounds of fish annually. The proposed AAGPC pipeline system will require 125 million gallons of water during the winter construction season the pipeline is placed in the ground. Water supplies are scarce during the winter and while the Applicant indicates it does not intend to utilize such waters, it may become necessary to remove water from areas used by fish for critical overwintering areas. This could result in lower populations by killing fish and injuring eggs. It is probable that spills of fuel, lubricants, and toxic fluids would cause water pollution. The greatest chances for spills will be at Prudhoe, Camden, and Demarcation Bays and at compressor station sites. One compressor station is located on the Jago River which flows to the Beaufort Sea approximately 6 miles from Kaktovik. Dewatering critical fish overwintering areas and spills of fuel, lubricants, and toxic fluids may have a significant adverse impact on local subsistence harvest of fish since fish populations could be severely reduced.

In summary, the proposed AAGPC pipeline will have major and significant adverse impacts on subsistence activities of people living in Kaktovik in the form of hunting, fishing, and trapping--an important, major element of the traditional lifestyle of Native Alaskans. Basic necessities, such as food, can be obtained through public assistance programs (food stamps) or enhanced cash income opportunities resulting from construction, operation, and maintenance of the proposed AAGPC pipeline system. These, however, will not be sufficient to maintain the existing lifestyle of self-sufficiency and community sharing now present in Kaktovik.

It is concluded the proposed AAGPC pipeline system will likely increase the rate of change in the existing traditional, though dynamic, culture and habits of the residents of Kaktovik. It is probable that this change will occur over time without the project.

3.1.1.11 Land Use

Impact on Current Land Uses

The proposed AAGPC pipeline system involves areas where the following land uses are important: production of petroleum (Prudhoe Bay and associated fields); production of waterfowl; production of large mammals such as polar bear and caribou; subsistence; wilderness; recreation; and national defense.

Lands in the Prudhoe Bay area are already committed to a primary use of petroleum production. The State is actively considering issuing oil and gas leases in unidentified portions of State-owned submerged lands in the Beaufort Sea. Accordingly, the proposed AAGPC pipeline system will have a beneficial effect on development of oil and gas on State lands and especially in the Beaufort Sea Offshore Province.

Production of waterfowl and large mammals such as caribou and polar bear, and the recreational and subsistence use of wildlife species is a primary use of the Arctic National Wildlife Range. The proposed AAGPC pipeline system will alter existing natural distribution of wildlife populations through increased human activity in an area where there now is little. Accordingly, the proposed AAGPC system will have a significant adverse impact on existing uses of the Arctic National Wildlife Range related to wildlife production and subsistence and recreation uses of these resources. (See sections 3.1.1.10 and 3.1.1.13 for discussions of impact on subsistence and recreation, respectively.)

Barter Island DEW (distant early warning)-line site was established for national defense purposes. The proposed AAGPC pipeline system will increase the intensity of human activity, especially air transportation, in the vicinity of the DEW-line area by monitoring aircraft activity along the Arctic Coast. The overall impact of the proposed AAGPC pipeline system on national defense associated with aircraft monitoring is considered slight since other DEW-line and military radar units are located in areas having substantial aircraft activity. It might require that more personnel or more equipment be installed at Barter Island in order to cope with increased aircraft use.

Approximately 30 percent of the proposed AAGPC pipeline system would be located on State-owned lands supporting substantial industrial activity in conjunction with the development of the Prudhoe Bay oil field. That area, due to its ownership and use, is not eligible for consideration as wilderness under the Wilderness Act of 1964.

The remaining 70 percent (about 135 miles) of the proposed AAGPC pipeline system, however, is located on Federal lands within the Arctic National Wildlife Range, which meets the criteria established by Congress for inclusion in the National Wilderness Preservation System. The Arctic National Wildlife Range (with very minor exceptions listed below) is a wilderness which encompasses the only remaining largely undisturbed continuum of arctic ecosystems and vegetation types from the Arctic Ocean to the interior of Alaska. It is the only place in the United States where it is still possible to conduct long-term investigations into the natural history of arctic plant and animal communities in protected portions of the Arctic Coastal Plain, Arctic Foothills, Brooks Mountain Range, and the Porcupine Plateau. Nowhere else in the Alaskan Arctic are these physiographic provinces compressed into such a short distance. This continuum will be lost if the proposed pipeline system is constructed.

Former Secretary of the Interior Seaton stated prior to establishment of the Arctic National Wildlife Range that "the proposed Arctic Wildlife Range offers an ideal portion of the Arctic large enough to be biologically self-sufficient." The establishing Public Land Order stated management objectives of the range "for the purpose of preserving unique wildlife, wilderness, and recreational values."

As required by the Wilderness Act of 1964 (78 Stat. 890), the Arctic National Wildlife Range has been studied to determine its suitability for inclusion into the National Wilderness Preservation System. This study was completed by the U.S. Fish and Wildlife Service in 1972 and the following conclusions were drawn:

All 8,900,000 acres of the Arctic National Wildlife Range are currently suitable for inclusion in the National Wilderness Preservation System, except a 456-acre track at Camden Bay, a 420-acre tract near Beaufort Lagoon (Figure 3.1.1.11-1), those lands selected by the villagers of Kaktovik as designated by the Alaska Native Land Claims Settlement, and all of the 4,500-acre Barter Island withdrawn by the Air Force under PLO 715 and the 141-acre townsite of Kaktovik under PLO 3849.

Action has been deferred on the preliminary wilderness proposal because of Departmental responsibilities under the Alaska Native Claims Settlement Act of 1971.

Construction of port facilities at Camden Bay and temporary intensive human use for 2 to 5 years during construction of the proposed AAGPC pipeline system will enlarge the area unsuitable for wilderness. The loss of prospective wilderness could be as small as the several hundred acres physically occupied by the wharf and storage area, 2,400-foot gravel airstrip, and ancillary facilities. The loss could amount to several hundred thousand acres if the port became a focal point for future exploration and development of the Beaufort Sea Offshore Province. Impacts on wilderness values would be severe in this case. When considered as an isolated component, the impact of development of facilities at Camden Bay on wilderness in the Arctic National Wildlife Range is considered likely to be slight to modest since the area does not qualify for wilderness designation.

Construction of port facilities at Demarcation Bay with a 2,400-foot gravel airstrip and ancillary facilities would have an impact on wilderness similar to that of the port at Camden Bay except in this case it would involve construction and operation of a pipeline in an area where there are no exclusions from proposed wilderness designation. Wilderness values will be eliminated due to the construction, operation, and maintenance of the proposed AAGPC pipeline for which the following facilities will be erected in a line: berm over the buried pipeline; 10 block valves and heliports at intervals of more than 15 to 16 miles; 3 compressor station sites, 2,400 foot gravel airstrip, communication towers from 140 to 280 feet high (although the Applicant has recently stated it is seriously investigating the possibility of using satellite communications) and ancillary buildings at intervals of approximately 47 miles (Figures 1.1.1.2-1 and -2). These facilities will combine to form nodes connected by the pipeline berm. Each node will have a different impact on wilderness.

While the site for the future compressor station is not large in area, the impact of its physical presence in the open arctic landscape is great. Primary physical elements of compressor stations are: (1) concentration of massive man-made structures; (2) exhaust plume from compressor (7200 gal/hr of water vapor at 600° F); and (3) a communication tower. Operation of these facilities adds another dimension which in the Arctic is important--noise. Compressor stations will have 30,000 hp compressors and other

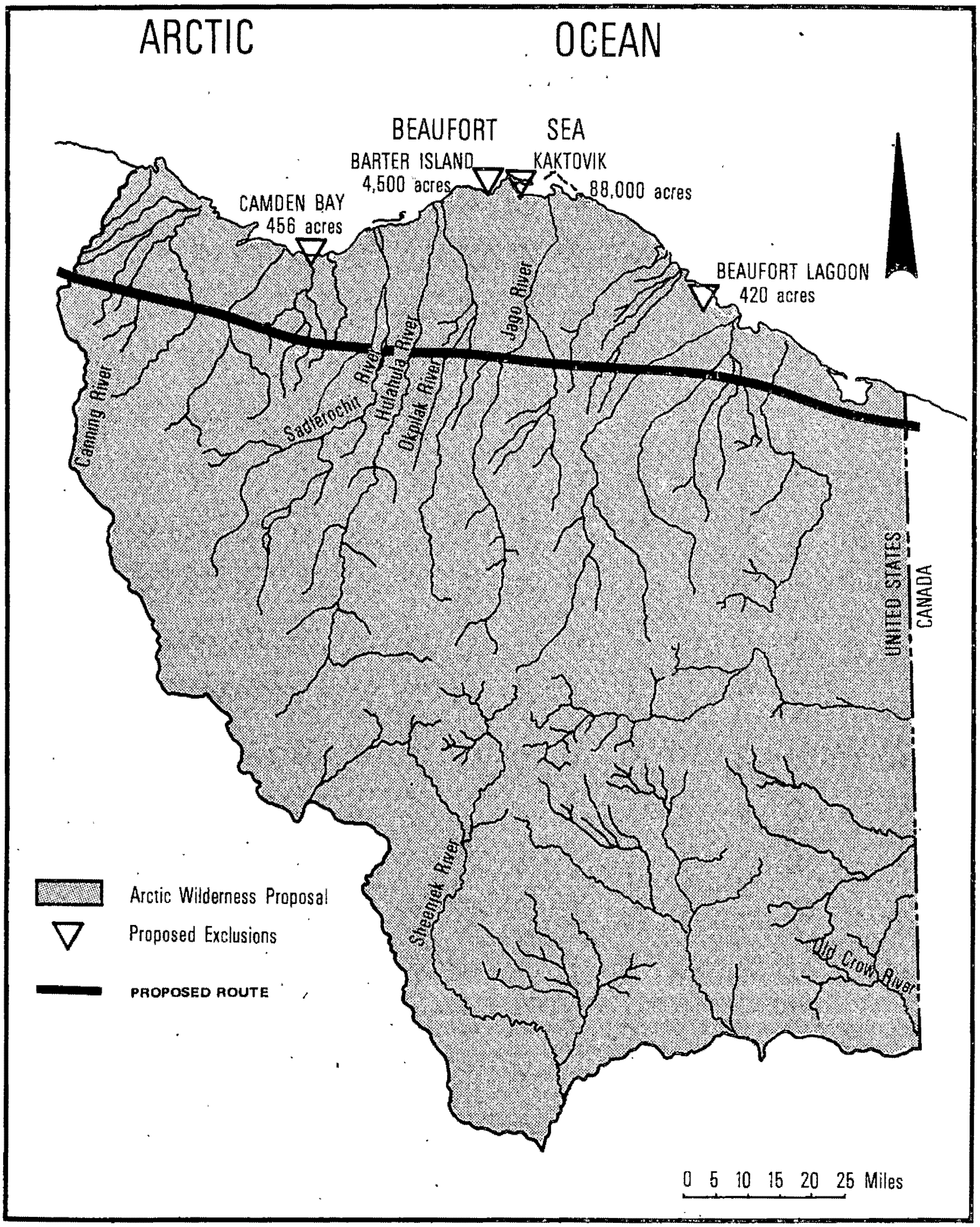


Figure 3.1.1.11-1 Lands recommended for wilderness status by U.S. Fish and Wildlife Service, 1972

mechanical devices emitting large volumes of industrial sound. Although the Applicant will be required to meet established national standards for sound emissions, the presence of any sound will be significant to wilderness values. It is nct inconceivable that compressor station operation may be audible at distances of 30 to 40 miles or more downwind from these sites under favorable climatic conditions since the terrain and vegetation do not provide the acoustical baffling found in more temperate climates. The level of noise, however, is expected to be low. Another major source of noise which will impact wilderness will be aircraft used to transport people along the pipeline and for routine monitoring of the pipeline system. The Applicant states that these flights will be at least weekly and probably more frequent during the spring when high water and ice scour combine to produce hazards to pipeline integrity. The adverse impact of noise and sight of the compressor station complex on wilderness will affect an elliptical zone 20 to 30 miles wide on an east-west basis (along the pipeline) and 30 to 40 miles long windward (north to south). (For discussion of Noise, see Section 3.1.1.15.)

Block valves and heliports will also impact wilderness because they will stand out from the landscape.

The pipeline berm is the binding thread connecting block valves with larger compressor stations. The berm will be punctured at frequent intervals to permit crossing of caribou and to minimize disruption of existing surface drainage. Accordingly, there will not be a continuous ridge of earth across the entire 195 miles of the proposed route in Alaska. This berm, however, will be revegetated with species of plants non-native which will be distinctive for many years. Assuming that the Applicant is correct in his conclusion that native species eventually will become reestablished, the development of a frost bulb could make a microclimate where it is unlikely that the native plants will be similar to adjacent plants. This vegetation-berm visual accentuation will be an estimated 120 feet wide and 195 miles long.

Impact on Land Ownership

The proposed AAGPC pipeline system will have no impact on State land ownership since leases or rights-of-way are expected to be granted by the State.

The proposed AAGPC pipeline system will have no impact on Federal land ownership since special permits or rights-of-way would be granted for project related facilities.

The proposed AAGPC pipeline system is not expected to have an impact on lands which may be selected by the North Slope Borough, Arctic Slope Native Regional Corporation, or Kaktovik Native Village Corporation.

Virtually no private lands are associated with the project. There are, however, 12 pending Native allotments which could become private lands. Some are associated closely with the proposed AAGPC pipeline system. It is not known what impacts the proposed system would have on private ownership of these lands but their original uses (hunting, trapping, fishing, berrypicking, or related subsistence uses) are expected to be significantly altered.

Impact on Land Use Planning

The Joint Federal-State Land Use Planning Commission for Alaska (JF-SLUPC) was authorized and established by U.S. Congress in 1971 as part of the Alaska Native Claims Settlement Act. The Commission is authorized to undertake a process of statewide land use planning, review and make recommendations on changes in laws, programs, or policies adversely affecting land use in Alaska and to review all Federal areas in Alaska which had been previously set aside for specified uses such as national defense, parks, and wildlife refuges. In August 1973, the Commission completed its initial review of Federal lands identified for potential addition to the national park, forest, wildlife refuge, and wild and scenic rivers systems. Because the Arctic National Wildlife Range was already in existence, no specific recommendations were made on its land use plan. Review of Federal lands such as the Arctic National Wildlife Range has not been completed. A statewide land use plan has not been completed.

The JF-SLUPC in its recommendations to the Secretary of the Interior on use of 80 million acres of Federal lands in Alaska made two pertinent statements relating to land use planning in Alaska affected by the proposed AAGPC pipeline system (Senate Committee on Interior and Insular Affairs, Comm. Print, 1974):

> 1) The Commission finds that land use should determine transportation patterns, rather than the reverse... (p. 27)
>
> 2) There needs to be a "policy for the Arctic" and it is necessary to recognize the necessity to minimize effects of human activity, especially in crucial activities such as...transportation and settlement plans.

The proposed AAGPC pipeline system will establish a new pipeline for natural gas. Associated with the proposal is the establishment of new air transportation in Alaska where none now exists. Development of the gas pipeline and air transportation will promote future establishment of related facilities including new oil and gas pipelines. Location of the proposed AAGPC facilities could lead to development of oil and gas within the Arctic National Wildlife Range as well as the Beaufort Sea Offshore Province specifically and influence development of the entire Alaskan arctic coastal area including Naval Petroleum Reserve Number 4 (Pet. 4) (Figures 1.1.1.2-1 and -2). Accordingly, the proposed AAGPC pipeline system will have a significant, adverse impact on statewide land use planning as commitments will have been made for both transportation and population distributions in the Arctic prior to the development of land use plan or policy for the Arctic. (See Section 3.1.1.10 for discussions of impact on population and transportation.)

The North Slope Borough is charged with mandatory, areawide responsibilities for planning, platting, and zoning. This newly established Borough is preparing a plan to implement these responsibilities. Accordingly, the impact on land use planning is assumed to be similar to that described for statewide planning.

Kaktovik has not received title to lands it selected under the provisions of the Alaska Native Claims Settlement Act. Accordingly, the impact of the proposed AAGPC pipeline system on land use planning by Kaktovik cannot be analyzed. (See Section 3.1.1.10 for discussion of subsistence.)

The State of Alaska has not prepared a land use plan for lands in the Prudhoe Bay area. The proposed AAGPC pipeline system crosses an area of

State ownership. This area is developing rapidly into a major petroleum exploration and extraction area under State direction. Accordingly, it appears that in this particular area the proposal will not affect existing land use planning on State lands. It would, however, enhance leasing of State-owned lands offshore from the Arctic National Wildlife Range. There are major implications to overall State land use planning since the proposed AAGPC system commits State-owned gas (12.5 percent by the Prudhoe Bay Field) for export without use elsewhere in Alaska (see section 8.1.1.1, Alternatives).

The land use plan for the Arctic National Wildlife Range is to protect unique wildlife, wilderness, and recreational values. On December 18, 1973, the Secretary of the Interior recommended that the existing Arctic National Wildlife Range and 3.76 million acres south of the proposed AAGPC pipeline system be established by the Congress as the 12.7 million acre Arctic National Wildlife Refuge. It was further recommended that within 3 years after the status of the existing Range was changed to Refuge by the Congress that the Secretary would submit his recommendations on the suitability or nonsuitability of the area for inclusion in the National Wilderness Preservation System. Accordingly, the proposed AAGPC pipeline system would preempt wilderness designation of the coastal region of existing Arctic National Wildlife Range (see Section 3.1.1.11-C, Wilderness). Thus, the impact of the proposed pipeline system is considered major and adverse on land use planning for the Range.

There is no comprehensive land use plan for gathering lines and pump stations for the Prudhoe Bay, Kemik, or Kavik fields or for connection of these fields. There is no plan for relating these fields with Petroleum Reserve No. 4 (Pet 4) to the west or potential fields to the east.

The proposed AAGPC pipeline system crosses the traditional calving ground of the Porcupine Caribou Herd and is some 5 to 30 miles inland from the Beaufort Sea (Figure 2.1.1.7-2). The Marsh Creek anticline and the Beaufort Sea are both considered to have very good potential for substantial oil and gas deposits. The Marsh Creek anticline could approach the size of the Prudhoe Bay Field while the Beaufort Sea Offshore Province is considered by the State of Alaska to contain estimated speculative reserves of 2.7 billion barrels of oil and 13.5 trillion cubic feet of gas. The Applicant reasonably predicts that the proposed AAGPC pipeline system (communications, pipeline, airfields, and port areas) will stimulate exploration and development of oil and gas along the Alaskan Arctic Coast.

Assuming there are significant deposits of oil and gas discovered in the Marsh Creek anticline and eastern Beaufort Sea, it will be necessary to construct an extensive system of gathering lines from wells to pump and processing stations, roads, and living quarters. These developments would be on a scale comparable to Prudhoe Bay (depending upon the ultimate size of the new fields). These new facilities would be located within the western and northern portions of the caribou calving grounds. It is further assumed that any major network of gathering and pump stations would connect to the Applicant's proposed facilities at the closest reasonable place instead of the initial facilities at Prudhoe Bay. Accordingly, the proposed AAGPC pipeline will adversely affect land use planning within the Arctic National Wildlife Range and under worst case conditions could result in total destruction of the Porcupine Caribou Herd (115,000 to 120,000 animals) and other animals and bird life by connecting the herd's traditional calving area to an interconnected maze of wells, feeder lines, processing plants, pump stations, and housing (see Section 3.1.1.7, Wildlife).

In summary, the impact of the proposed AAGPC pipeline system is considered likely to be severe and adverse since it commits land uses in the absence of a comprehensive statewide plan and a "Policy for the Arctic." This is especially important since the proposed AAGPC pipeline invades the only remaining large area on the Alaskan Arctic Coast where human activities are not already pronounced, or where land use commitments have not already been made which will increase activity.

Impact on Wilderness

The proposed AAGPC pipeline system because of its individual components will have a cumulative, long-range adverse impact on wilderness. Presence of the pipeline system will introduce machinery, noise, and workers. The presence of more people will have a long-term detrimental effect on resources which are scarcer each year--solitude and quiet. The proposed AAGPC 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 area to such extent that it would no longer qualify for inclusion in the National Wilderness Preservation System. The impact of the proposed project is, therefore, adverse and major on wilderness character. It is expected that the zone of lowered wilderness character will extend southward to the northern flanks of the Brooks Range, thereby removing entirely the wilderness continuum from the Beaufort Sea through the Brooks Range.

3.1.1.12 Historic, Archeological, and Unique Area Values

Impact on Historic Values

Dating from 1906, Leffingwell Camp on Flaxman Island off the mouth of the Canning River was built for scientific purposes. It was placed on the National Register of Historic Places in 1972.

The Applicant proposes to construct a new port facility at Camden Bay, approximately 30 miles east of Flaxman Island. It is conceivable that increasing human activity associated with the proposed AAGPC pipeline system could increase threat of vandalism to the historic Leffingwell Camp area. This is considered unlikely, and it should be noted that oil and gas drilling exploration is now actively pursued on Flaxman Island. Shipping of construction materials and supplies to Prudhoe Bay will pass offshore of Flaxman Island on its route from the Mackenzie Delta in Canada. Increased shipping is not considered a threat to the historic Leffingwell Camp area.

There are no other sites on or nominated for the National Register of Historic Places along the proposed route. Accordingly, the proposed AAGPC pipeline system is considered likely to have only slight impact if any from increased threat of vandalism of historic places along the Alaska Coast between Prudhoe Bay and United States-Canada border.

Impact on Archeological Values

Very little is known about prehistory of this portion of the Alaskan Arctic Coast. New information on prehistoric cultures obtained during ongoing studies and investigations of the trans-Alaska oil pipeline system from Prudhoe southward along the Sagavanirktok River indicate, however, that it may have substantial archeological values.

This project could provide a great abundance of information similar to that obtained from surveys along the trans-Alaska oil pipeline.

During the construction phase it is highly probable that excavation of sites will be carried out under difficult winter conditions (chill factors to -100° F) and tight construction schedules. Accordingly, it appears that impacts of the proposed AAGPC pipeline system on the partial or complete destruction of archeological sites could be severe unless specific precautions are taken.

Construction of airstrips will make the area more accessible in the future. Thus, unauthorized disturbance of antiquities and vandalism of archeological sites throughout the region are expected to increase. This secondary impact of improved accessibility on regional archeological values is considered significant and adverse.

Archeological values may have an adverse impact on the scheduled completion of the proposed AAGPC pipeline system. Provisions of the National Historic Preservation Act of 1966, Executive Order 11593, and the Archeological and Historic Preservation Act (P.L. 93-291) require that archeological values be identified and protected. Thus, it is possible that the construction of the pipeline or ancillary facilities could be delayed or rerouted within the permit area, to insure that archeological values are protected.

Impacts on Unique Areas

During the past several years, proposals have been made to the Joint Federal-State Land Use Planning Commission that a balanced and representative system of unique areas in Alaska be set aside in their undeveloped condition. One objective of this system would be to assure that there are areas where baseline data can be collected so that human influences on the environment can be minimized as land uses change. The proposed AAGPC pipeline system involves 15 areas which have been nominated for special management because of their unique geological and/or biological values. These sites are described in Section 2.1.1.12. The following discussion summarizes expected impacts on these unique natural areas:

Prudhoe Bay

The proposed AAGPC pipeline should have no impact on this proposal since there are still ample opportunities to select 100- to 500-acre sites of undisturbed coastal tundra, and the primary object is to measure such changes as would occur with the Applicant's gas pipeline system.

Sagavanirktok River

The proposed AAGPC pipeline system crosses the Sagavanirktok River near its delta in an area where there is substantial existing alteration of the environment. The upstream areas of the Sagavanirktok River are now being used as a source of gravel to build the trans-Alaska oil pipeline system. Although the proposed AAGPC pipeline route will affect the hydrology and biology of the river through additional gravel removal and development of a frost bulb (see 3.1.1.5, Water Resources) it is questionable that the proposed AAGPC project would seriously impair present values of the river as an example of an arctic braided stream.

Kadleroshilik River and Plain

The proposed AAGPC pipeline will have no appreciable effect on permafrost features over such large areas (see 3.1.1.3, Geology) and therefore little, if any, impact on the preservation of permafrost features.

Kadleroshilik Mound

A 160-acre site encompassing the pingo has been recommended for protection. The proposed AAGPC pipeline system avoids pingos and therefore, will have no impact on preservation of Kadleroshilik Mound.

Shublik Spring

Ten thousand acres surrounding the Spring have been recommended for protection. The proposed AAGPC pipeline is located 40 miles to the north but has water requirements for wintertime construction which may cause water withdrawals from this spring. It is believed that any activity requiring water withdrawal from this spring during wintertime would seriously lower, if not destroy, its existing natural values. The Applicant has stated that it would not, under any conditions, take water from this location for its needs.

Flaxman Island

The proposed AAGPC pipeline system is located inland of Flaxman Island. However, ships transporting supplies and materials to Prudhoe Bay for the AAGPC pipeline would pass near Flaxman Island. Overall, the AAGPC pipeline system is expected to have no impact on the unique values of Flaxman Island.

Fire Creek

The proposed AAGPC pipeline system shows no planned activities at this site. Accordingly, the proposed AAGPC system will have no impact on the paleontological values at Fire Creek.

Sadlerochit Spring

This large, warm water spring is located approximately 6 miles south of M.P. 113 on the proposed AAGPC pipeline system. Values are similar to those described for Shublik Spring and 640 acres have been recommended for protection. Impacts on Sadlerochit Spring resulting from the proposed AAGPC pipeline system will be similar to those described for Shublik Spring. However, because of the proximity to the pipeline route (6 miles), it is believed more likely to be affected by the project than Shublik Spring.

Neruokpuk Lakes

A total area comprising 60,000 acres and both lakes (Peters and Schrader) have been recommended for special management. Because both lakes are well upstream from the pipeline, there should be no impacts on their water quality. 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.

Jago River

The entire 400,000-acre Jago River basin have been proposed for special management. The proposed AAGPC pipeline system intersects the Jago on the interface between the Arctic Coastal and physiographic provinces. 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 is not directly associated with the Beaufort Sea. Temporary impacts could result from the ship transportation of materials from the Mackenzie River to ports at Camden and Prudhoe Bays. The extent of water transportation impacts on water quality and upon animal life in the Beaufort Lagoon is not quantifiable. 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 (see Section 3.1.1.5, Water Resources). In summary, potential exists for degradation of the unique qualities of Beaufort Lagoon.

Demarcation Bay

Approximately 18,200 acres of offshore bars and islands in the Demarcation Bay area have been recommended for special management as good examples of the island and bar formation along the eastern Beaufort Sea. The Applicant proposes to construct and operate a major receiving area for barged materials needed to construct the pipeline. The Applicant further indicates that such areas will be used for future exploration and development activities by other industries. Ships moving to the Demarcation Bay area for the 2 years during initial construction, and possibly when compressor stations are constructed during the next 2 to 5 years after initial operation of the pipeline, are expected to produce little, if any, impact on the natural formation or destroy offshore bars and islands. There will be major impacts on the birds, fish, and animals using offshore bars and islands in the Demarcation Bay area as a result of the port activities (noise and movement). See Section 3.1.1.7, Wildlife, for a more detailed discussion.

Icy Reef

Impacts at Icy Reef caused by the proposed AAGPC pipeline system would be similar to those described for Flaxman Island since the project is not directly associated with the 10,600 acres recommended for special management. No port facilities are planned at Icy Reef.

Clarence Plain

The proposed AAGPC pipeline system crosses the Clarence Plain but is not expected to appreciably affect the high concentration of permafrost features since the pipeline route avoids as many permafrost features as possible.

See 3.1.2.3 (Canada) for an impact analysis of pipeline construction, operation, and repair activities within the proposed Firth River Ecological Reserve (2,140 sq mi) in the adjoining Yukon Territory, Canada.

3.1.1.13 Recreational and Esthetic Resources

Impacts on Recreational Resources and Use

The recreational resources of the area through which the proposed AAGPC pipeline system will pass are based upon the natural features and character of the land and on the flora and fauna present in the area. The resources vary from a view of the Brooks Range or the Beaufort Sea to the thrill experienced by a successful sheep hunt. The land area protected by the establishment of the Arctic National Wildlife Range will and does provide most of the recreational use of the area.

Present recreational use of the area is light. About 150 people used the Arctic National Wildlife Range during the summer of 1974 for recreation. There is some winter recreational use (cross-country skiing), but it is minimal. The summer visitors included hunters (65 percent of use).

It must be realized that, given the small numbers of present recreationists, the lack of data on recreational use for the State as a whole, and the uncertainties of predicting recreational use even in well-known areas, meaningful quantification of impacts is impossible.

While the emphasis here is on impacts created by the proposed route of the AAGPC pipeline, it is evident that impacts will be compounded by the proximity of the Prudhoe Bay Field and its associated facilities, the most important of which, from a recreational point of view, is the possible future public use of the oil pipeline-related road.

Impacts on the existing company-owned recreational units at Prudhoe Bay probably will be minimal as any new company in the area will provide its own recreational facilities at an early date. There probably will be increased recreational use of the airstrip at Barter Island, some of which can be attributable to pipeline-related interest in the region.

Two types of primary impacts on recreational resources will occur as a result of pipeline construction and operation. First is the physical destruction of portions of the resource by digging into it, covering it over, or otherwise changing its structure. The extent of this is limited to the area beneath the pipeline and its related facilities, about 4,600 acres as estimated by AAGPC (1974a).

Second, with increased awareness of recreational opportunities created by pipeline-related activity, there will be increased recreational use and demand for recreational facilities with the attendant impacts described above. New recreational resources will be discovered with resulting demands for their use and preservation.

Projecting increased recreational use assumes that gas pipeline construction and operation may bring increased potential for recreational use of the area because increased numbers of people will become aware of the recreational possibilities of the area through publicity and personal association (employees). Assuming that increased use will bring increased control, recreationists may be affected by such things as reservation systems, reduced options for types of experiences, and restrictions on places they may go and length of their stay.

The "goodness" or "badness" of impacts vary according to the individual perceiving them. For example, the presence of pipeline-related airstrips would be considered "good" by recreationists who feel this "safety feature" in emergency situations is necessary to a reasonable recreational experience. Airstrips would be "bad" for those wishing maximum wilderness as a part of their recreational experience.

Although the pipeline itself will in the future be seen as a mound only a few feet wide, it will be visible to airborne sightseers from great distances. For the adjacent area in Canada, it is reported:

> Seen from the air initially, and for 3 to 5 years following construction, and possibly longer, the trunkline will appear as a heavily disturbed seismic line. A successful revegetation program will reduce impact, but the line will be visible for decades as has been the case for other lines through a variety of vegetation types in other parts of the world. Because of its almost central location between the coastline and the mountains, the pipeline will spoil low-level aerial viewing and ruin the photographic appeal of the scenery. For on-the-ground viewing, the backfill mound and other evidence of construction will mar vistas and general scenery (Environmental Protection Board, 1974).

Ground-level recreationists within several miles of the line will have their recreational experience affected by increased noise levels from construction and operation of the line. Noises will result from blasting (temporary and short-term), aircraft, vehicles, compressor operation, and gas flowing through the pipe (nearly continuous and lasting throughout the life of the pipeline).

Increased sport fishing coupled with slow growth rates of fish will reduce the numbers of trophy-sized fish and could reduce the total numbers of fish. This will make the area less attractive for fishermen.

Game populations will be affected by the construction and operation of the proposed project and by increased pressure from hunting and/or "viewing" harrassment. This will slightly reduce the total numbers of animals available and thereby reduce the recreational potential of the area.

Increased recreational use will bring increased demands for facilities on the Arctic National Wildlife Range not now proposed. If present policy holds, the demands will not be met; if the policy changes and facilities are built, impacts on the management of the area will be as follows:

The Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service will need to develop and enforce controls on land use to prevent intolerable destruction of ecosystems and hunted or fished species.

There will be demands for development of such recreational facilities as campgrounds, visitor centers, and trails.

Increased visitation will bring increased costs to taxpayers. These costs could be offset or eliminated by increased tax revenues created by increased income in the tourism sector of the economy.

Portions of the ecosystem will be destroyed through trampling by recreationists.

Increased recreational use will create in the general population an increased awareness and appreciation of arctic ecosystems and scenic values which in turn will bring about an increased demand for recreational facilities.

In summary, the proposed AAGPC pipeline project will change existing recreation uses, especially in the Arctic National Wildlife Range where wilderness recreational opportunities are a major attraction.

Impacts on Esthetic Resources

The esthetic resources of the area proposed to be crossed by the AAGPC pipeline system are primarily tied to the "wilderness mystique" exemplified by the Arctic National Wildlife Range. On the Wildlife Range the northern flanks of the Brooks Range are within 12 to 40 miles (19 to 64 km) of the Beaufort Sea. There, the natural continuum of arctic ecosystems from the sea coast to the crest of the Brooks Range is compressed into the smallest distance in Alaska.

For some people the development of a mammoth oil and gas reservoir or any other great engineering feat provides a great amount of esthetic enjoyment. For those people the proposed project will enhance the esthetic value of the area.

For those people whose appreciation of esthetic qualities is related to beauty, pure feelings or sensations, or to an individual's sense of "correctness" of the environment, the proposed project will have a severe effect. The effect will be immediate, long term, and adverse.

The Arctic Institute of North America (Namtvedt et al. 1974) presented the following impression of impacts of oil development in the Arctic. The relationships described below apply to the AAGPC proposed project:

> Wilderness and solitude are two of the major resources of Alaska and both are extremely susceptible to disruption by encroachment of technological society (Butters, 1973). Establishment of camp facilities and exploratory drilling structures will detract from the solitude and wildness of the area.
>
> Unless strictly controlled, chronic low-level pollution resulting from solid and liquid waste disposal may negatively affect the aesthetic qualities of the area. Operation of aircraft, surface vehicles, and equipment will create an added factor of noise pollution to the Arctic. Odors generated by human waste and drilling wastes will negatively impact the aesthetic value of the area. These will be largely site specific, but may become local during development and production phases. Regional impacts may result with increasing levels of activity across the Arctic.
>
> Impacts on the aesthetic character of the Arctic may have effects outside the study area. Many people, State- and nation-wide, attain a certain peace of mind knowing there is a vast and essentially untouched area in existence. The idea of having roads, drilling rigs, and heavy equipment present in this untainted area destroys the image of vast openness and mystery and eliminates the last vestige of the great American Wilderness.

On-the-ground viewers also will be able to see from great distances such facilities as the communications towers, the buildings at compressor sites, the block valves, and port. At times, even the pipeline mound will be visible from great distances to those hiking in the mountains south of the pipeline. Lights on communications towers and at compressor stations will be visible over long distances. This will mainly affect winter users as sunlight is nearly constant during the summer.

The regular (i.e., non-natural) shape of compressor site gravel pads, airstrips, and roads will give a man-made appearance to the presently natural landscape.

Without defined trails (the present situation), it is possible that hikers and skiers will pass over borrow pits, access roads, and other off-the-pipeline right-of-way disturbances as well as the pipeline itself. Those passing over the pipeline during summer will see the exotic vegetation used to stabilize the pipeline ground cover.

Boaters on rivers and hikers near them will be aware of places where the pipeline crosses rivers and their experience will be affected by barge traffic and gravel extraction sites.

Artificial odors will be introduced from engine exhausts, fuel areas, and camps.

In summary, construction and operation of the pipeline will affect the esthetics of the area. It also will reduce the diversity of esthetic (natural beauty) resources available to mankind, and will thus reduce man's ability to have a maximum variety of esthetic resources.

Section 3.1.1.11 presents a detailed discussion of the impact of the proposed project on the wilderness aspect of the area.

3.1.1.14 Air Quality

Impact on Air Quality

Several elements of the proposed AAGPC pipeline system will cause at least temporary deterioration of air quality--exhaust emission from construction equipment, dust, emissions from the Prudhoe Bay field office, emissions from future compressor stations, and release or escape of natural gas from the pipeline system.

Exhaust Emissions from Construction Equipment

The proposed AAGPC pipeline project will require use of at least 30 bulldozers in the 100- to 200-hp class, 100 bulldozers over 200 hp, 50 pipelayers, 100 units of earth-moving excavation equipment, 100 units of compressor drills, 6 pipe benders, 9 crushing units, 110 tractor-trucks, 120 trucks in the 5- to 16-ton class and 240 trucks between 1/2 and 5 tons. The Applicant proposes to use approximately 47,000 tons of fuels and lubricants for surface vehicles and aircraft. The primary period of concentrated use of these vehicles will be during the single winter construction season that the pipe is assembled and placed in the ground. Equipment will be in use, however, during the entire 3 years that the project is being built. For example, the Applicant will be extracting gravel and sand during the summer and early winter, building port facilities and compressor station pads, and distributing supplies over the 2 years preceding pipe burial.

Major construction activities will be concentrated during the winter months and will cause temporary deteriorations. Construction equipment will not be in a fixed location and will be short term. Accordingly, the impact of construction equipment exhaust on ambient air quality is considered not to be a significant air quality deterioration as defined in the existing air quality standards for either Class I or Class II air quality management areas. There may be secondary short-term adverse impacts on air quality when ice fog is created around construction equipment (including the large amounts of heat necessary to weld the segments of pipe together prior to placing it in the ditch). The Applicant has stated he will use 47,000 tons of fuels and lubricants in this portion of the project. Assuming that 80 percent of the equipment used will be diesel, then the emissions inventory would be as follows:

	CO	UHC	NO_X	SO_X	Part.
Gasoline operated equipment (tons)	3,200	281	159	12	15
Diesel operated equipment (tons)	84	191	312	56	154
TOTAL:	3,284	472	471	68	169

These emissions will be dissipated over a period of 3 years and a distance of 195 miles, with concentrated usage during the single winter of construction. Areas where the pollution levels will be the highest are in inversion basins, river bottoms, and ice fog concentrations.

Dust

There is an abundance of sand, silt, and other fine materials along beaches, lake shores, and streambeds. Wiggins and Thomas (1962) observed that the amount of fine dust from these sources is very great and that prevailing strong winds carry dust long distances in August and September before the ground freezes. A substantial amount of this dust is swept along, only a few inches above the surface. With winds having maximum velocities of 35 to 47 miles per hour between August 21 and 26, 1960, Wiggins and Thomas (1962) reported deposition of an average of 0.25 inch of fine materials among plants on a flat surface of tundra next to a recently drained lake and up to as much as 1.5 inches of fine material 75 yards (68.6 m) downwind from the lake behind a small hummock. In addition to smothering, wind-driven particles have an abrasive effect upon plants, with tender growth being killed back to older more protected parts. Lichens are very sensitive to sulfur dioxide. Long exposure to 0.05 ppm is considered damaging by Schofield and Hamilton (1970). The ambient SO_2 averaged over the 3 years of construction would be less than 0.002 ppm.

The proposed AAGPC pipeline will require at least 3.1 million cubic yards of sand and gravel. This material will be used to construct heliports, airstrips, compressor stations, port and material storage areas, and for selective pipe trench backfill at the several locations along the route. Most borrow materials will be taken from active and fossil flood plains. The Applicant plans to extract gravel and sand from active flood plains during the summer and early winter. The mechanical action of excavation will expose a new source of fine-grained materials which, when in a dry condition, would add dust to the environment. Transporting borrow materials to proposed sites for airstrips, compressor station pads, etc. will provide new sources of fine-grained materials which will add dust to the environment. The anticipated impact of dust resulting from the proposed AAGPC pipeline construction activities is considered to be local and not a significant deterioration of air quality since amounts of dust should be small and of only a short duration. In addition to wind-carried dust, operation of fixed-wing aircraft and helicopters from gravel airfields and helipads will produce unknown but long-term addition of small amounts of dust in the air at new locations. Dust at those places will be reflected as a secondary impact on vegetation to the downwind side of dust sources.

Most construction equipment will be operated during the wintertime on snow/ice roads. Accordingly, additions of dust to the environment are not anticipated from their use. In the event the existing trans-Alaska oil pipeline haul road is used to supplement barge transportation of construction materials for the proposed AAGPC pipeline system, addition of dust to the environment by vehicles using the gravel road would occur. Amounts of dust are speculative, but assumed not to be substantially different from those resulting from movement of supplies for the oil pipeline system.

The Applicant indicates that nine crushing plants will be used to process granular materials. The location of these plants and the period of use are unknown. Therefore, the impact of the dust added to the environment from operation of these nine plants is unknown. It is noted, however, that crushing plants do produce substantial amounts of dust locally and that there may be serious temporary air quality deterioration as well as secondary impacts on vegetation.

Prudhoe Bay Field Office

The proposed AAGPC pipeline system will require construction of a permanent field office at an unannounced location in the Prudhoe Bay area. The field office includes office space for a permanent operating, maintenance, and monitoring staff of 39 people, housing, repair shop, maintenance and equipment storage, utilities, and graveled parking areas. The Applicant has not provided information on the type of heating or utilities associated with the field office. Accordingly, the impact of the field office on air quality cannot be evaluated. Because of the small size of the field office and general character of existing air quality at Prudhoe Bay, it is presumed that any pollutants released in the air from these permanent facilities would meet standards for either Class I or Clas II air quality management area.

Port Areas

The proposed port sites at Camden and Demarcation Bays would contain a construction camp and will serve as the focal point for landing all equipment needed for the construction of the proposed AAGPC pipeline. Ships and barges will be used to transport construction materials (except for borrow materials) to these two sites and the existing port site at Prudhoe Bay. Anticipated use of the three Alaskan port sites will be limited to a few years during construction phases, with major activities during the 6-week shipping season and during the winter, when snow/ice roads will be used to transport materials from port sites to the pipeline route. Impacts from exhaust emissions of equipment and construction camps at the proposed AAGPC Camden and Demarcation port sites are similar to those described for construction equipment and construction camps in that air quality changes would be temporary and local. Quantification of this impact on air quality is speculative, but because of the landward movement of prevailing winds, it could be major. Because both Camden and Demarcation Bay areas are presently uninhabited, the impacts on air quality will be as significant on potential ecological reserves as on inland sites. The impact of exhaust emissions at the existing Prudhoe Bay port site is considered modest and would be an incremental reduction of air quality in the area.

Port sites at Camden and Demarcation Bays are identified by the Applicant as having prospective long-term use for other oil and gas exploration and development activities (such as in the Beaufort Sea offshore area). Thus, it is likely that the existing air quality of the Arctic National Wildlife Range would reflect industrialization similar to that now observed in the Prudhoe Bay area. The long-term impact of such an action on air quality is considered significant and major since prevailing winds will distribute air pollutants from the east inland to the Brooks Range.

Future Compressor/Chiller Stations

Ultimate planned operation of the proposed AAGPC pipeline system will require construction of four compressor/chiller stations between Prudhoe Bay and the United States-Canada border. Construction of these facilities is necessary when the volume of gas to be transported in the pipeline exceeds 2.25 bcf/d (billion cubic feet per day). This is expected to occur between 2 and 5 years after the pipeline system is operational. Air quality will suffer if these stations are placed in inversion basins.

During pipeline construction the four Alaskan compressor/chiller station sites will be used as the location of major (500- to 800-person) construction camps. The first compressor site (CA-01) is located within the industrialized area of Prudhoe Bay at Mile Point 44. The remaining three compressor sites are within an uninhabited area within the Arctic National Wildlife Range.

There will be intermittent emissions of hydrocarbons (unburned fuel) as a result of leaks, venting, upsets, and other accidental emissions. Each station will have a 30,000-hp turbine-driven compressor and a 17,000-hp refrigeration unit. The refrigerant used will be propane.

There will be living quarters and facilities for 30 people at each station, although they normally will be unmanned. The portion of these facilities that could affect air quality are an incinerator, a 250- to 300-kw generator, and building heating systems.

The projected emissions from each compressor/refrigerator station, as projected from A.S.M.E. bulletin 75-DGP-20 (Dietzmann, 1974) would be as follows for the average gas turbine compressor of 30,000 hp and a 17,000 hp gas turbine refrigeration compressor at the stock outlet.

NO_X	134 lb/hr	If the sulfur level in the gas is
THC	9.32 lb/hr	20 grains/100 cubic feet, the SO_2
CO	4.66 lb/hr	discharge will be 9.384 lb/hr.

The dispersion of these emissions will vary due to atmospheric conditions and distance from the facility.

At present the behavior of emissions within ice fogs has not been researched to enable predictability; however, it is known that a large percentage of ice fog particles do have particulate nuclei. Since the compressor stations will be expelling both nuclei and water vapor, it may be assumed that ice fog will form and be a problem. The stack effluent will contain about 26,000 lb/hr of water vapor which would form 32,000,000 CFH of ice fog (Ohtake, 1970). At present, this area may expect 90 days of fog annually and 118 days of visibility of less than 1 mile.

Methods have been developed to enable the prediction of dispersion of emissions. Whether this method holds true in ice fog conditions is not known (Turner, 1970). For purposes of such estimation, each compressor station is considered as a point source. Then the measured emission rate, wind speed, inversion propensity, and stack height are used in the appropriate dispersal relationship. Using this basis the following worst case estimates can be made for NO_X.

Distance from source	Inversion (worst case)	Normal (most frequent case)
500 m	491.4 μg/m³	33 μg/m³
1,000 m	262 μg/m³	17.6 μg/m³
10,000 m	32.4 μg/m³	2.3 μg/m³

The limit set by the EPA's National Air Quality standards for the annual arithmetic mean is 100 μg/m³.

The tariff proposal of the Applicant suggests that there may be as much sulfur content as 20 grains/100 cubic feet of gas. If this is so, the sulfur dioxide level in the effluent will rise. Tests have determined that below 0.002 ppm lichens are not injured by SO_2, that between 0.006 to 0.03 ppm chronic exposure may cause injury and that above 0.03 ppm acute exposure (hours or days) may cause injury. If as much as 20 grains per hundred cubic feet of total sulfur were permitted in the gas, then under very high wind conditions (25 mph) it would be possible for concentrations to rise on the ground as high as 0.006 ppm. More likely, however, would be temporary concentrations of 0.001 ppm with 10 grains per hundred cubic feet and 5-mph winds. Since these would be short-term exposures under the usual variations of wind speed and direction it is most likely that the chronic exposure of lichen will be below the chronic damage threshold for epiphytes.

This deterioration of existing air quality appears to be within the limits of Class III air quality management areas. As indicated earlier, it is debatable whether the individual or cumulative impact of deteriorating pristine air quality resulting from exhaust emissions within the Arctic National Wildlife Range is acceptable as a Class I area.

3.1.1.15 Environmental Noise

The predicted impact of noise emissions from the proposed pipeline is addressed separately for humans and wildlife. The impact is further subdivided in terms of the construction phase and the operational phase. In general, the construction noise will be short-term and widespread, while the operational noise will be long-term and more localized.

Effects on Humans

Construction Phase

The construction phase will produce both indirect and direct noise impacts. The indirect noise impact will be due to the road traffic generated by the project and the direct will be construction site noise.

Road Traffic

The primary cause of noise impact due to road traffic will be heavy diesel trucks hauling construction equipment and pipe. Since most of the construction equipment will remain on the site, except when hauled around major waterway obstacles, the pipe hauling operation is estimated to create the largest impact. It was not possible to determine the population that will be exposed to hauling truck traffic since the access roads from the three initial material stockpiles (Camden, Prudhoe, and Demarcation Bays) will need to be constructed and their exact locations have not been decided.

Right-of-Way Construction

Construction of the pipeline along the right-of-way will require large numbers of heavy equipment which will operate in groups doing various phases of the construction. Most of this equipment will be diesel engine powered. Typical noise levels (in dBA at 50 feet) of construction equipment are given in Figure 3.1.1.15-1 (U.S. EPA, 1972). These are levels that are found while the equipment is performing its task and would represent those levels observed on the pipeline construction site. It is estimated that the welding equipment would be acoustically similar to stationary air compressors.

The energy mean of dBA values measured at 24 sites during excavation (corrected to a distance of 50 ft) is 84 dB (N.Y. Dept. of Env. Cons., 1974). This level is estimated to be representative of the day-night sound level (L_{dn}) at 50 ft (since there is no nighttime construction planned). No residences could be located within the area impacted by a L_{dn} in excess of the U.S. Environmental Protection Agency (EPA) goal (55 dB) for protection of human welfare (U.S. EPA, 1973).

Blasting and Vibration

Blasting operations during the construction phase will produce direct impacts on nearby structures. Drilling and blasting will be required where trenching through rock cannot be accomplished by ripping and removing the loose material with a backhoe. The detonation of explosive materials induces transient motion in the rock which is then transmitted through the surrounding rock and through any overlying or underlying strata. It is this motion, referred to as ground motion, which directly or indirectly damages structures. Direct damage to structure occurs when the motion produces stress levels sufficient to cause structural failure such as cracking of foundations, loosening of mortar, and other damage to the primary structure. Safe limits of ground motion from blasting (Crandell, 1949; Hendron and Oriard, 1972; Soliman, 1973; and Steffens, 1966), for structures, building components, and sensitive equipment have been established at an acceleration level of 38.6 inches per second from 5 to 15 Hz and a velocity level of 0.4 inch per second above 15 Hz. Below these levels structural failure generally does not occur, but rather a secondary effect may occur which is the settlement or compaction of soil caused by ground motion.

Under sustained vibratory loads or repeated impacts such as caused by blasting operations, the internal structure of soils may change, thereby producing settlement of surface or possibly a reduction in strength. It is well known that loose, saturated cohesionless soils are particularly susceptible to compaction by impacts or vibration.

For example, damage from traffic induced ground motion in medieval cathedrals of England and Wales has been investigated (Crockett, 1963), and predominant cracking and settlement were reported within those structures located adjacent to roads even though the ground motion levels were substantially below those specified above as safe limits. Approximately 10 miles of blasting will be required between Mile Posts 81 and 111, where the bedrock is exposed at the surface or covered with less than 10 feet of unconsolidated materials. No buildings along the route appear close enough to be damaged by blasting.

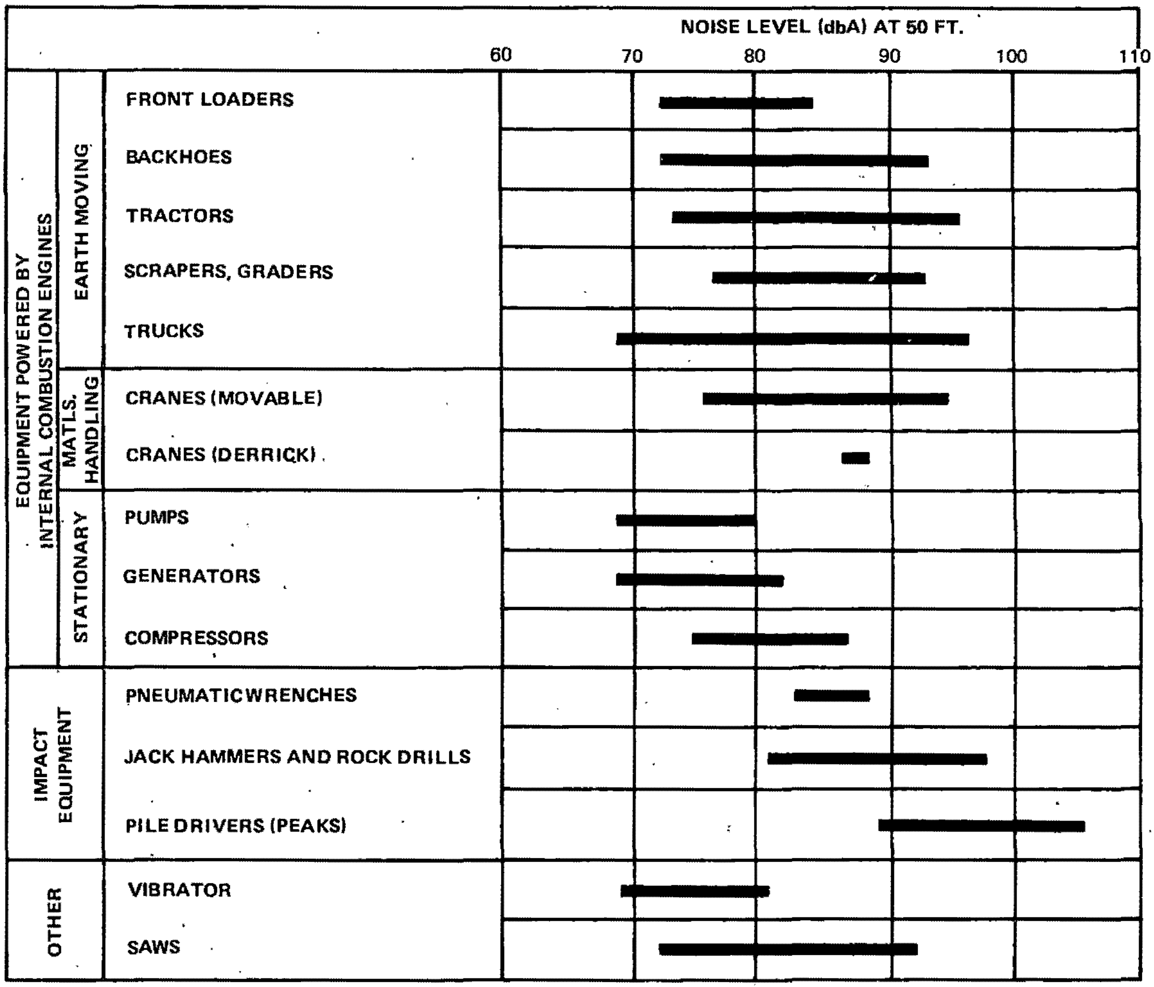


Figure 3.1.1.15-1 Construction equipment noise ranges

Ground vibration caused by construction equipment and hauling trucks is estimated to be sufficiently small at any vibration sensitive buildings that no adverse impact can be identified.

Compressor Station Construction

Construction of the compressor stations will entail only small amounts of grading; most of the activity will be hauling of materials and construction of the buildings. Those activities should be of short duration and spread out over several months, starting with clearing the site to installing the compressors. Zero impact is predicted, because no residences could be located within audibility of the proposed compressor station locations.

Operation Phase

Compressor Station

The major potential noise sources of significance during the operational phase of the project are the compressor stations, which are long-term, continuous, and fixed noise sources. The estimated distance at which stations would impact residences with normalized day-night sound levels (L_{dn}) in excess of the U.S. EPA goal for protection of human welfare is 7,800 feet. [L_{dn} is normalized to correct for quiet, rural communities (10 dB) and for no prior experience with compressor station noise.]

No impact is predicted, since no residences could be located within 7,800 feet of the proposed compressor station locations.

Effects 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 effect will be to reduce utilization of habitat areas impacted by noise. Whether this effect will be long or short term is unknown and is likely to be variable between species.

Construction Phase

Very little research has been completed on the reaction of wildlife to construction noise. Since construction noise is temporary, it is probable that the impact, if any, will be short term.

Caribou

R. Korzan (personal communication as cited in Calef, 1974) reported that caribou can tolerate winter blasting if they have not been subjected to hunting; their reactions during the summer have not been observed.

There are scattered caribou located year around in the vicinity of the proposed pipeline route at milepost intervals: M.P. 00 to 07 and 18 to 44. Milepost interval 56 to 69 passes through a winter range containing a few hundred caribou (Northern Engineering Services Co., Ltd., 1973).

Dall Sheep

Sheep were observed to interrupt their activities in response to sound levels of 105 decibels (weighting not specified) produced by blasting 3.5 miles away and even these moderate reactions appeared to decrease over time (Lent and Summerfield, 1973 as cited in Reynolds, 1974).

Construction will take place on the periphery of a sheep winter range in the Sadlerochit Mountains (AAGPC, 1975). A communications tower will be constructed on a portion of this range which supports approximately 25 sheep (AAGPC, 1975).

Blowdown

Periodic venting of high pressure gas from the compressor stations or along the line would cause temporary but severe increases in sound level (Table 3.1.1.15-1). These blowdowns will occur either because of an emergency or as a part of maintenance check or repairs. Blowdown of a compressor, or a pipeline section ending at a compressor station (unit blowdown), would occur at the station. Blowdown of a pipeline section would occur at each end of the section.

Station blowdowns are predicted to occur 3 times per year per station. Unit blowdowns are expected to occur 6 to 12 times per year per station. The maximum noise is estimated to occur over most of the period which is approximately 5 minutes for a station blowdown and 45 minutes for a pipeline blowdown.

Based on this data, it is estimated that a station blowdown would be near 70 dBA at 3 miles.

Bears

It is possible that winter bear dens may be disturbed by grading, ditching, or borrow operations (Kucera, 1974). The same soil types which typically harbor bear dens are also best suited for borrow operations (Slaney & Co., 1973a and Jakimchuk et al., 1974, as cited in Kucera, 1974). It is estimated that construction operations located at least 1,500 feet from a den will not rouse the occupants (Craighead, personal communication and Pearson, personal communication as cited in Kucera, 1974). Jonkel (personal communication as cited in Kucera, 1974) reported that a black bear did not leave its den which was located approximately 300 feet from highway construction activities.

Potential areas for polar bear den sites were identified at pipeline crossings of the Sagavanirktok, Canning, Tarayariak, Ratakturuk, Okerokovik, Auchilik, Siksikpaluk, Kongakut, and Clarence Rivers. Potential denning areas for grizzly bears occur where the pipeline crosses the Sagavanirktok River (Northern Engineering Services Co., Ltd., 1973).

Snow Geese, Canada Geese, White-Fronted Geese and Whistling Swans

Birds with young would not approach a drilling rig within a radius of 2-2/3 miles (Barry and Spencer, 1971 as cited in Jacobson, 1974). Birds are not expected to be in the pipeline area during winter construction (AAGPC, 1975).

Table 3.1.1.15-1 Blowdown Noise*

Distance (ft.)	Station Blowdown 16" Valve Vent	Station Blowdown 10" Valve Vent	Unit Blowdown
100	115 dBA	113 dBA	108 dBA
300	105 dBA	104 dBA	98 dBA
1,000	94 dBA	93 dBA	87 dBA
3,000	84 dBA	82 dBA	75 dBA

* No silencing measures taken.

Peregrine Falcons

F. Beebe (personal communication as cited in Jacobson, 1974) commented that falcons will accommodate to construction noise, excluding explosives, if it is not centered near the nest. Herbert and Herbert (1969 as cited in Jacobson, 1974) noted that six nests were deserted in response to construction activities. Birds are not expected to be in the pipeline area during winter construction (AAGPC, 1975).

Operation Phase

Gas Compressor Stations

Several studies have been performed to determine the response of wildlife to gas compressor station noise (McCourt, et al., 1974; Reynolds, 1974; Gollop, Goldsberry, et al., 1974a; and Gollop and Davis, 1974). These investigations all utilized a system designed by J-mar Electronics which consisted of a number of loudspeakers, noise generators, and filters to reproduce the noise of a 20,000-hp gas compressor station.

The maximum horizontal distance at which different wildlife species have been observed to react to simulated gas compressor station noise is presented in Table 3.1.1.15-2. It is predicted that these are the maximum distances at which decreased utilization of habitat will result from gas compressor station noise.

The estimated maximum land areas in which decreased utilization of habitat will occur or which will be avoided by wildlife in response to gas compressor station noise are presented in Table 3.1.1.15-3. The impact of this habitat loss on wildlife survival cannot be interpreted without data regarding the total amount of suitable habitat area available to the wildlife, the present degree of utilization, and the carrying capacity. For example, one of the compressor stations to be located on the Arctic National Wildlife Range (ANWR) is within a caribou calving area (AAGPC, 1975). This station is anticipated to result in decreased utilization of approximately 1 square mile of calving habitat. The ANWR is estimated to have a total of 4,000 square miles of calving grounds. Therefore, it is predicted that compressor stations in the ANWR will result in decreased usage of 0.03 percent of the areas presently used by caribou for calving.

Caribou--McCourt et al. (1974) concluded that caribou will tend to avoid a gas compressor station within a radius of one-eighth mile and may make decreased use of an area within one-half mile of a station. Deflection around stations was observed at calving grounds and during spring migration, summer movement, and fall migration, though the distances at which the avoidance occurred and the percentages of caribou deflecting differed by season.

Dall Sheep--Seventy-five percent of the sheep observed abandoned their summer range to within 1 mile of a gas compressor station simulator (McCourt et al., 1974). Mineral licks were not abandoned by sheep, but there was decreased usage of areas closest to the simulator at licks one- and three-fourths mile away (Reynolds, 1974). Three explanations may be proposed for the differences in the reaction of Dall sheep to compressor station noise on their summer range and mineral licks. The explanations are: differences in the (1) proximity of alternative habitat, (2) amount by which the simulator noise exceeded the ambient at the sheep's location, and (3) prior exposure to aircraft noise (Reynolds, 1974).

Table 3.1.1.15-2 Maximum Horizontal Distances at which Wildlife React to Gas Compressor Station Noise

Wildlife	Estimated Maximum Horizontal Distance (ft) of Reaction as a Function of Station Horsepower	
	Simulator 20,000 hp*	Proposed 47,000 hp**
Caribou	2,640	3,300
Dall Sheep	5,280	6,800
Ground Squirrels	0	0
Red Foxes	5,280	6,800
Snow Geese	15,840	15,840
Lapland Longspurs	2,980	3,800

*These distances are based on observed reactions of wildlife to a simulator of noise emissions from a 20,000 hp station.

**These distances are adjusted to correct for the additional horsepower of the proposed stations. The 47,000 hp listed is the sum of a compressor and a refrigeration unit.

Table 3.1.1.15-3 Maximum Land Area Avoided by Wildlife due to Gas Compressor Station Noise

Wildlife	Season or Activity	Number of Stations in Their Vicinity	Estimated Total Maximum Land Area (sq mi) Avoided or Having Decreased Usage during each Activity or Season*
Caribou	Calving	1	1
	Post-Calving Aggregation	1	1
	Migration	3	3
	June-August Location	4	5
	Winter	1	1
Red Foxes	-	4	18
Snow Geese	Pre-Migratory Staging Grounds	2	57

*Assumes a hp of 47,000 for the stations.

Ground Squirrels--Simulated gas compressor station noise did not affect the number of squirrels nor the activities in which the squirrels were involved (Reynolds, 1974). Therefore, gas compressor stations are predicted to have no impact on ground squirrels.

Red Foxes--Foxes ceased hunting within a 1-mile radius of a simulator of gas compressor station noise (Reynolds, 1974).

Snow Geese--Snow geese initially deserted an area within 3 miles of a simulator of station noise. Some later returned to within 1.5 miles only to leave again when a plane landed nearby (Gollop and Davis, 1974).

A significantly fewer number of flocks circled and landed near decoys when impacted by simulator noise. (The decoys were located within 600 feet of the simulator.) A significantly greater number of flocks flared (veered sharply away and gained altitude) or altered their direction of flight when impacted by simulator noise (Gollop and Davis, 1974).

Sixty-one percent of snow geese flying towards a simulator of gas compressor station noise was observed to alter their flight direction by greater than 90 degrees. Gollop and Davis (1974) suggest that gas compressor stations, if located near staging areas, may result in decreased conservation of energy by forcing the geese to make wide detours around the station when flying between feeding areas. This may indirectly increase the snow geese mortality rate by increasing the probability that the geese will commence their southern migration with less stored energy and thereby be forced to make more stops along the way. This, in turn, will increase the probability of hunting mortality (Gollop and Davis, 1974).

Lapland Longspurs--Nesting longspurs did not desert their nests which were located within 2,980 feet of a simulation of station noise, but there was a tendency for the percentage of eggs hatched to decrease and for the predation rate to increase (Gollop, Goldsberry, et al., 1974a).

Aircraft

The applicant states that surveillance aircraft will fly above the pipeline approximately once per week at an altitude of 200 feet over most areas and 500 feet over wildlife areas. Aircraft being used primarily for transportation and other purposes will be flown at 2,000 feet. The maximum diagonal distances at which different wildlife species have been observed to react to aircraft are converted into maximum horizontal distances as a function of aircraft altitude in Table 3.1.1.15-4. It is predicted that these are the maximum distances at which habitat utilization will be reduced due to aircraft inspection flights along the pipeline.

The maximum predicted land area avoided by wildlife in response to pipeline inspection flights is presented in Table 3.1.1.15-5. The impact of this habitat loss on animal survival cannot be interpreted without data regarding the total amount of suitable habitat area available to the wildlife, the present degree of utilization, and the carrying capacity. For instance, aircraft surveillance of the 51-mile pipeline stretch, which crosses caribou calving grounds in the Arctic National Wildlife Range (ANWR), (AAGPC, 1975) would be estimated to result in decreased utilization of 17 square miles of the calving grounds. Since there are 4,000 square miles of calving areas within the ANWR, this impact would affect 0.4 percent

Table 3.1.1.15-4 Maximum Distances at which Wildlife React to Aircraft Noise

Wildlife	Estimated Maximum Diagonal Distance (ft.) of Reaction to Aircraft	Estimated Maximum Horizontal Distance (ft.) of Reaction as a Function of Flight Altitude		
		200 ft.	500 ft.	2,000 ft.
Caribou	1,000	980	866	no reaction
Dall Sheep	5,280	5,276	5,256	4,887
Moose	600	566	332	no reaction
Grizzly Bears	1,000	980	866	no reaction
Black Bears	1,000	980	866	no reaction
Wolves**	0	no reaction	no reaction	no reaction
Wolves***	1,000	980	866	no reaction
Snow Geese	26,403	26,402	26,398	26,327
Canadian Geese	5,654	5,650	5,632	5,288
Waterfowl	5,280	5,276	5,256	4,887
Black Brants	10,560	10,558	10,548	10,369
Common Eiders	3,000	2,993	2,958	2,236
Glaucous Gulls	3,000	2,993	2,958	2,236
Arctic Terns	1,000	980	866	no reaction

* Wherever sufficient data was available on reaction to fixed-wing aircraft, it was used in preference to rotary-wing maximum reaction distances.

** If aerial hunting is prohibited.

*** If aerial hunting is not prohibited.

Table 3.1.1.15-5 Maximum Land Areas Avoided by Wildlife due to Noise Emissions from Pipeline Surveillance Aircraft*

Wildlife	Season or Activity	Estimated Total Nbr of Pipeline Miles**	Estimated Maximum Area (sq mi) Avoided by Wildlife
Caribou	Calving	58	19
	Post-Calving Aggregation	38	12
	May and June	90	30
	July and August	58	19
Sheep	Summer Range	13	26
Moose	-	8	1
Grizzly Bears	-	99	32
Snow Geese	Pre-migratory staging grounds	77	770

*Assumes a flight altitude of 500 feet.
**Based on material supplied by Northern Engineering Services Co., Ltd.

of the areas presently utilized by caribou for calving. Sound levels of overhead aircraft flybys are presented in Table 3.1.1.15-6.

Caribou--An altitude of 500 feet is the approximate threshold for caribou reaction (walk or run away) to both fixed-wing and rotary aircraft; above this altitude, aircraft will elicit a response from less than 50 percent of the caribou (McCourt et al., 1974). McCourt et al. (1974) estimate that 1000 feet is the minimum tolerance altitude for caribou. At altitudes above 1,000 feet, aircraft provoke inconsistent responses from caribou. Jakimchuk et al. (1974) observed 30,000 caribou "flee frantically" in response to a helicopter flying between 500 and 1,500 feet.

The reaction of caribou to aircraft was demonstrated to vary not only with flight altitude, but also as a function of caribou group size, the activity of the caribou previous to disturbance, caribou sex, season, and terrain (Jakimchuk et al., 1974; Klein, 1973; McCourt et al., 1974; McCourt and Horstman, 1974; and Calef, 1974).

When caribou evade an aircraft's approach they are expending energy at the rate of 64 kilocalcries per minute of running and 20 kilocalories per minute of walking (Geist, 1971 as cited in Klein, 1973). This energy loss must be countered by increased food consumption or body food reserves will be decreased (Klein, 1973). This impact is more hazardous to the survival of caribou during the winter and dry seasons (Geist, 1971). If this energy loss results in a 17 percent or more loss in body weight, pregnant caribou in early gestation may reabsorb their embryos (Geist, 1971). Flight from aircraft may also result (1) in abortion, if the snow is deep and has a hard crust, or (2) in the trampling of the newly born at calving time (Geist, 1971).

Dall Sheep--Feist et al. (1974) state that sheep "were markedly disturbed by helicopters at distances up to one mile away." Eighty-five percent of sheep exposed to a helicopter flying at a diagonal distance of 300 to 500 feet exhibited panic running (36 percent) or walked away (49 percent) up to 300 feet (Lenarz, 1974). There was no significant difference in their degree of reaction to helicopters as a function of season, aircraft location (above, level with, or below sheep) or group size (Lenarz, 1974).

A helicopter caused 9 out of 10 male sheep to leave the area after 2 hours of exposure; 3 hours after the helicopter left, the sheep began to return (McCourt et al., 1972). Sheep evidenced decreased usage of traditional areas subsequent to pipeline activities involving rotary and fixed-wing aircraft and communication tower generator noise (Linderman, 1972 as cited in Kucera, 1974).

The reaction distance of sheep to fixed-wing aircraft was not studied. Jakimchuk et al. (1974) state that sheep flee fixed-wing aircraft at relatively high altitudes. Reynolds (1974) noted that sheep at mineral licks would only look towards fixed-wing aircraft at distances of one- to three-fourths mile.

Kucera (1974) suggests that energy loss from aircraft avoidance activities may affect sheep survival, natality, and abortions in the same manner as discussed with regard to caribou. The age at which sexual maturity is attained and all other phases of the reproductive process are dependent upon the nutritional state of the sheep (Summerfield, 1974), which can be affected by evasive activities.

Table 3.1.1.15-6 : Aircraft Noise*

Aircraft Type	HP Rating	Normal Cruising Speed (MPH	Sound Level (dBA) as a Function of Altitude 100 ft	200 ft	500 ft
Piper Supercub	150	94	90	81	78
Cessna 185	300	145	103	92	85
Helicopter (FH 1100)	274	95	95	82	81

* Table reproduced from Klein, 1973.

Moose--At altitudes of 200 feet and less, more than 50 percent of moose react to fixed-wing aircraft by running, trotting, or discontinuing the activity in which they are engaged (McCourt et al., 1974). Similar reactions are obtained from 38 percent of moose exposed to aircraft flying at altitudes of 200 to 600 feet (McCourt et al., 1974). Doll et al. (1974) also indicate that the frequency of moose reaction to aircraft is inversely related to flight altitude.

Moose which run from aircraft are usually cows with calves (Klein, 1973). Jakimchuk et al. (1974) state that "moose appear to be disturbed more readily by aircraft during late winter and in deep snow conditions."

Moose approached too closely may show aggression towards the aircraft (Ruttan, 1974a).

Grizzly Bears--Grizzly bear reactions are highly variable and are not consistently related to aircraft altitude (McCourt et al., 1974 and Ruttan, 1974b). The greatest distance at which bears were observed to run in reaction to a helicopter's approach is one-half mile (Ruttan, 1974b). Eighty percent of the bears observed by McCourt et al. (1974) reacted to fixed-wing aircraft flying at altitudes greater than 1,000 feet by interrupting their activity or by walking, trotting, or running away. Seventy-five percent of grizzlies, observed by Doll et al. (1974), reacted to an unspecified type of aircraft by running (52 percent), backing off, gathering cubs, or watching. Bears running from fixed-wing and rotary aircraft were 58 and 71 percent, respectively, as observed by Quimby (1974).

Ruttan (1974b) noted that bears would show aggression towards helicopters, rather than desert a kill. Quimby (1974) observed that a single pass by a helicopter flying at 100 feet would normally force a bear to temporarily desert its kill.

Fifty percent of the bears tracked by aircraft abandoned their den sites (Quimby, 1974). Quimby (1974) suggests that energy loss from actions taken by bears to evade aircraft could have deleterious effects on their ability to store sufficient energy for the winter denning period.

Black Bears--Black bears have been observed to run from aircraft flying at altitudes between 100 and 1,000 feet, 40 percent of the time (Doll et al., 1974).

Musk Oxen--No distances were recorded in observations of musk oxen reactions to aircraft. Roseneau and Warbelow (1974) suggest that heavy helicopter traffic may have resulted in a 16-mile shift of a traditional summer range. R. Hubert (personal communication cited in McCourt and Horstman, 1974) states that musk oxen in undeveloped areas react strongly to aircraft, whereas those located in the vicinity of airfields evidence mild or no reaction at all, indicating an ability to adapt. Schweinsburg (1974a) commented that musk oxen sighted during an aerial survey of bird populations did not appear to be frightened. Musk oxen have been observed to form their characteristic defense circle when approached by aircraft and then break into butting contests (Spencer and Lensink, 1970 as cited in Kucera, 1974). Gray (1971, as cited in Kucera, 1974) reported that though a herd might hold ground during an aircraft passby, it often deserts the area at a run once the aircraft is gone.

Wolves--Wolves reacting to aircraft by scattering, making rapid escape, trotting, running, or evidencing panic were 79, 31, and 42 percent for flight altitude categories of 25 to 100, 200 to 500, and 600 to 1000 feet, respectively (Doll et al., 1974).

Wolves readily adapt to aircraft noise if they are not subjected to aerial hunting (Klein, 1973 and Mech, 1970). Since aerial wolf-hunting has been banned in Alaska since 1972 (Brook, 1972 as cited in Kucera, 1974), aircraft noise is predicted to have zero impact on wolves as long as the ban continues.

Foxes--The distances between aircraft and foxes were not recorded for the encounters observed.

Two of four red foxes observed during an aerial survey of bird populations ran in response to the aircraft's approach (Schweinsburg, 1974a).

Of the 15 arctic foxes sighted by aircraft surveying bird populations, only 1 took notice of the aircraft (Schweinsburg, 1974a). This fox took cover inside its den.

Snow Geese--The lateral distances at which 100 percent of the snow geese flushed in reaction to fixed-wing aircraft is provided as a function of aircraft altitude in Table 3.1.1.15-7 (Salter and Davis, 1974). There was no significant difference between the reaction of geese to aircraft as a function of flock size. Jacobson (1974) estimates that airport traffic will result in decreased usage of an area more than 250 square miles centered on the airport. There are two airports proposed where pre-migratory snow geese staging takes place from August 15 to October 1.

Canadian Geese--Canadian geese were observed to flush in response to fixed-wing aircraft flying one-half mile away at an altitude of 5000 feet (Campbell and Shepard, 1973 as cited in Jacobson, 1974).

R. Schmidt (personal communication, as cited in Jacobson, 1974) observed that the geese were flushed during prenesting studies by fixed-wing aircraft traveling at altitudes of 200 to 500 feet, but that females located near an airstrip would rarely flush even for aircraft as low as 50 to 100 feet.

Eggs in nests which were temporarily deserted in response to helicopter disturbances, were subjected to attacks by parasitic birds such as jaegers and herring gulls (R. Schmidt, personal communication, as cited in Jacobson, 1974).

Waterfowl--Molting waterfowl (primarily oldsquaw and scoters) reacted mildly (swam further from shore and/or evidenced restlessness) to aircraft at distances of 1/2 to 1 mile, before the aircraft was visible (Gollop, Goldsberry, et al., 1974b).

The reaction of waterfowl to aircraft appears to depend on the size of the body of water. At a small lake, the waterfowl was reduced by 60 percent in response to aircraft disturbance, whereas on a medium-sized lake no change in population size was observed (Schweinsburg, 1974b).

Table 3.1.1.15-7 Distances at which all Snow Geese Flush in Response to Cessna 185 Fixed-Wing Aircraft

Altitude (ft.)	Lateral Distance (mi.)	Diagonal Distance (ft.)
300-400	1-5	26,403
700	2-9	47,525
1,000	2-4	21,144
5,000	2-5	26,869
7,000	as aircraft approaches or is above	6,000
10,000	as aircraft approaches or is above	10,000

The waterfowl population of two lakes (one was used as a float plane base for 2.5 months prior to the investigation and the other was nearby) took little notice of the arrival and departure of aircraft, indicating the ability of some arctic loons, red-necked grebes, and scaups to adapt to float plane activity (Schweinsburg et al., 1974b).

Lapland Longspurs--Subjecting nesting longspurs to an average of two helicopter flights per day at an altitude of 50 feet appeared to decrease fledgling production and population turnover rate and to forestall the onset of breeding activity (Gollop, Davis, et al., 1974). The effects of aircraft disturbances at greater distances have not been investigated.

Gollop, Davis, et al. (1974) suggest that aircraft disturbances may delay the selection of otherwise optimal nesting sites and thereby reduce the productivity of these sites.

Lapland longspurs, as well as golden plovers, eventually abandoned areas near Churchill, Manitoba, indicating that long-term disturbances may lead to desertion of traditional habitats (Jehl and Smith, 1970, as cited in Gollop, Davis, et al., 1974).

Black Brant--Black brant have been observed to flush in response to aircraft flying at distances of 1 to 2 miles (Einarsen, 1965). One out of two incubating brants flushed when helicopters flew by at altitudes of 500 feet or less (Gollop, Black, et al., 1974).

Helicopter disturbances when coupled with human disturbances may lead to a decrease in nesting success (Gollop, Black, et al., 1974).

Common Eider--Incubating eiders did not flush in response to rotary or fixed-wing aircraft flying at altitudes as low as 20 feet, whereas non-nesting eiders flushed in response to helicopters at altitudes up to 3,000 feet (Gollop, Black, et al., 1974).

Arctic Tern--Non-incubating and incubating terns were observed to flush in response to fixed-wing and rotary aircraft flying at altitudes up to 1,000 and 500 feet, respectively (Gollop, Black, et al., 1974). Terns may take flight in reaction to fixed-wing aircraft flying at altitudes higher than 500 feet, since altitudes above 500 feet were not studied.

Helicopter and human disturbances combined may result in a higher nest abandonment rate and a lower hatching rate (Gollop, Black, et al., 1974).

Birds of Prey--No data are available concerning the distances at which birds of prey are disturbed by aircraft.

Hancock (1966) noted the reaction of bald eagles to helicopters used to survey their egg productivity in 1964. It was necessary to circle low over the nests to flush incubating eagles and the eagles would return immediately to the nest when the helicopter left. In 1965, the nests which had been surveyed by helicopter in 1964 had a 50 percent reduction in the number of young produced when compared to nests which had not been surveyed by helicopter in 1964. Normally, only 15 percent of eagle nests used in 1 year are abandoned in the subsequent year; 45 percent of the nests surveyed by helicopter in 1964 were abandoned in 1965.

Hancock (1966) reported that bald eagles do not flush as often in response to float planes as to helicopters nor as often to helicopters maintaining a straight course of flight as to helicopters which circle the nest. Einarsen (1965) observed that bald eagles only turned their heads to keep in sight an aircraft flown parallel to their perch altitude (300 feet).

With respect to golden eagles, Hickman (1972) reported that "incubating eagles could not be flushed, even with repeated passes, from the nests during aerial flights." Boeker and Bolen (1972) observed that golden eagles would only flush in response to aircraft which passed by in close proximity to their perches.

Campbell and Davies (1973 as cited in Jacobson, 1974) commented that whereas helicopters elicit strong responses from peregrine falcons, there is some evidence that falcons at traditional sites can adapt to overflights by aircraft.

Gyrfalcons are disturbed by helicopters flying over their nests, but gyrfalcons rarely flush in reaction to similar fixed-wing aircraft flights (F. Beebe, personal communication as cited in Jacobson, 1974).

Air Cushion Vehicles (ACV)

These vehicles will be utilized to transport the necessary equipment to a site requiring repair work. The sound levels of this vehicle when cruising at 40 to 45 mph are presented in Table 3.1.1.15-8. The maximum horizontal distances at which certain birds have been observed to flush in response to an ACV are listed in Table 3.1.1.15-9 (Staney and Co., 1973b). Reactions of mammals to ACV have not been investigated.

Black brant evidenced increasing sensitivity to disturbance by ACV. The first flushing occurred at 750 feet, the next at 1,200 feet, and the third at 3,900 feet.

Impact of a repair necessitating the use of an ACV will only be in a 25-mile region along the pipeline, since the ACV will only be required to handle the equipment from the nearest compressor station (AAGPC, 1975). (The stations are spaced approximately 50 miles apart.)

3.1.1.16 Pipeline System Repairs

The Applicant plans to construct the system largely during the winter months when most wildlife species are not living in the project area and when the ground is completely frozen. The Applicant properly recognizes the serious environmental consequences of other than wintertime construction. The Applicant intends to prepare detailed repair procedures at some future date but has provided general information on how repair would be done. These generalized plans have been considered throughout the various impact evaluations. The purpose of this section is to summarize and collect in one place a preliminary evaluation of the effects of pipeline repair.

Because of the large costs invested in the delivery of natural gas from Prudhoe Bay to domestic markets in the eastern, midwestern, and western United States and the large numbers of people dependent upon a reliable delivery schedule, it is not reasonable to assume that major repairs will be postponed until ideal conditions exist.

Table 3.1.1.15-8 Air Cushion Vehicle (ACV) Sound Levels*

Location	Sound Level (dBA)
on ACV deck	106
150 ft. from ACV	98
500 ft. from ACV	87
4,200 ft. from ACV	60

* ACV was cruising at 40 to 45 mph.

Table 3.1.1.15-9 Maximum Horizontal Distance at Which Birds Flush in Reaction to Air Cushion Vehicle Noise

Bird	Estimated Maximum Horizontal Flushing Distance (ft.)
Greater Scaup	3,960
Black Brant	3,900
Whistling Swan	1,416
White-Fronted Goose	750*
Glaucous Gull	601*
Dabbling Ducks	273

* Average flushing distances

The proposed AAGPC pipeline system is located in an unpopulated area of Alaska and therefore, pipeline failure will not directly threaten human life or private property.

Impact of Wintertime Repair

Wintertime repairs of the proposed AAGPC pipeline system will create impacts similar to those described for initial construction with one major exception. Initial construction is planned to be conducted from snow/ice roads prepared in advance. Emergency repairs will not allow time for building snow/ice roads and therefore, will involve movement of heavy equipment across the frozen tundra regardless of snow depth. Under "worst case" conditions the break would occur in late winter when the probability of surface water being available for snow/ice road construction is questionable.

Airfields at compressor stations are planned to be 2,400 feet long to accommodate STOL (short take off and landing) aircraft. Therefore, large cargo carrying planes cannot be used to move heavy equipment. Helicopters do not have the capability to move large repair equipment. Although lakes can be used as landing areas for cargo planes, it is assumed that there are no lakes near the break or that ice conditions are not safe for aircraft landing.

Accordingly, the Applicant is committed to move equipment needed to repair the pipeline by surface without benefit of snow/ice roads. The resulting damage to the surface by compacting or disturbing the surface will have a greater impact on the environment than that from initial construction.

Impact of Nonwinter Repair

Under "worst case" nonwinter conditions, the Applicant describes the equipment needed to make a major repair of the pipeline at M.P. 95. The Applicant assumes that the Katakturuk and Hulahula Rivers are in flood and difficult to cross with low ground pressure vehicles (see section 1.1.1.6 for Applicant's complete description).

Air-cushion Vehicle

An ACV (air-cushion vehicle) will be dispatched from either Prudhoe Bay or Inuvik in Canada. This will require the ACV to move over land approximately 95 miles (if from Prudhoe Bay) or approximately 300 miles (if from Inuvik). The ACV has the primary function of transporting heavy equipment. During the past several years ACV has been undergoing active development and testing in the Alaskan and Canadian Arctic. ACV's can be categorized as self-propelled and those requiring external propulsion means for all lateral motion. The self-propelled ACV is limited on payload (25 to 50 tons), expensive, and require extensive maintenance; therefore, the self-propelled ACV is not a likely choice for the Applicant. The non-propelled ACV is generally referred to as a barge or platform and requires towing behind a vehicle. Cushion pressures are low, 1.5 to 3 psi and can traverse any terrain suitable for the two vehicles. These barges can be made to accommodate most payloads, possibly up to 500 tons, and could be available in relatively short time when needed.

F.F. Slaney and Co., Ltd. (1973b) concluded the noise from the prototype ACV tested produced a frequency spectrum of noise of 90 to 100 Hz and amplitude up to 10 dB. Noise was highly directional to the side of the vehicle. Ear plugs are necessary.

Tests in Canada (ibid) showed the following flushing distances for birds:

greater scaup	1,320 yards	
whistling swan	472 yards	
black brant	250 yards	
white-fronted goose	250 yards	(avg)
glaucous gull	197 yards	(mean)
dabbling ducks	91 yards	

These tests also showed that black brant became less tolerant after prolonged exposure to the ACV with a second flushing occurring at 400 yards and the third at 1,300 yards. There also appears to be a correlation between the sound and the motion of the tested ACV.

Under the "worst case" condition the ACV will be used on the Arctic Coast when waterfowl are present and when pregnant caribou are migrating to or just reaching their traditional calving area. The ACV will have major impact on these animals and may induce abortion, death, or population redistributions of animals encountered (see Section 3.1.1.7, Wildlife).

Helicopters and Fixed Wing Aircraft

Low-flying helicopters and fixed-wing aircraft will be used to transport people and small or disassembled supplies to the repair site from the two adjacent compressor stations. Both large and small helicopters will be used. Increased and intensive aircraft use will occur at the 2,400-foot long gravel airstrips at both compressor stations. In addition, aircraft use will be increased over the entire system as equipment is checked and replaced in operation after the repair is completed. These will cause noise impacts on animals encountered (see Section 3.1.1.15, Environmental Noise).

Ground Equipment

Low ground pressure vehicles (LGP) with backhoes and sideboom tractors, 40 ton LGP for transporting sideboom tractors, and 20 ton LGP cranes will be used. If helicopters are not available, 10 ton LGP's will be substituted for transportation of men and lightweight supplies.

It is assumed that the Applicant will not be able to confine his transportation movements to the area directly adjacent to the pipeline route. Flood-swollen streams and terrain will cause detours away from the pipeline of up to 1/4 mile, if not more.

The operation of the LGP vehicles over the tundra with the normal traction loss and turning of the tires or tracks will cut and break the tundra surface. The weight of the vehicles will result in tundra compaction and it is noted that wet tundra will suffer deeper compaction than dry tundra. Airbag-tired vehicles squeeze soil in front of the airbags and cause suction behind, disturbing substrata. Compaction of tundra vegetation may have a short-term (4 or 5 years) benefit of improving growth by increasing soil microbe activity. There is no way to avoid cutting the surface of riverbanks and breaking polygon rims which will not result in erosion. Every instance of vegetation and soil compaction, along with any cutting of the soil surface causing direct surface erosion, affects the thermal regime of the tundra vegetation and underlying soils, resulting in permafrost degradation.

The obvious movement and noise associated with LGP vehicles hauling heavy loads over land between adjacent compressor station repair sites will be disturbing to some degree to all species of birds. The physical contact with nests will destroy eggs and cause disruption of the birds' habitat and the vehicles passing close to nests and habitat will flush birds, leaving nests with eggs vulnerable to predator attacks from ravens, gulls, and jaegers, which are less disturbed by the vehicles. Repeated trips over a period of several days will thwart the efforts of nesting birds and some will not return to the nests to hatch their eggs. Young, or newly hatched, birds left unattended at the nest site are subject to confused wandering and quickly become vulnerable to predatory birds and animals. Mosquitos, a major arctic predator, will kill unprotected young birds or reduce their survival chances.

Fox dens are not readily discernible to operators of large LGP vehicles and are subject to collapse as the vehicles roll over them. Destruction of fox dens during summer is especially critical because this is when the fox bears its young.

Caribou calving takes place during early summer. The newly born caribou, requiring constant care for survival, are dependent on their mothers for a period of several weeks after birth. The repeated overland travel by large LGP vehicles during the several days of pipeline repair activities will affect the calving and rearing of these animals.

Spawning areas for fish will be disturbed and water quality will be lowered as restoration will be conducted during a time when accelerated erosion will occur (see Sections 3.1.1.6 and 7, Vegetation and Wildlife, respectively).

It is important to note that disruption of the heat balance through destruction of the insulating surface cover and capture or concentration of surface drainage by repair procedures will cause the permafrost to deteriorate. Subsequent permafrost degradation, in turn, establishes a new cycle of heat balancing that can threaten pipeline integrity.

In summary, under the "worst case" conditions, both as to site of repair work and time of the year the repair work would be undertaken, there will be substantial adverse impacts on vegetation, soil, permafrost, water quality, and wildlife resulting from nonwinter emergency repair of the proposed AAGPC pipeline system.

Factors of Design Affecting Integrity of a Chilled Pipeline Buried in Permafrost Areas

The Applicant has not made a comprehensive analytical determination of the maximum stresses that can exist concurrently with pressure induced stresses during pipeline operation. These analyses should cover thermal stresses for the worst possible combination of installation and operation temperature, stresses associated with worst case frost heave phenomena, the effects of bouyancy and the attendant weighing and/or anchoring, differential settlement for the worst anticipated soil conditions, earthquake induced strain effects, pipeline behavior in regions of soil slippage, and the additive effects of construction induced initial stresses. The results of these studies should be used in conjunction with an appropriate design criteria to determine pipe wall thickness.

In order to be assured of an adequate factor of safety against pipe rupture it is necessary to evaluate the magnitude of stresses and strains induced in the pipe from all sources, and to compare these stresses and strains to levels at which the pipe will rupture and/or leak. The Applicant's stress analysis document presents detailed discussions of the various loading conditions, the analytical procedures used to evaluate the effect of these loading conditions on the pipe, and a proposed design criteria in which allowable values for pipe stresses and strains are established.

The Applicant has identified three classes of loading conditions which affect the pipeline:

1) Design Loading

   a) Gas pressure

   b) Hydrostatic test pressure

   c) Temperature differentials

   d) Pipe, hydrostatic test medium, and jacketing weights

2) Seismic Loadings

3) Geotechnical Loadings

   a) Differential soil settlement

   b) Differential frost heave

   c) Bouyant uplift

   d) Overburden loads

   e) Soil deformation at field bends

The maximum levels for the design loadings conditions are deterministic and appropriate. The seismic loadings levels have been specified by Dr. N. M. Newmark (March 1974). The conservatism of the levels selected for the geotechnic loadings is not so easily determined. The Applicant states that frost heave, differential settlement, and soil deformation at field bends will have very low magnitudes in permafrost and cites the Prudhoe Bay test results; for the reasons cited below these results do not necessarily establish that these loadings are insignificant.

The data presented for the Prudhoe Bay test section show axial force, vertical and horizontal bending moments, and vertical displacements of each 800-foot long test leg for a period covering approximately 15 months. The reported results indicate very low pipe stresses as well as small pipe displacements. However, only small credence may be put in the vertical deflection measurements as presented by the applicant since they were made with transit rather than a level, were conducted by inexperienced surveyors, were not obtained as part of a conventional, closed loop, level circuit, and are admittedly not self consistent.

The strain gage data show that stresses in the test loop were generally low during the 15-month period, but, since the gages were not installed and/or calibrated until after the pipe was in the ditch the installation stresses were not measured. A check of the cross section constants used in data reduction indicates that the data were for a 0.28-inch wall thickness pipe rather than the 0.8 inch wall pipe scheduled for use. No discussion of the correlation between the two pipe sizes is given.

The Applicant has provided detailed design criteria covering allowable stresses and strains resulting from the application of various combinations of loading conditions (NESC, 1975). These are summarized in Table 3.1.1.16-1. These criteria does not meet the requirements of Parts 192.103 and 192.105, Title 49 with regard to the allowable combinations of pressure induced loading and other external loadings in two important respects:

1) Criteria for limiting the maximum levels of longitudinal tensile and compressive stresses for all loading combinations are not provided (e.g., bending induced stresses acting concurrently with temperature, pressure, and earthquake), and

2) The criteria for stress intensity* (i.e., the value of the sum of the absolute values of the hoop tension and longitudinal compressive stresses) are so liberal for some loading conditions, that yielding of the pipe is permitted.

Part 192.105 states that ... "additional wall thickness required for concurrent external loads ... may not be included in computing design pressure." A more specific restatement of Part 192.105 is that additional wall thickness is required only if the stresses resulting from loadings other than internal pressure interact with the pressure induced stresses in such a way that the capability of the pipe to resist the internal pressure without yielding is reduced. The use of the Tresca yield criteria is generally accepted as a reasonably accurate and conservative way by which to determine the proximity to a yielding condition when a material is subjected to a biaxial stress condition. The Tresca criteria predict the onset of yielding when the equivalent tensile stress is equal to the material yield stress. Equivalent tensile stress is defined as 1) the maximum of the hoop tension and longitudinal tension stresses when both are positive, or 2) the difference of these stresses if they are of opposite sign. Since the explicitly stated stress criterion in Part 192.105 is expressed as a Design Factor (F) times the stress to cause yielding (SMYS), in the absence of other detrimental loadings the proper allowable value for equivalent tensile stress is the same factor times the equivalent tensile stress at which yielding occurs. Numerically the allowable for equivalent tensile stress is equal to maximum hoop stress. The use of a higher factor for equivalent tensile stress results in allowing the pipeline to operate in a stress state which has a lower factor of safety against yielding than that specified by Part 192.105.

The above interpretation of Parts 192.103 and 192.105 is considered to be the proper one to ensure safe operation of the pipeline. This criterion should be applied directly to all loading conditions and combinations which may reasonably be expected to affect the pipe on a continuing basis. A moderate increase in the design factor for combined loading conditions involving very infrequent transient conditions such as earthquakes or abnormal temperature extremes has precedent in ANSI B31.4 which allows an increase from 0.72 to 0.8 for tensile longitudinal stress. Since a gas pipeline is inherently more hazardous than a liquid filled pipeline, a value of 0.8 SMYS for the stress intensity represents an absolute maximum allowable value for these extreme conditions.

A factor which cannot be dismissed without note is that API X-70 steel represents the upper limit of permissible yield points for all steels

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*Phenomena described by the Applicant as stress intensity is more correctly designated "Equivalent Tensile Stress."

Table 3.1.1.16-1 Estimated magnitude of various stress states

Cause	Hoop Stress Direct	Hoop Stress Bending*	Longitudinal* Stress
Internal Pressure = 1680	+50,400 psi	0	Tension ≅ +15,120 psi
Temperature Excursion	0	0	±21,000 psi/100°F change
Frost Pressure on Opposite Sides of Pipe	Negligible	±12,500 psi/10 psi unpressurized <±12,500 psi/10 psi pressurized	~0
Buoyancy	0	Small	Beam bending
Differential Settlement	0	0	Beam bending
Seismic †	0	±12,500 psi/10 psi nonuniform load	Beam bending
Construction Initial Stress	Negligible	±12,500 psi/10 psi	~0
Cold Bend			σ = S during bend $\sigma \approx \lambda$ S residual $\lambda \ll 1$

*Calculations of these stresses are shown in attachment C of this section.
†Local effects at a fault line are not evaluated here.

covered by the API specification. As such, it represents the lower limit in the ratio of ultimate strength to yield strength, and in ductility. For example, API X-42 steel has a 22 percent greater spread between its yield and ultimate strengths than X-70 and a 37 percent greater elongation capability. The corresponding numbers for X-52 are 8 and 26 percent, respectively. Since the same basic code applies equally to these steels' yield points, it must be recognized that the actual safety factor against rupture is less for the higher strength alloys. Experience gained with the use of more forgiving steels cannot be taken at full face value for X-70 steel.

Fracture Toughness

The Applicant has not specified an absolute minimum toughness of the pipe, although he has specified an average minimum value.

Any time steel is used at low temperatures, the possibility of brittle or quasi-brittle fracture must be considered. Because of brittle fracture considerations, conventional safety factors based on operating loads and the static strength of the steel are generally insufficient for safe designs at low temperatures. There must be the requirement of some kind of notched strength or, as it is generally termed, toughness.

The Applicant has proposed the inclusion of a drop weight tear test (DWTT) requirement in the material specification to insure against brittle fracture and a Charpy V notch (CVN) requirement to assure adequate toughness.

The drop weight tear test requirement should, insure against brittle fracture. The Applicant sponsored tests (Battelle) correlating Charpy V notch energies with fracture initiation. Although most of the tests were conducted on steel pipe of lower strength than X-65 and X-70 and with thinner walls, the tests that have been made on X-65 and X-70 line pipe made from controlled rolled plate give comparable results. However, these tests were made on thick-walled pipes with very high Charpy energy rather than with pipe exhibiting the minimum energy values allowed by the specification. The Applicant states that similar tests for steel pipe at the minimum Charpy energy value were planned for 1975 (December).

The material specification shows average values of Charpy energy with absolute minimum not specified. The specification of an average rather than a minimum would result in use of a pipe joint (40 feet) with virtually no toughness because it came from a heat which displayed minimum average values of material toughness. Since the higher pipe steel properties are due primarily to the processing rather than composition, very low toughness properties in some pipe sections could occur. Pipe sections of low toughness are susceptible to brittle fractures which many extend many hundreds of feet.

The Applicant recognizes this and proposes to use mechanical reinforcement at intervals along the pipelines as a mitigating measure to arrest cracks since at the present time, crack arrest behavior of line pipe made from controlled rolled steels cannot be reliably predicted.

In addition, the Applicant states that he has conducted successful tests demonstrating that reinforcement bands around the circumference of the pipe will arrest a running crack.

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4 MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

4.1 ARCTIC GAS PIPELINE PROJECT

4.1.1 Alaska Arctic Pipeline

In this section, mitigating and/or environmental control measures proposed by the Applicant are discussed and conclusions as to their effect are stated. Additional mitigating, geotechnical, or environmental control measures not proposed by the Applicant, but which, if applied, could significantly reduce adverse environmental effects are also discussed.

4.1.1.1 Climate

Mitigation of the Impact on Climate

The pipeline will cause no measurable change in the climate.

Mitigation of the Impact of Climate on the Proposed Project

Proposed by Applicant

No specific measures proposed.

Conclusions

In the eventuality of a light snow year, snow will be manufactured to provide that portion of the snow road and pad provided to support a construction start of 1 October. This will require a large water supply. A water withdrawal plan has not been developed by the Applicant.

The nature and special characteristics of the water tankers that would be used for snow road and pad construction have not been defined. These tankers are anticipated to require a low ground pressure configuration and to be insulated and/or heated to preclude in situ freezing of the water during transportation from the extraction point to the road/pad site.

The use of snow roads and pads for heavy traffic during the month of May is considered marginal. Combinations of sunlight, air temperatures, and wind speed prevalent during this month may lead to thawed soft surfaces. Traffic under these conditions may be harmful to the underlying vegetation.

The entire problem of constructing a pipeline in the hostile environment of the North Slope of Alaska within the time frame of approximately 5 months must be further addressed, providing for all contingencies and demonstrating ability to complete the project and successfully establish chilled gas flow after the pipeline is inactive for a summer thaw.

Additional development of ditching and blasting techniques is required. The Applicant's development work in this area should be continued.

Pipe toughness, as specified by an average (of three speciments) can result in accepting a pipe joint (40 feet) of less than the average toughness. Such pipe is susceptible to brittle fracture from low temperatures. An absolute minimum toughness value should be specified.

Additional Measures

(a) Provide a detailed plan for developing ditching and blasting techniques appropriate for ditching in frozen gravels and other stubborn permafrost areas.

(b) Prepare a detailed plan that addresses the entire problem of constructing a pipeline in the hostile environment of the North Slope of Alaska within a 5-month time frame. Provide for all contingencies and describe in detail the impact of up to one or more years delay in establishing chilled gas flow.

(c) Provide a comprehensive Snow Road and Pad Construction Plan which includes as a minimum all elements identified by the Applicant. This Plan shall include design criteria, anticipated water requirements and a description of all equipment and vehicles required to support road and pad construction in a light and normal snowfall year. This Plan should be provided to the appropriate statutory and/or regulatory agency(s) for review and approval.

(d) Provide an Availability of Water Requirements Plan. This Plan shall include a statement of total water requirements from site specific locations for snow road and pads, and all other requirements for all construction spreads. Water sources and withdrawal rates shall be identified. The equipment to be used to transport water without environmental impact shall be identified. This Plan shall be provided to the appropriate regulatory and statutory agencies prior to issuance of permits.

(e) Submit a construction plan specifying in detail the entire construction operation. Include detailed schedules based on "material in hand." Schedule the commencement of the project after all critical components of the pipeline have been delivered to the construction area.

(f) The toughness value specified should be an absolute minimum acceptable toughness of the pipe as well as an average minimum.

4.1.1.2 Topography

<u>Mitigation of the Impact on Topography</u>

Proposed by Applicant

Restore the natural contour of the terrain along the pipeline route, where possible. A mound will remain over the pipeline ditch. No mitigation is provided for this change in topography.

Use some material sites for waste disposal and mitigate impact by stabilizing natural and fill surfaces, using revegetation and maintenance measures. Identify pipeline location by marking with milepost signs or some other means.

Conclusion

It is estimated that change in the topography due to the backfill mound will essentially disappear in 1 to 2 years.

The effects of blasting to excavate a trench will be temporary and will disappear once the pipeline is constructed.

Mitigation of impacts on topography in relation to material and disposal sites by stabilization, revegetation, and maintenance is acceptable.

Additional Measures

Provide a plan for disposal of spoil materials and for pipeline marking.

4.1.1.3 Geology

Mitigation of the Impact on Bedrock and Mineral Resources

Proposed by Applicant

No specific measures proposed.

Mitigation of the Impact on Permafrost

Proposed by Applicant

Operate the pipeline at temperatures below freezing to maintain the pipeline and the soil contiguous thereto in a permafrost condition, and construct from snow/ice roads to preclude damage to the permafrost. Changes will occur since the active layer would be different after pipeline installation but these differences are not assumed to be significant. Use special erosion control procedures to control ground and surface water. Has considered the case of the unchilled pipeline for a year or more, and has stated that thaw depths would be greater than indicated for a chilled pipeline.

Instigate a revegetation program as an additional long-term mitigating measure to maintain the permafrost. Use of insulation mats is mentioned but no specifics are provided.

Analysis

The chilled pipeline, erosion control and revegetation mitigating measures proposed would be adequate. Not considered are conditions that could exist through startup and stabilization of pipeline temperature, and the effect of spillage of methanol hydrostatic water test agent. During unchilled installation, surface water infiltration and freezing are mentioned by the Applicant.

Proposed snow roads and work pad may not preclude damage to surface mat, therefore, they could disturb the thermal regime and thus degrade the permafrost.

Conclusions

Chilled pipeline operation at temperatures below freezing will maintain the soil in a permafrost condition. Thermal effects of an unchilled pipeline buried in permafrost are not expected to impact the permafrost, but will cause subsidence of the ditch mound, with a tendency to side channel and increase the active layer on both sides of the trench. Snow/ice roads will probably alter thermal balance and cause an increase in depth of the active layer.

The development of a leak during hydrotesting will require replacement of saturated backfill (fine-grained soil). The need to strip the sides and bottom of the trench and to replace the bedding material has not been addressed by the Applicant.

The size of the leak that is detectable by visual inspection of the trench has not been defined by the Applicant. This is essential in view of the discussion presented on the effect of a water-methanol solution on fine-grained soils.

Operation of the chilled pipeline at temperatures below freezing will maintain the soil in a permafrost condition. Failure of the gas chiller at the line inlet at Prudhoe Bay could melt the permafrost around the pipe.

The Applicant's test program has considered most of the important pipeline temperature influences on the thermal behavior of the permafrost. An area not considered, however, is the ground heaving effect associated with initation of chilled gas operation with an initial water saturated backfill at some river crossings where unfrozen ground may be found.

The Applicant has considered the case of the unchilled pipe buried in permafrost but his computations of mound subsidence, mound side channeling and active layer penetration depth do not consider ponding and water flow along the ditch.

A significant problem requiring treatment is the foundations supporting valve systems.

The Applicant has not provided any criteria for the inspection of the individual lengths of pipe for damage prior to incorporation into the pipeline, nor has he provided criteria for ispection of the pipeline prior to and subsequent to other required operations.

It follows that the mitigating measures proposed to maintain permafrost are not adequate.

Additional Measures

(a) Provide thermal analyses for all operating conditions of the pipeline and for worst case assumptions in startup conditions, such as backfill water content and depth of pipe burial, and show that the permafrost will be maintained.

(b) Prepare a contingency plan for handling leaks and spills of the hydrotest fluid. The plan should indicate the potential damage to the permafrost, measures that would be taken to minimize the potential for spills, and restoration methods that would be used when spills occur. This plan should be submitted to the appropriate regulatory and/or statutory agencies for approval prior to construction.

(c) Develop criteria to specify the gas temperature (maximum) that will be permitted on a temporary basis to accommodate the eventuality of Gas Chilled Failure. These criteria shall be submitted to the appropriate regulatory and/or statutory agencies for review and approval.

(d) The thermal, ground settlement, and frost heave effects of an unchilled pipeline should be analyzed including ponding and water flow and results provided to the appropriate regulatory and/or statutory agencies.

(e) Incorporate ponding and water flow in an analytical model and determine specific locations for which the proposed mitigating measure of increased berm height (surcharge) is expected to be an effective method to mitigate frost heave effects.

(f) Data or analysis should be presented regarding heat soakback from exposed piping, such as from the scraper trap assemblies and mainline block valves.

(g) Propose a detailed hydrotest procedure. Develop appropriate handling procedures and personnel safety practices, taking into consideration the toxic nature of methanol vapors. Quantify the size of leak that can be detected visually during hydrotest and the size of leak that can be detected by pressure gauges.

(h) Establish a threshold level of leakage which would not cause permafrost degradation.

Mitigation of Impacts on Slope Stability

Proposed by Applicant

Select route to avoid any marginally stable slopes. Slopes less than 3° (5.2 percent) are considered stable and no special measures are anticipated necessary to control slope instability. Slopes greater than 3° may be subject to instability but less than 10 percent of the slopes are in this category. In these cases mitigation of adverse effects is to be accomplished by using several slope stabilization techniques and erosion control measures. The removal of vegetation on the slopes during construction has two negative effects: it increases the rate and depth of thaw, which could lead to instability and affects the heat balance so that stable slopes could become unstable due to changes in the evapotranspiration rate along disturbed areas. Develop design criteria and analytical methods in order to assess and mitigate the current and future slope stability conditions and to provide for the design of erosion control measures.

Analysis

As slope instability is a major hazard to the pipeline, the proposed route avoids marginally stable slopes based on available information.

The stabilization of slopes is to be mitigated mainly by erosion control techniques. The problems connected with steeper slopes in permafrost, the means of slope stabilization, the effect of construction, the mechanical erosion control methods and the analytical tools available are extensively discussed by the Applicant.

Conclusions

The description of slope stability problems, including the analytical models used to assess active layer slope instability is general and does not specifically categorize the slopes as to their hazard to pipeline integrity or erosion potential. Such assessment is inadequate. Detailed geotechnical field data are needed.

The assumption that all slopes below 3° are stable cannot be supported and does not provide an acceptable criterion to mitigate slope failure.

The slope stabilization techniques and erosion control measures proposed are general and descriptive and not applied to specific slopes along the pipeline route. Therefore, the proposed mitigation cannot be considered adequate.

Additional Measures

Identify all potentially unstable slopes affected by construction with a determination of the factor of safety by the McRoberts Method; the Applicant indicated that this will be done during the final design.

(a) All slopes should be categorized with respect to their potential instability, relative angle with respect to the pipeline, and mass wasting hazard. Slope stability analysis should cover the case of chilled and non-chilled gas and resulting impact if they fail.

(b) Typical slopes from each of the categories should be selected for detailed review. External loads on the pipe resulting from mass wasting should be established and slope stabilization method (if required) should be defined.

(c) Determine the degree of slope movement that can be expected and establish criteria for including loads resulting from this factor into the pipeline thickness determination.

(d) Develop allowable loads criteria for each unavoidable landslide bench traversed by the proposed pipeline with supporting analysis. These criteria should be provided to the appropriate regulatory and/or statutory agencies for review.

(e) Identify all slide areas; all such areas (active or dormant) should be avoided. For any slide area that cannot be avoided, stabilizing procedures and mitigating measures should be investigated. Blasting on slide areas should also be avoided, particularly in areas where unfrozen subsoil may exist.

(f) Restore surface drainage which will be affected by the pipe inactivity period along the pipeline route to pre-construction conditions, except that, wherever closed depressions existed on a bench, these depressions would be regraded to permit runoff of the surface water over the edge of the slope. The Applicant confirmed his intention to do this.

(g) Determine in detail conditions created by possibility of the inactive pipeline buried for one or two seasons, as well as by pipeline flowing chilled gas, together with proposed stabilization methods.

(h) Measure solifluction and creep displacement by field observation and describe in detail measures that will be taken to control such displacements.

(i) Estimate maximum differential settlement due to solifluction, creep, seismic activity or other factor and use these criteria in the determination of pipeline wall thickness.

(j) Reevaluate the method of restoring slopes by natural sloughing processes, including an examination of slopes where this method has been applied, reporting any instances of excess erosion or degradation of cover. All slopes to be so treated should be identified by location, soil type, and evidence should be provided that excess thaw will not occur. Insulation as an erosion deterrent on cut slopes should also be considered. The Applicant indicated in a later disclosure that this will be done if required. Make a similar reevaluation of the use of snow or ice fill, reporting on damage incurred by the melting of such fill.

(k) Provide comprehensive bore hole data along the pipeline route, particularly for slopes, river approaches, under rivers, and at compressor stations.

(l) Provide more information on creep and deep-seated failure in frozen soil, where the Applicant states that substantial field investigation is called for. Specifically, a survey should be made in the field of potential sites for each type of failure, the soil creep measured, and the deep-seated failure potential evaluated by the methods described in the Applicant's Submission.

(m) Identify areas where the need for blasting is anticipated and evaluate the stability of these areas to substantiate the statement.

Mitigation of the Impact of Frost Heave, Buoyancy, and Seismic Activity

Proposed by Applicant

Only internal pressure has been considered in sizing the wall thickness for the proposed pipeline. External factors, such as seismic activity, compactness of backfill due to the weight of hydrostatic test fluid, and weighting the pipeline at river crossings are discussed but are not considered in determining pipe thickness.

Analysis

Wall thickness for the proposed pipeline is considered adequate based on internal pressures. However, external loads which may contribute significant stress to the pipeline are not provided for.

Conclusion

(a) A deficiency in the Applicant's discussion of seismicity is failure to provide a relation between seismic data presented and specifications for a seismic design, however limited the requirement may be.

(b) A contingency plan should be provided to check and reestablish pipeline integrity of this seismic activity.

(c) The Applicant has identified all potential significant sources of loading which may influence the pipeline mechanical design and has demonstrated a capability to properly perform engineering analyses to predict the internal stresses and strains resulting from the various loading conditions. However, he has not shown conclusively that all geotechnic loadings are insignificant.

(d) The design criteria proposed by the Applicant does not meet the implied requirements of Part 192 of Title 49 with respect to the effects of interaction between pressure induced stresses and stresses resulting from other loadings, and with respect to the permissibility of strains beyond those corresponding to a uniaxial tension of 0.72 x SMYS.

The risk of failure of the pipeline during operation is greater than the level corresponding to a pipeline designed in strict accordance with Part 192 of Title 49.

(e) The Applicant is well aware of frost heave problems and means at his disposal to mitigate them. However, there is an uncertainty about the amount of overpressure (surcharge) required to arrest frost heave because of soil variation, river scour, erosion and subsidence, the latter becoming more pronounced with the unchilled pipe in the ground. A detailed review of near-worst but realistic conditions is required to minimize potential frost heave hazard and pipe overstressing.

Additional Measures

Make a comprehensive analytical determination of the maximum stresses that could exist concurrently with pressure-induced stresses during pipeline operation. These analyses should cover: (1) thermal stresses for the worst possible combination of installation and operation temperatures; (2) stresses associated with worst case frost heave phenomena; (3) effects of buoyancy and the attendant weighting and/or anchoring; (4) differential settlement for the worst anticipated soil conditions; (5) earthquake-induced strain effects; (6) pipeline behavior in regions of soil slippage, and (7) the additive effects of construction induced initial stresses. The results of these studies should be used in conjunction with appropriate allowable stresses and operation pressures to determine pipe wall thickness.

Submit each design for governmental review and approval during each phase before authorization is granted by the Government to proceed. The design phases are normally defined as conceptual, preliminary, and critical (final) design review. The design in the application is considered a conceptual design. Any changes required in a final design are usually the subject of separate design reviews for each proposed change.

Provide a contingency plan for checking and reestablishing pipeline integrity after seismic activity.

Install seismic instrumentation in the vicinity of Flaxman Island, considered the most likely center of seismic activity along the route.

Conduct additional tests and/or analyses to evaluate the worst case high temperature of the active layer at pipeline startup, combined with a worst case ground moisture content in the unchilled and chilled conditions. The lowest anticipated gas temperature should be used once the test is started and maintained throughout the test to demonstrate the effect of frost heave induced on the pipeline by freezing of this active layer. The effect of supercooled ground liquid should also be evaluated.

4.1.1.4 Soils

Mitigation of Impact of Mixing the Soil during Excavation and Backfilling

Proposed by Applicant

No mitigation for soil mixing during excavation or backfill of the pipeline trench is proposed. However, where tundra mat is thick enough the mat will be stripped and replaced over the backfilled ditch.

Conclusions

Mixing of the soil during excavation and backfill operations is unavoidable with conventional construction techniques. The adverse effects can partially be mitigated with fertilizer applications and revegetation procedures as described in Section 4.1.1.6.

Stripping, stockpiling, and replacing the tundra mat is desirable, but under arctic construction conditions the probability of successful accomplishment is not high.

Additional Measures

Conduct studies to determine existing conditions and ways to effectively mitigate the mixing of soils.

Mitigation of the Impact of Excess Spoil Material Disposal

Proposed by Applicant

Dispose of excavated material not suitable for or in excess of backfill requirements by burying it on the right-of-way, at maintenance stations, in abandoned borrow pits, or as approved or specified by regulatory authorities. The waste areas will then be covered with at least 24 inches of fill, stabilized, and vegetated.

Analysis

Ice-rich material, which is basically what the spoil is composed of, is highly susceptible to liquefaction by thawing. It is questionable whether the 24 inches of fill will retard the melt to assure stabilization which is necessary to promote revegetation.

Conclusions

The proposed mitigation procedures will provide reclamation of waste disposal areas through a continual maintenance program.

Additional Measures

Prepare detailed plans for disposal and stabilization of waste materials. Delineate where the 24 inches of fill will be acquired, what the composition of fill material will be, and what stabilization procedures will be used.

Mitigation of the Impact on Soils by Spills of Fuels and Lubricants

Proposed by Applicant

Follow Environmental Protection Agency Regulation, 40 CFR Part 112, "Oil Spill Prevention and Control Contingency Plan," prevent leaks by training the personnel who handle the fuel, and use fuel cleanup techniques. Fuel cleanup will be accomplished by hand and nutrients will be added to enhance rate of microbial degradation cf petroleum products.

Conclusions

Proposed mitigation is considered adequate.

Mitigation of the Impact of Reduced Soil Temperature and Consequent Lower Nutrient Availability in the Pipeline Berm

Proposed by Applicant

No mitigation is proposed to maintain soil temperature.

Analysis

A frost bulb will be created around the chilled pipeline and will decrease the thickness of the normal active layer and will reduce the nutrients available for plant growth.

Conclusion

Fertilization is discussed in 4.1.1.6, Vegetation, should help to alleviate this problem. However, periodic low level fertilizer applications for the life of the project may be necessary.

Additional Measures

Provide a plan for fertilizing and monitoring to assure an adequate supply of required soil nutrients.

4.1.1.5 Water Resources

Mitigation of the Impact on Water Quality

Sewage Control

Proposed by Applicant

Comply with State and Federal sewage control laws, rules, and regulations by obtaining permits in accordance with section 402, Federal Water Pollution Control Act, as amended PL 92-500, Oct. 17, 1972, 40 CFR 125, and Title 46, Chapter 03, Laws of Alaska, Sections 46.090 through 120 Alaska Administrative Code, Title 18, Chapter 72. Sewage will receive secondary treatment. Treated effluent will be released into a lagoon with capacity for 1 year storage. Effluent will be discharged in a regulated manner at certain times of year when it will be carried off during spring flood. When it is impractical to discharge effluent as described, the treated effluent will be drained onto the tundra.

Analysis

Some package sewage treatment plants are not effective under Arctic conditions. The effects of discharging effluent as proposed could create an impact on water quality by reducing dissolved oxygen levels or addition of nutrients. Sewage control during interim when construction starts and the sewage treatment plant is installed is not addressed by the Applicant.

Conclusions

The effects of an accidental discharge of sewage effluent or a controlled discharge onto the tundra are unknown.

Additional Measures

Submit plans for proposed sewage treatment plants for approval prior to installation.

Provide thorough training for sewage plan operators to assure proper secondary treatment prior to discharge.

Provide plans for the sewage disposal between start of construction and completion of sewage disposal system for approval by the responsible agency prior to commencement of field activities.

Control of Silt from Spoil Disposal Sites

Proposed by Applicant

Locate spoil disposal sites in abandoned material sites. Most of the proposed material sites are located in active streambeds. The Applicant will construct a berm to preclude siltation.

Conclusion

Reduction in water quality is likely to result from introduction of silt and/or mud from spoil disposal areas.

Additional Measures

Prepare a comprehensive plan for control of siltation effects from spoil disposal areas including such measures as coffer dams and settling basins.

Control of Siltation from Gravel Extraction

Proposed by Applicant

Extract gravel during the summer and early winter months from borrow sites located within the active flood plains. Location of borrow source is dependent on its effect on water quality and requirements and if possible, a buffer zone will be left between the active flow and the borrow operation. A berm will be built between the borrow pit and any flowing channel, and the berm will be breached to permit cleaning by the stream during the spring.

Analysis

High water flows within this proposed project area commonly are associated with summer and early fall storms, therefore gravel borrow areas will be flooded sometime during the extraction activities, which will induce added silt loading to the stream.

Conclusions

Siltation from gravel extraction cannot be completely eliminated but is considered insignificant.

Additional Measures

Use buffer zones in all cases that are designed on a site specific basis.

Control of Siltation from Pipeline Construction

Proposed by Applicant

Restrict pipeline construction activities to the wintertime. Control drainage on and across the right-of-way. The impacts from siltation in some tundra streams may be high but of short duration, and construction procedures are planned to minimize siltation.

Analysis and Conclusions

Disturbance of the surfaces over the pipeline trench will cause thermal degradation and promote surface erosion, and siltation of streams during summer thaw. Siltation caused by erosion during late summer, when streams are normally clear, is an adverse impact not adequately addressed. The statement that construction procedures will be planned to minimize siltation is not definitive enough to assure adequate mitigation.

Additional Measures

Implement a continuous monitoring and repair program designed to prevent sediments from entering streams until the disturbed area has stabilized.

Mitigation of Impacts on Water Quality Resulting from Use of Water During Construction

Proposed by Applicant

The impact of water withdrawal on water quality will be mitigated by performing field surveys to determine availability and quality of water prior to construction and by taking water only where approved by the Government.

The hydrostatic test fluid will be disposed of by controlled spray dispersal on snow surfaces or on land. To mitigate the effects of spraying the 26 percent methanol-water mixture on the surface, the mixture will be diluted with water so that the residual will not exceed 1 percent methanol concentration.

Water for domestic uses will be obtained from the same sources as described above, and disposal will be mitigated as stated in Sewage Control under this section (4.1.1.5).

Analysis

The nature of the studies and the laboratory efforts are not described in enough detail regarding disposal of the water/methanol solution. The proposed mitigation of adverse impacts on water quality created by disposal of the test solution is questionable.

Conclusion

The conduct of field surveys and obtaining Government approval prior to withdrawal of water is considered adequate mitigation for water supply aspects.

Reduction of the residual test solution from 26 to 1 percent methanol prior to discharge to the surface, appears to be adequate.

Leaks during hydrostatic testing while the test solution is 26 percent methanol will be harmful to vegetation and aquatic life and could create localized conditions in the pipe trench which inhibit formation of a frost bulb resulting in slope instability.

Mitigation of Impacts of Fuel, Lubricant, or Toxic Material Spills on Water Quality

Proposed by Applicant

Provide facilities for safe storage and proper disposal of oil and grease. Careful handling procedures to prevent entry into water courses will be established.

Analysis

The proposal is practical but does not account for the accidental spills that could occur from handling, rupture of storage facilities, or equipment failure at storage sites. Probability of spills occurring is high and should not be discounted.

Conclusion

Spills will occur and could have a long-term adverse impact on water quality.

Additional Measures

Store fuel in such a manner that it would not enter a drainage course if storage facilities failed. Develop cleanup procedures and techniques on a site specific basis. Provide rigid training for all personnel handling fuel. See 4.1.1.4, Spills of Fuels and Lubricants.

Mitigation of the Impact on Surface Water, Ground Water, and of Borrow Material Excavation on River and Stream Hydrology

Proposed by Applicant

Several methods for controlling erosion are presented. The overall plan is to minimize interference to natural drainage wherever possible, and to revegetate disturbed areas to establish thermal equilibrium. To mitigate unavoidable disruptions of drainage patterns, control measures such as mound breaks, diversion dikes and ditches, plugs on downslope slides, riprap to control gullying, ditch plugs, and grading will be used.

Erosion control mitigation procedures have been submitted by the Applicant. The proposed type of control measure indicated on the maps was selected on the basis of soil type and slope.

A chilled pipeline will create a frozen condition in thawed gravels by developing a frost bulb around the pipe. The bulb could in time block water flow. Where necessary, dual lines will be constructed and development of frost bulb will be controlled by alternating gas flow through the lines or deep burial could be utilized and the weight of the surcharge will be depended upon to counter the conditions which cause frost heave. In cases where the potential for scour, erosion, or channel relocation would be so large that deeper burial is prohibitive, pipe protection will be provided by means of bank armoring and/or river training.

Analysis

Significant modifications of the existing hydrological regime could occur, regardless of the construction method or season of construction. Countless opportunities exist for cross-drainages to be diverted parallel to the pipeline and for thaw degradation ponding situations to develop.

No criteria are presented for maintaining runoff velocities below erosive velocities. Overfill of berm required to compensate for thaw consolidation aggravates the problem and necessitates more comprehensive criteria.

Permafrost would be 1.5 feet higher along the trench than the adjoining slope. During spring thaw and fall freeze, there would be a time when the permafrost along the pipeline would intersect the surface, while the upslope and downslope contiguous area has thawed to a depth of 1 to 1.5 feet. During spring, the quantity of moisture in the soil would be high. Although mound breaks would be provided, they would be blocked by localized aufeis and heavy drifted snow, which would precipitate erosive velocities and channelization outside the mound breaks. The improper handling of this problem could clearly modify surface drainage. Revegetation would be successful in areas where the cycle of hydraulic and thermal erosion had been prevented or arrested to a large degree by mechanical control measures for 2 to 5 years after initial disturbance.

The problems associated with pipeline river crossings could affect both the pipeline and the environment. General criteria for river engineering considering the various factors are presented by Blench and Associates (1973). A goal of the pipeline construction is to keep the pipe buried at the approach to and under the river under all foreseeable conditions. In this, river scouring, channeling, bank erosion, and flood plain erosion must be considered. The environment could be affected if the pipeline construction precipitated mass wasting on some of the slopes, riverbed degradation, and formation of ice bulbs around the chilled pipe in the unfrozen ground below the riverbed. It is also known that considerable frozen ground exists within active flood plains. Thus, the problem is not merely one of creating frost bulbs, but also of thawing and differential settlement.

The vertically asymmetrical growth of the frost bulbs around the pipe could result in an upward shifting of the pipe from its original position.

There is also a question regarding the calculation of the frost bulb. The Applicant states water flow velocity as 0.945 ft/hr while the figures show 0.00945 ft/hr. Presumably, the lower figure was used in the calculations. The soil water content is not specified, nor is the method of calculation of the convective heat flux, which is presumably much higher than the conductive one.

Interpretation of figures submitted by the Applicant indicates a burial depth of 5 feet (between the original riverbed level and the top of the pipe). This may not be sufficient to avoid scour; calculations performed by Northern Engineering Services Co. (1974) (Appendix B) show a scour depth of 12 feet for a typical braided river and 13 feet for a single channel river. In a survey of the areas, Taylor (1972) considered the possibility of scour depth resulting from local summer channeling of 20 to 30 feet below the normal streambed elevation.

The negative buoyancy provisions, while discussed, are not quantitatively defined and it can only be inferred that the negative buoyancy would be between 5 and 20 percent.

To obtain a better understanding of the local problems at stream crossings, it would be necessary to examine data from a few critical river crossings.

Conclusions

Success in utilizing the proposed erosion control methods depends upon the criteria used for the selection of control methods for each case.

The Applicant provides an adequate review of problems associated with river crossings. However, methods to mitigate the problems are inconclusive. More details on depth of pipe burial under braided and channeled rivers, flood plain criteria, and compatibility of the pipeline with the lateral erosion risk zone are needed for assuring effective mitigation.

Possible pipe displacement caused by asymmetrical frost bulb growth under the rivers has not been adequately mitigated. (See 4.1.1.3 Geology.)

External pressures at river crossings are not adequately provided for. (See 4.1.1.3.)

Details on the negative buoyancy provisions of the pipe when crossing critical terrains are needed.

Additional Measures

Develop criteria which will allow areas with a high potential for accelerated erosion to be defined on a detailed basis and in a manner suitable for portrayal on construction drawings. These criteria should provide methods for the calculation of required quantities of backfill, mound breaks, culverts, ditch plugs, borrow, and other control and restoration measures. Criteria should consider soil type, including thermal state and moisture content, topography, climate, hydrology, construction mode, and grading geometry. Analysis should show that the measures proposed will accommodate worst case ground and surface water conditions in the presence of the ice bulb.

Provide specific criteria to restore any riverbanks that have been breached for crossing and to protect them from excessive erosion.

Provide for review and approval of flood plain criteria and demonstrate that the pipeline design is in conformance with these criteria. Details of pipe negative buoyancy provisions as functions of the terrain crossed should be provided and substantiated by analysis.

Specify the design flood used and substantiate the choice with analysis of risk for the projected pipeline life versus cost of increased safety.

Provide for review and approval of detailed design for all river crossings with supporting analyses to show that depth of burial and negative buoyancy provisions are compatible with worst case assumptions. These analyses should show that frost bulb growth (worst case) will not have an adverse effect on water flow.

Mitigation of the Impact of Borrow Material Excavation

Proposed by Applicant

Borrow pits would be restored by grading, contouring, fertilizing, and seeding.

Analysis

Some of the borrow pits shown on the alignment sheets are near or in the riverbeds, short distances from the pipeline. Removal of material from streams and riverbeds could result in changes in scour depth and changes in riverbed location. Because some borrow areas are upstream from the pipeline, the pipeline integrity would rely to some degree on the success of erosion control measures. These subjects have been covered under 4.1.1.3 (Geology) and 4.1.1.4 (Soils).

Conclusions

Mitigation of impact is acceptable.

Additional Measures

Develop a maintenance program for erosion control of borrow pits.

4.1.1.6 Vegetation

Revegetation

Proposed by Applicant

The Applicant indicates that the broad objectives of the revegetation program are to promote soil stability and encourage the reestablishment of natural plant communities. As the primary objective of the revegetation program, soil stability will form the basis for the disturbed area classification and revegetation specifications. The prevention of water erosion and slope failure are of prime concern. Engineering design features must provide the initial erosion control; however, revegetation will be used in conjunction with them to supplement and protect the physical erosion control measures. In time, revegetation is expected to replace the physical measures as the primary erosion control system, but in the early years will function mainly as a backup system.

In areas where erosion is not a problem, the main objective is to aid in the reestablishment of the native plant communities. In these areas, high seed and fertilizer application rates may serve only to return natural recovery; therefore, applications will be minimal and used to encourage natural revegetation rather than substitute for it. Though native vegetation will be much slower to establish, it is better adapted to the cool, low nutrient environment encountered in tundra and boreal forest regions and over the long term will provide a more stable, low maintenance cover.

The Applicant recognizes that the line will traverse numerous different terrain, soil, and drainage conditions.

(a) He proposes to establish plant cover for:

1. Pipeline area with crown and spoil pile.
2. River crossings.
3. Borrow sites except those which form natural lakes.
4. Areas where snow and ice roads have failed.
5. Around the gravel pads built for construction camps, and
6. Emergency repair trails used during operations in case of pipe failure. He recognizes that movement of heavy equipment will cause some site damage.

(b) The Applicant proposes to accomplish the above by various seed mixtures, fertilizers, stripping and replacement of the tundra mat, hand planting of stem cuttings and laying preseeded soil binding mats.

He indicates that extensive field research has been carried out to develop revegetation techniques. As a result, specifications were developed to cover the exotic and native seed mixtures required for various ground conditions which will be encountered along the route. The Applicant indicates that revegetation studies will be continued and improvements in seed mix and application techniques may result. In case of local failure or poor success of the revegetation efforts, the Applicant is prepared to revegetate and stabilize as necessary.

The Applicant's current revegetation specifications, which are to be refined, are contained in Table 4.1.1.6-1. These specifications are based on his own review of his most current studies, revegetation literature, climatological classification, and vegetative regions. The Applicant indicates that before the pipeline is constructed it would be necessary to develop new detailed revegetation specifications for all disturbed areas along the route.

Applicant's current specifications which relate to Table 4.1.1.6-1 are as follows:

Drainage Classification: In general, the proposed classification system takes drainage into account with areas of high, medium and low erodability being analogous to the drainage classes of dry, moist, and wet. The actual application of this classification to the route will await the final route selection and analysis of physical parameters which will take place prior to the final design stage.

Species and seed-impregnated mats: Species are to be selected which survive in the wide range of environmental conditions. From the studies underway since 1969, certain species have shown a potential for use in revegetation work north of 60° N. latitude.

The seed specifications for the initial seeding are a combination of slow-establishing, hardy species and faster establishing, less hardy species in an attempt to optimize immediate erosion protection and longevity (Table 4.1.1.6-1). Seed-impregnated mats will be used in areas of high erodibility. In these cases, the mats will function as the immediate erosion control measure and will be sown with the more hardy species to provide the long-term protection. In areas of medium erodibility, a combination of species will be sown with emphasis on rapid establishment. Areas of low erodibility will receive only a light seeding of slower establishing, more hardy species. The followup seed specifications are for those areas where revegetation is slow or more difficult. Reseeding would probably occur the year following the initial seeding and would only apply to areas of high or medium erodibility. In both cases, the species proposed are the slower establishing but longer-lived varieties.

Native species have been suggested as logical inclusions in northern revegetation programs because of their apparent adaption to the environment of these regions. Currently, grasses native to arctic and sub-arctic Alaska and Canada are being studied in species' trials. In the Prudhoe Bay regions, studies over a 3-year period have shown the *Puccinellia* spp., *Arctagrostis latifolia*, *Calamagrostis canadensis*, *Deschampsia* spp., and *Poa glauca* are some of the hardiest and best cover producers. The only introduced species which performed as well was Arctared creeping red fescue, a variety which is commercially available. In the Inuvik-Tuktoyaktuk region of the Northwest Territories, studies have shown that, though much slower to establish, the two native grasses *Arctagrostis latifolia* and *Calamagrostis canadensis* are winter hardy and highly productive. Both of these species produced 50 to 90 percent row cover and three to five times more biomass by the third year than either of the surviving introduced grasses, Nugget Kentucky bluegrass and Arctared creeping red fescue. Many problesm related to dormancy and flowering mechanisms still need to be solved before seed will be available for use in commercial quantities. The development of a native seed supply is considered an important part of the revegetation

Table 4.1.1.6-1 Proposed specifications for right-of-way revegetation; Prudhoe Bay to Alaska-Yukon border

Climatic Region 1/	Erodability Rating	Common Name	Seed Specifications: Initial Seeding rate (Kg/ha)	Seed Specifications: Follow-up Seedings rate (Kg/ha)	Revegetation Measures: Sod Replacement	Revegetation Measures: Seed Mats	Revegetation Measures: Stem Cuttings
Low Arctic Tundra	High	Nugget Kentucky Bluegrass	18	9	No	Yes	Yes at crossings 2/
		Arctared Creeping Red Fescue	38	19			
	Medium	Arctared Creeping Red Fescue	40	19	Yes	No	No
		Engmo Timothy	6	9			
		Meadow Fox Tail	6	-			
		Redtop	6	-			
	Low	Arctared Creeping Red Fescue	22	None Planned	Yes	No	No
		Nugget Kentucky Bluegrass	6				

1) based upon major vegetation zones
2) will be used if available

Source: Applicant's comment of Oct. 1975 as amended (Project Report by C.A.G.P.L. Sept. 1975) program in the Arctic; however, until successful seed production has been achieved, none of these species will be included in the seed specifications.

Fertilizers: Fertilizers will be applied to all seeded areas. Studies have shown that soil nutrients are uniformly low over most of the tundra and boreal forest regions and the fertilizers containing nitrogen, phosphorus and potassium applied at 56, 112, and 56 kg/ha (kilograms per hectare), respectively, provide good growth. A fertilizer mix meeting these specifications will be applied to all plantings in areas of high or moderate erodibility. Areas of low erodibility and areas where a followup seeding is required will receive this same mix at one-half the rate. Refertilization will take place only on areas of medium or high erosion potential as determined by an aerial monitoring program. Fertilizer specifications for tundra areas have not been developed but considerable data from successful research projects are available and are under review to aid in this development. A basic premise for determining fertilizer use is that minimum quantities to achieve the necessary growth of grasses will be specified, avoiding unnecessary addition of nutrients into naturally low ecosystems.

Stripping of the tundra mat or sod replacement: The Applicant indicates plans to use sod replacement in areas of medium and low erodibility.

Stem cuttings: The use of stem cuttings of available shrubs species has been tested. Studies conducted have shown that several of the common willow species (*Salix alaxensis*, *Salix arbusculoides*) occurring along the proposed route can be propagated using soft or hard stem cuttings with a potential survival rate of 90 to 100 percent. These cuttings are proposed for use in the stabilization of areas of high erosion potential, particularly at river crossings, along the proposed route.

Analysis

The Applicant has proposed a revegetation program to promote soil stability and encourage the eventual reestablishment of native plant communities. These are considered reasonable objectives since complete cover reestablishment will be slow at best. It is recognized that reseeding will not prevent melt-out and subsidence of materials, however, it can reduce soil erosion although not prevent it during the first 3 years. According to Haag and Bliss (1974) "... if litter is not replaced, increased plant cover has little effect on active layer depth during the first three years of re-growth."

As noted, the Applicant plans to establish cover on all areas he disturbs. He has recommended certain species for certain site conditions in his "Revegetation Specifications" for the low Arctic Tundra. Application of these specifications based on general plant community data supplied by the Applicant indicates that he would use the high erodibility mixture on an estimated 83 miles of the route, medium on 88 miles, and low on 22 miles.

The Applicant indicates he will seed, fertilize, strip and restore organic material, hand plant stem cuttings and lay preseeded soil binding material where necessary. These items are analyzed as follows:

(a) Seed species and mats. The Applicant is placing heavy reliance on grass species which are exotic to the area. He has, however, worked with some native species and indicates there are the usual problems of native species propagation.

Seed-impregnated mats as proposed can be very valuable for quick establishment of vegetation cover.

(b) Fertilizer and application. Fertilizer is proposed and recognized as essential.

(c) Stripping of the tundra mat or sod replacement. The stripping or replacement of tundra is planned by the Applicant, however, there is no indication of how this will be accomplished under frozen ground conditions.

(d) Stem cuttings. It appears that the use of stem cuttings may be a feasible and valuable technique for quicker cover establishment in areas of high erosion.

The Applicant has indicated he plans to continue his proposed revegetation studies. Because of the lack of adequate experimental data, this is a necessary prerequisite to a successful reseeding program.

Seeding failure and poor success are recognized as problems. In some areas it will be many years before a suitable seedbed exists. Also of importance here is the fact that the Applicant recognized the necessity of mechanical stabilization which will come before revegetation.

Conclusions

The Applicant's revegetation objectives are to promote soil stability; and encourage the reestablishment of natural plant communities. It is of necessity that a perennial plant cover be established as soon as possible. Where the program is successful, however, this new cover will have little short-term benefit in helping to prevent the reduction of permafrost. Studies indicate that in areas where thaw consolidations and settlement may lead to excess erosion immediately following surface vegetation disturbance in winter, attempts should be made to return the insulating organic layer.

The Applicant recognizes that numerous types of terrain, soil, and drainage conditions will be encountered as he attempts to establish cover on the various disturbed areas.

The Applicant has not explained how he would strip or replace the frozen tundra (sod replacement) as he has proposed. Without explanation and based on what is known about the frozen tundra, this is a questionable procedure which may not be at all feasible.

All of the Applicant's proposals presented for revegetation are in need of continued study since he has not adequately demonstrated that the methods will work in the northern Arctic Tundra Region.

Additional Measures

Consult with the University of Alaska's Institute of Agricultural Sciences, Soil Conservation Service for local revegetation procedures. Contacts should also be made with representatives of the appropriate Federal and State of Alaska agencies for their recommendations on revegetation.

Avoid disturbance of organic layers in permafrost areas outside the pipeline system. Apply dust control measures to prevent vegetation destruction in adjacent areas.

In planning layout of material sites, primary emphasis should be placed on prevention of soil erosion and prevention of damage to vegetation.

Vegetative organic mats stripped from material sites should be stockpiled for reuse in restoration.

Surplus excavated material should be disposed of in an environmentally acceptable manner as approved by the responsible agency.

Clearing boundaries for construction activities should encompass the minimum required area as approved by the responsible agency.

Precautions should be taken to minimize vegetative disturbance during clearing operations. Dozer blades should be equipped with skid shoes and vehicles should be powered adequately to avoid slippage of wheels and/or tracks.

In order to protect the vegetative cover, mobile ground equipment should not be operated off the approved right-of-way, access roads, state highways, or authorized areas.

Use of explosives should be limited to trained personnel in order to avoid environmental damage. The Applicant should develop procedures to eliminate the scatter of blasted material beyond the immediate working area.

Temporary access roads should be left in a stabilized condition after use. Revegetation should take place in all permafrost areas where the vegetative organic mat has been removed to help establish a thermal balance.

Research which is already in progress should be continued and expanded. This includes species and fertilization trials at Prudhoe Bay which are being conducted by Drs. W.W. Mitchell and J.D. McKendrick. Quantitative observations of native species invasion should also be made on these plots.

Additional revegetation studies should be conducted on site conditions similar to those created by the berm over the pipeline. The purpose of this research will be to provide better methods and techniques for establishing a vegetative cover on the berm. Tests conducted on the Arctic Coastal Plain indicate that the berm may be difficult to revegetate.

A search for ways to strip, stockpile, and replace the tundra organic layer in the winter so that it regrows the following summer would be significant to a successful tundra revegetation program. It would permit better control of thermal balance and would provide an efficient means of replacing native vegetation.

Methods for Establishment of Willows, Birch, *Vaccinium* sp., and Other Nonherbaceous Plants on the Tundra

Willows, birch, *Vaccinium* sp., and other woody dicots are important but not dominant species of the Arctic Coastal Plain. Research on the establishment of these species on disturbed sites in the Coastal Plain has been neglected, yet AAGPC specifies this as an alternative method of revegetation (AAGPC, 1974a). Knowledge gained from this study would provide adequate information for proper assessment of the feasibility of tundra revegetation programs.

Tundra fertilization has been shown to have a favorable effect on seed production of tundra species (e.g. *Eriophorum vaginatum* and *Carex* aquatilis). However, these tests have shown only the feasibility of such a process, and more detailed research is required for adequate evaluation.

Determination of ways of increasing the reproductive capacity (seed production) of undisturbed tundra could significantly improve the rate of return of native species to disturbed sites.

Selected grasses have been the primary native tundra species evaluated for use in tundra revegetation programs; a number of other species have potential and should be tested. Two of the most versatile species, i.e., they occur over a very broad range of site conditions, are cottongrass (Eriophorum vaginatum) and Carex aquatilis. Preliminary autecological work is available for cottongrass but virtually nothing is known about Carex.

The success of a revegetation project is determined by the ability of the vegetation established to meet the stated objectives. There are no data now available to determine the ground cover or rooting density required for erosion control, esthetics, etc. The requirements for the various objectives are not necessarily the same.

There is no currently available means to determine success of a project for these various objectives. The amount of cover will determine the seeding and fertilization rates. Research conducted here will provide answers to these questions.

Fertilizer is needed to establish grass stands and to maintain some of the species. Grass species have been tested but optimum rates of fertilizer application are not known. Initial data on annual grasses are available but not for the perennial grasses, which are the main species to be used in revegetation. Determination of optimum rates of fertilizer application is necessary to assure success of the revegetation.

Mitigation of the Impact on Vegetation Caused by the Spillage of Fuels and Lubricants and Methanol Spillage During Hydrostatic Testing

Proposed by Applicant

As diesel fuel and fuel oil are required to operate ground vehicles and equipment two potentials for accidental leaks or spills exist: (1) during unloading and stockpiling along the coast, and (2) on land during construction, and to a lesser degree during operation of the pipeline.

Plans are to clean up the leaks on land by hand to minimize damage caused by the operation of heavy equipment to the vegetation and soil.

In regard to hydrostatic testing with methanol (methyl alcohol) which will be used as an antifreeze in gas pipeline testing, the Applicant has done some testing in Canada. Preliminary studies in the Inuvik test area have shown that diluted water and methanol solution during winter does not detectably affect shrub-tundra vegetation at proposed levels.

Analysis

It is probable that fuel, lubricant, and methanol will be spilled at both fixed installations and along the route.

The effects of full-strength methanol being spilled are not known. It is not known whether the tests at Inuvik are applicable to any or all of the

Alaskan Arctic Slope traversed by the proposed system since the vegetation and soil conditions at the test site are considerably different from those in Alaska.

Conclusion

Fuel and lubricant spillage will kill plants and constitutes an impact which will need to be mitigated to the extent possible by cleaning up each spill. It appears that the Applicant plans to do just that.

The impacts resulting from 26 percent methanol water spilled on the surface are unknown and no mitigation has been proposed.

Additional Measures

Additional data will need to be presented or studies made to fully determine the effects of methanol on vegetation.

4.1.1.7 Wildlife

Mitigation of the Impact on Wildlife

Mammals

Caribou

Proposed by Applicant--Winter construction, route selection, aircraft avoidance during certain periods, altitude limits, revegetation, noise mufflers on machinery, and prohibition of hunting, will be used to avoid or mitigate adverse impacts to the Porcupine Caribou Herd during construction of the project. These items have been discussed based on the considerable amount of research on the herd that has been done by the Applicant.

Analysis--Winter construction is the major mitigation proposed to reduce impacts on the herd. Summer activity associated with the project, however, will affect the well-being of the herd and the proposed overflight altitudes may not be sufficent to prevent harassment of the herd. The proposed fencing around ancillary facilities may adversely affect travel along traditional migration routes or may be rendered ineffective by drifting snow. The proposed revegetation program has not been completely researched and may not be as successful as proposed. Unsuccessful revegetation would cause secondary adverse impacts on caribou habitat. Prohibiting hunting by construction crews and muffling machinery by 8 to 10 dB would be effective in reducing impacts on the herd by the Applicant's personnel. Refer to Section 4.1.1.15 for more information on noise.

Conclusion--The mitigation methods proposed will be effective in reducing adverse impacts of the project on the Porcupine Caribou Herd during the winter.

There will remain, however, a residual adverse impact caused by increased access, aircraft, and other project related activities with the possibility of a much greater disturbance factor during and after the construction of the proposed compressor stations that the Applicant has not addressed. It is probable that a reduction in the size of the herd will occur.

Additional Measures--Monitor the caribou movements during the spring construction period to ensure that activities do not interfere with migration.

Avoid mobile ground equipment operation off the right-of-way, or off access roads, state highways, or authorized areas, in order to minimize contact and disturbance to wildlife.

Provide blasting schedules that prevent disturbances of the caribou herd.

Conduct sufficent research to determine a safe (non-disturbing) aircraft altitude over the herd. Investigation into low-noise aircraft procurement, particularly helicopters, should also be made.

Conduct a monitoring program sufficently long and detailed to determine effects of the total project (line and compressor stations) on the herd. Program objective should be determined and adverse impacts mitigated by readjusting operating procedures.

Moose

Proposed by Applicant--Conduct preconstruction searches of route alignment, haul roads, and borrow areas to identify and "where possible" avoid sensitive areas. The Applicant will not allow harassing and hazing of animals.

Analysis--Further studies to delineate sensitive areas, especially wintering areas, are needed to provide more adequate information upon which to base avoidance measures.

Conclusion--There will be a loss of moose habitat, resulting in population relocation or loss should this proposal be initiated.

Additional Measures--The Applicant should identify all critical areas, especially moose wintering areas, and avoid them during all phases of project construction.

Restricting speed limits and enforcing safe driving practices will help reduce moose-vehicle accidents.

Musk Ox

Proposed by Applicant and Analysis--Same as for moose.

Conclusion--There will be a loss of musk-ox habitat resulting in population relocation or loss should this proposal be initiated.

Additional Measures--Measures recommended are similar to those for moose except that because musk oxen are shyer and of more interest to most humans than are moose, aircraft and other vehicle avoidance distances must be greater than those for moose.

Dall Sheep

Proposed by Applicant--The Applicant has no mitigation proposal because he can foresee no impact.

Analysis--None.

Conclusion--Some sheep winter range and perhaps lambing areas will be avoided by the sheep populations of the Sadlerochit Mountains and the Canning River Valley. The project could have a minor impact on Dall sheep, but the Applicant has not proposed ways to mitigate the impact.

Additional Measures--Identify and establish minimum flight distances and altitudes over sheep habitats.

Identify the area and time of lambing and provide more complete protection to the animals by establishing zones where activities are restricted or eliminated.

Wolf

Proposed by Applicant--Identify and avoid wolf den sites where possible, regulate aircraft movements, prohibit hunting by project-related personnel, prohibit firearms in camps, dispose of garbage in a manner not to attract wolves and other carnivores, and fence camp areas, airfields, and other facilities.

Analysis--Project-related activities could reduce the wolves' prey species. It is probable that some dens will be disturbed. Drifting snow may accumulate along fences which may make them ineffective for keeping wildlife out of camp areas in the winter.

Conclusion--There will be a reduction of wolves in the project area that will come about because of project-related activities.

Additional Measures--None.

Arctic Fox

Proposed by Applicant--Similar to those for wolf.

Analysis--Additional area access may increase trapping pressure, and destruction of den sites will reduce fox populations.

Conclusions--There will probably be some reduction of the fox population in spite of proposed mitigation.

Additional Measures--None.

Grizzly Bear and Wolverine

Proposed by Applicant--Similar to those for all other large mammal species and including winter construction den area identification and avoidance, fencing, restricted hunting, etc.

Analysis--The grizzly bear and wolverine are true wilderness species requiring large areas free from man's intrusion and development. The Applicant's proposal, especially the winter construction period and avoidance of den sites, will help reduce the project-related impact on these species.

Conclusion--There will be an unavoidable reduction of grizzly bear and wolverine numbers along the pipeline route. This will come about because some bears and wolverines will avoid and/or leave the area, some will be shot because of their nearness to camps, some will be taken because of increased hunting pressure, and some will be harassed by aircraft until they die or leave the area.

Additional Measures--None.

Polar Bear

Proposed by Applicant--Similar to those for grizzly bear. The Applicant has conducted studies to determine polar bear denning sites on land.

Analysis--Denning polar bear are extremely sensitive tc disturbance. There are known land-denning sites near the pipeline route and the proposed wharf areas. Winter activities such as supply movement, blasting, and construction will cause the land-denning bears to avoid the area. This may cause a reduction of cub production which could result in low reproduction of the Beaufort Sea population.

Conclusion--Because of their secretive and sensitive nature, denning polar bears will tend to avoid the project area, which may have an adverse effect on the polar bear population. This cannot be mitigated.

Additional Measures--None.

Other Marine Mammals

Proposed by Applicant--One method (straw spreading-pick up) of cleaning up fuel and other floating pollutants spilled on the ocean near the wharf and stockpile areas has been identified.

Analysis--Pollutant spills would directly affect the marine mammal species involved if they were contacted by the pollutant. The severity of the effect would depend on the pollutant. A spill may have secondary effects because it could reduce the amcunt of food available to the animals. Some illegal hunting might be carried on by the shipping personnel.

Conclusion--The Applicant has not provided sufficient information nor made adequate plans to reduce impact from fuel spills.

Additional Measures--Conduct a research program detailed enough to identify marine mammal populations, their locations, time in the shipping area, and their food supply. Train personnel in proper fuel handling techniques.

Small Mammals

Proposed by Applicant-- A revegetation plan is proposed which will have the secondary benefit of reducing the loss of small mammals by restoring their habitat area.

Analysis--Basic objective of revegetation is to reduce soil erosion and thermal disturbances.

Conclusion--There will be a physical nonretrievable loss of habitat because project facilities will be placed upon the tundra. There will also be a short term (if the revegetative program is successful) loss of habitat where the pipeline ditch is dug. There will also be some habitat loss because of pollutant spills and destruction of den areas. Areas lost, unless there is a massive vegetative failure or borrow removal that causes destruction of large den areas, will be minor in the overall amount of habitat. If the revegetation program is successful, small mammal numbers should not be severely affected over a long period.

Additional Measures--As indicated in this and other subchapters and in the discussion on vegetation, there is some doubt as to the success of the Applicant's revegetation program. Mcre on-site research should be carried out to increase the chance of success.

Birds

Swans

Proposed by Applicant--No special proposal for mitigating swan losses is presented.

Conclusion--There will be a reduction in the numbers of swans produced in the project area because of the project.

Additional Measures--Delineate swan use areas and promulgate and enforce avoidance regulations. These regulations should include but not be limited to aircraft flight lines, altitudes, and zones and times to be avoided.

Geese

Proposed by Applicant--To mitigate the impact on waterfowl in general, the route was selected to avoid, as much as possible, areas of major importance to waterfowl. Also aircraft movements will be controlled during construction and operation to avoid unnecessary disturbance, work crews will not be permitted to use company vehicles to visit critical habitat areas, and barge traffic will be kept to a minimum or routed away from molting areas.

Analysis--There are indications brought out by research conducted by the Applicant that staging snow geese are sensitive to aircraft disturbance at flight levels well above 1,000 feet. In addition, black brant and other geese are present at the same time as snow geese, although in different areas, and are also sensitive to aircraft disturbance at that time.

Conclusion--Construction and operation of the pipeline will reduce or relocate snow geese and other geese in the area.

Additional Measures--Detailed studies of disturbance factors that could cause population losses should be made. Adjustments of schedules to reduce impacts will be made if studies indicate a need.

Continuing flights for maintenance and surveillance purposes over and to the proposed pipeline will constitute a continued disturbance factor on geese and fresh water ducks. Studies should be conducted to determine lateral distance disturbance thresholds, possible accommodation to disturbance, possible cumulative and long-term effects of disturbance, and reactions to other types of craft by geese, particularly snow geese, and fresh water ducks. Schedules should be adjusted to reduce impacts. Conducting this research may also adversely affect snow geese population unless carefully devised and carried out, probably without aircraft or other vehicle support.

Ducks

Proposed by Applicant--None except noted above for geese.

Analysis--The molting and nesting stages are the most sensitive periods of the ducks' life cycle in the north. Barge, lighter, and aircraft traffic will cause disturbance to these birds during those times.

Conclusion--There will probably be some losses of ducks because of the project.

Additional Measures--The effect of barge and lighter traffic on waterfowl using the areas of shipping and unloading should be studied to assure that waterfowl will not be disturbed during the molting period.

An adjustment of shipping periods cannot be made, because of the short time during which the coast area is free from ice and used by both the molting birds and shipping. Molting areas and times should be delineated so that shipping lanes and wharf areas can be chosen and shipments scheduled or restricted accordingly.

Peregrine Falcons

Proposed by Applicant--In addition to the general proposals listed, a 2-mile buffer zone around nest sites is proposed.

Analysis--There may also be some effect on peregrine population because the pipeline crosses their hunting range and peregrine prey species may be affected.

Conclusion--There may be a small effect on the peregrine falcon but a complete analysis cannot be made at this time.

Additional Measures--Conduct additional research into the feeding areas and habitat of the falcon to devise and initiate additional mitigation procedures.

Other Birds

Proposed by Applicant--No proposal has been made to reduce the impact on birds other than those stated above.

Analysis--Hawks, owls, ravens, songbirds, and other tundra dwelling birds will suffer the least impact. There will be some loss of nesting and feeding areas as with the small mammals but it should be minor. Pollutant spills during the summer could cause harm if not cleaned up promptly.

Conclusion--There will be some losses to song birds and other tundra-dwelling birds and the raptors and ravens. If the Applicant's proposal is followed, and if the revegetation program is successful, these losses should be mitigated over the years.

Additional Measures--Study effects of diluted and concentrated methanol on microtines, passerines, and waterfowl. The studies should at the least determine the effects of methanol when applied to the exterior of the animal and the effects on the animal (eggs, young, and adults) after ingestion of the methanol or vegetation containing methanol. This would aid in determining the best method of diposal.

Fish

Proposed by Applicant--Protect fish habitat by preventing sediments from getting into streams. Control surface drainage to keep it in present channels. Restrict water withdrawals to standing and flowing water where there are no fish. Prevent fuel, lubricants, waste fluids, and methanol used for hydrostatic testing from entering streams.

Pollutant spills on lands and water are to be cleaned up by one of two methods; e.g., application of absorbent materials to clean up spills on water and hand removal and/or adding of nutrients to enhance the rate of microbe degradation of petroleum on land spills. Buffer zones have been proposed between the right-of-way and all but one of the identified fish spawning and overwintering areas. Blockage of streams will not be permitted during construction activities. Angling by construction personnel and official visitors will be prohibited and competent aquatic biologists will observe and regulate construction, operation, and maintenance procedures from the standpoint of protecting fisheries.

To avoid contamination of water bodies, sewage wastes will be processed in biological or physical-chemical treatment plants which will provide secondary treatment and discharge clear effluents into a holding pond. The treated water will be discharged into existing natural drainage courses, as approved by governmental regulatory authorities (AAGPC 1974a).

The Applicant has proposed a number of items that, if successful, will reduce project impact on fishery resources. He has provided adequate contingency plans to mitigate impacts on aquatic life in the following situations which could result from construction activities: changes in stream temperature regimes, aufeis formation, lowered oxygen levels associated with sewage disposal, and reduced water levels associated with withdrawals for ice roads, construction camps, and compressor stations.

Analysis--A successful revegetation program and pollutant spill control may cause addition of fertilizers to streams which could reduce the oxygen levels of the water. Concentrations greater than 1 percent methanol are toxic to fish; leaks during line testing and disposal of the used methanol water mixture may have adverse effects on the fish. Surface drainage controls may not be effective because of changes caused by the frost bulb around the pipe. The Applicant has identified fish wintering and spawning areas for some of the streams to be crossed.

Conclusion--Project construction, operation, and maintenance will cause some reduction of fishery resources. Stream side borrow pits and drainage from upland pits could add sediments and change channels in streams unless the borrow areas are carefully selected and extraction methods carefully controlled. Angling may need to be controlled during the operation phase. The full amount of damage will not be apparent until after a number of years of operation because changes of stream flow and surface drainage from frost bulb formation may not be apparent for several years. In summary, the Applicant has not effectively mitigated impacts which threaten potential damage to fish.

Additional Measures--Implement studies to determine optimum time of sewage effluent discharge. If the treated effluent is to be chlorinated before discharge, the effect of residual chlorine on arctic fish and other aquatic species should be studied to determined safe levels which must be met after treatment. Experience with the Trans-Alaska Pipeline System has shown that when construction camps have had short-term peaks of personnel employment, the sewage system was overloaded and spills occurred.

Additional studies are needed on the effect of methanol test fluids. Effects of this proposal must be fully assessed before such a procedure is approved.

Studies should include the effect of ambient methanol on fertilization success of fish species. Sperm and to a lesser extent the unfertilized egg could be extremely sensitive to small doses of methanol in the environment. It is also possible that sublethal doses of methanol would interfere with the chemosensory mechanisms integrally involved in the spawning process.

Establish programs to monitor the effects of the gas transmission system on natural systems and animals. Monitoring programs should include, but not be limited to, the following:

1) The effect of operating a cold pipeline and releasing treated sewage effluent on fish habitats.

2) Changes in location, thickness, and extent of aufeis areas along the proposed route for a distance of 1 mile up and downstream from the centerline of the pipe during all seasons.

3) Temperature of all streams that support a fish population downstream from proposed sewage treatment outfalls.

4) Pre-construction temperatures and post-construction temperatures immediately downstream, 100 yards downstream, and 1/2 mile downstream of the pipeline.

This information is necessary to determine if the operation of a cold pipeline and release of treated sewage effluent will change the temperature regime of a stream enough to affect fish population. If this happens, methods must be devised to relieve the problem.

Construct settling basins to intercept silted water resulting from construction activities.

Identify spawning and overwintering areas in those streams and estuarine areas not already surveyed.

Mitigation of the Long Term Secondary Impacts on Mammals, Birds, and Fish

Proposed by Applicant

Monitoring programs designed to detect changes in the environment which may develop over a period of time as a result of the project, including determination of the long-term effects of aircraft disturbance on species of waterfowl, ungulates and furbearers; determination of the impact of various vehicles and construction equipment on vegetation; and evaluation of the environmental suitability of various pipeline construction techniques.

Analysis

The monitoring programs will provide valuable information that should influence operation of the project and indicate less environmentally damaging arctic construction methods. These proposed monitoring programs may also give an indication of the capacity of wildlife species to adjust to increased disturbance before a general reduction in numbers and species diversity starts.

Conclusion

It is concluded that proposed mitigation efforts are minimum.

Additional Measures

Avoid alterations of existing spits, bars, barrier beaches, and offshore islands to minimize impact on seabird nesting and on use of sheltered lagoons for molting. A research program should be conducted to identify barge routes, wharf sites, and areas amenable to further development. Monitoring of the barge routes must be carried out to assure that molting birds are not being adversely affected by the barge and lightering activities.

A monitoring program at compressor stations should be conducted to determine effects on wildlife species. Monitoring should start 2 years before the start of compressor station-maintenance station construction. Records should be kept of numbers, species, and dates of animal and bird sightings.

Sampling should continue through all phases of station construction and operation so that sufficient records will be gathered to judge the effect of the operation of compressor stations on wildlife species.

Mitigation of the Impact on Invertebrates

Proposed by Applicant

The only direct proposal dealing with invertebrates is that no insecticides will be used in pipeline activities in Alaska. Mitigative measures proposed for other species, such as those to reduce sedimentation in streams, will also affect invertebrates.

Analysis

Those factors that were listed as affecting fish population will probably also affect aquatic invertebrates. Project effects on land invertebrates will probably be minimal. If methanol is sprayed over a large land area, insect populations may suffer.

Conclusions

Impact of project construction will have little effect on land invertebrates unless large areas are sprayed with a sufficient concentration of methanol to kill invertebrates. Aquatic invertebrates will be affected if sedimentation increases, oxygen levels fall, or areas become de-watered because of project activities.

Additional Measures

Perform research to determine lethal levels of methanol on all life stages of arctic invertebrates.

4.1.1.8 Ecological Considerations

Mitigation of the Impacts of the Construction and Operation on Tundra Ecosystems

Proposed by Applicant

Applicant states that the general mitigative measures outlined in the Environmental Impact Report of Alaska Arctic Gas Pipeline Company, Chapter VI, will ensure minimal disruption to ecosystems.

Analysis

The mitigation measures proposed by the Applicant have been outlined in sections on water, soil, vegetation, and wildlife, which in general address the tundra ecosystem. The disturbed area is relatively small compared to the remaining undisturbed area.

Remedial actions to be taken "where possible" and "if possible" do not assure mitigation of effects of the proposed construction.

Conclusions

Complexities of processes and interactions within ecosystems, and the general lack of knowledge about the processes in even a "simple" tundra ecosystem make it impractical to predict the impact and effect of mitigation for the proposed project on ecosystem functions.

The Applicant's belief that the general mitigation measures proposed in his application will be adequate is overly optimistic with respect to local impacts on the ecosystem.

Additional Measures

Regulate surface travel and minimize terrestrial disturbance by mechanical equipment.

Deeper burial of the chilled pipeline to permit surface soil temperature regime to return to natural conditions.

Secondary effects on tundra consumer insects, mammals, birds, and fish from application of fertilizer should be studied.

4.1.1.9 Economic Factors

Mitigation of the Impact on Employment and Income in Alaska

Proposed by Applicant

The Applicant states that the effect of the proposed natural gas pipeline system will be favorable, in social and economic terms, for Alaska because of the general economic expansion of the North Slope area, increased employment for local residents, and increased tax revenues for the newly established North Slope Borough.

Analysis

The timing of this gas pipeline project will be the key to benefits accruing to Alaska. If the project starts just as the oil pipeline employment decreases, then it will employ some of the workers who would otherwise be unemployed.

Experience with the Alyeska oil pipeline has indicated that unemployment went up in 1974 as additional people came to Alaska looking for jobs (see Section 3.1.1.9. for discussion). It is questionable that the gas pipeline will help alleviate unemployment, if the lure of jobs is the same as experienced with the Alyeska oil pipeline.

Conclusion

Timing the proposed project to follow the Alyeska oil pipeline construction would be a desirable mitigating measure.

Additional Measures

Close coordination between AAGPC and all governing bodies to anticipate, direct, control, and maximize economic benefits.

Mitigation of the Impact on Income to the State of Alaska from Gas Production Taxes and Royalties

Proposed by Applicant

The Applicant states that development of the proposed system will produce substantial revenue to the State of Alaska, directly from royalties and indirectly from tax revenue from the Applicant and increased employment. He further states that while engendering the above benefits, the proposed route will have minimal impact on the economic environment because it will not cause the degree of economic disruption which will accompany a less localized project, would draw fewer migrant workers to the State of Alaska, and thus will cause no major increase in the demand for social services. However, this is not true of local situations.

Analysis

It is clear that substantial revenues will be generated by this project and enjoyed by the State of Alaska. The route location, however, precludes use within by the State of Alaska of the gas resources from the Prudhoe Bay Field.

Conclusion

The project will have a slight beneficial impact on the State of Alaska in revenue from gas development. The adverse environmental effects of the project that cannot be mitigated must be considered as a cost to the State.

4.1.1.10 Sociological Factors

Mitigation of the Impact on Population, Housing, and Community Services

Proposed by Applicant

The Applicant states that because of location, the project will have little impact on the sociological environment. No specific mitigating measures are proposed.

Analysis and Conclusion

Because of location, winter construction timing, and the fact that this project will be built after the trans-Alaska oil pipeline, effects on Alaska's population, housing, and community services will be relatively minor. The project may stimulate more unemployment during the summer months.

Mitigation of the Impact of Solid Waste on the Environment

Proposed by Applicant

Dispose of solid waste by salvage and removal from the area, incineration, and/or burial. Disposal pits for incinerator ash and non-combustible solid waste will be fenced.

Analysis

The Applicant's proposal is based on ideal conditions which, because of arctic conditions, must be tailored to accommodate severe climatic conditions.

Conclusion

The Applicant's proposal is not adequate to mitigate the impact of solid waste on the environment.

Additional Measures

Require immediate cleanup and enforce anti-litter rules. The Applicant should be required to remove all solid wastes from the Arctic National Wildlife Range for disposal elsewhere. Burial of solid waste is not an acceptable disposal method on the Game Range.

Mitigation of the Impact on Transportation

Proposed by Applicant

No specific measures are proposed.

Analysis

Barge, truck, rail, and air transport will be used to carry material to the construction sites.

Conclusion

This project will have a positive effect on transportation facilities. Docks and roads on the Arctic National Wildlife Range will be major impacts on the wilderness characteristics.

Additional Measures

Investigate the possibility of using the already established DEW-line sites on the Beaufort Sea Coast as transportation (barge) facilities. Provide arrangements for supplemental service to lessen impact on the existing systems.

Mitigation of the Impact on Native Subsistence Economy

Proposed by Applicant

No specific measures are proposed.

Analysis

The semi-nomadic life of the North Slope Eskimos, anchored to a subsistence economy, virtually ceased in the twentieth century as they moved into a partial cash economy through employment at military installations, through commercial hunting and fishing, and through government economic assistance.

At present, North Slope Natives are caught between two worlds. Gradual acculturation has ended the willingness of most people to maintain a solely subsistence economy, but the lack of a fully developed cash economy has left them far below the defined level of poverty. The substandard housing, health care, and education of North Slope Natives can be improved only after a balanced local economy has been developed.

Conclusion

This project will tend to increase the rate of dependence upon a cash economy and decrease reliance upon the subsistence way of life. It would also increase the unemployment during the summer.

4.1.1.11 Land Use

Mitigation of the Impact on Land Use Planning

Proposed by Applicant

The Applicant has not identified any specific measures to be undertaken to mitigate impacts on land use planning efforts other than to maintain close coordination with State, Federal and local agencies during planning, constructing, and operation of the project.

Analysis

Land use plans have not been completely developed for this part of Alaska. The Joint Federal-State Land Use Planning Commission, the State of Alaska, the North Slope Borough, and the Village of Kaktovik all have recognized responsibilities in developing land use plans, but have not as yet completed them.

The State of Alaska has designated its lands in the Prudhoe Bay area for resource development. The proposed pipeline system will have a significant impact on statewide and local land use planning as commitments will have been made for transportation corridors, population distributions, and additional exploration and development without benefit of an overall land use plan. The proposed project will stimulate exploration and development of oil and gas along the Alaskan Arctic Coast.

The land use plan for the Arctic National Wildlife Range calls for protection of the unique wildlife, wilderness, and recreational values. There is no comprehensive land use plan for new gas wells, gathering lines, or pump stations for the Prudhoe Bay, Kemik, or Kavik Fields or for connecting these fields. There is no plan for relating these fields with Petroleum Reserve No. 4 to the west or the potential oil and gas basins to the east of Prudhoe Bay.

Conclusion

The impact of the proposed pipeline system on land use planning is considered to be severe since it commits land uses in the absence of a comprehensive statewide plan and a "Policy for the Arctic." This is especially important since the proposed pipeline invades the only remaining large area on the Alaskan Arctic Coast where human activities are not already pronounced, or where land use commitments have not been made to increase human activity.

Additional Measures

Comply with any plans developed in the future for lands within the right-of-way. This is especially important regarding those lands within the Arctic National Wildlife Range.

Mitigation of the Impact on Current Land Use

Proposed by Applicant

Monitoring various construction and operation plans of the project, winter construction, use of snow and ice roads, revegetation and restoration of areas disturbed, burial of pipe, various pollution control measures, and restriction on aircraft flights.

Analysis

Lands in the Prudhoe Bay area are already committed to a primary use of petroleum production. Accordingly, the proposed pipeline system will have a beneficial effect on development of oil and gas on State lands, particularly in the Beaufort Sea Offshore Province.

The wildlife implications are discussed in preceding Section 3.1.1.7, Wildlife, a discussion of subsistence is found in Section 3.1.1.10, and recreation is discussed in Section 3.1.1.13; each is a current land use in the project area.

Conclusion

The Applicant proposes a variety of measures to mitigate impacts that will significantly alter the existing land uses of the project addressed throughout this section.

Additional Measures

Public Improvements--Protect existing telephone, telegraph, and transmission lines; roads, trails, fences, ditches, and similar improvements during construction, operation, maintenance, and termination of the pipeline system. Avoid obstructing any road or trail with logs, slash, or debris. Damage to public utilities and improvements should be promptly repaired by the Applicant to a condition which is satisfactory to the responsible Federal or State agency.

Regulation of Public Access--Except in emergencies or when specifically approved in writing by the responsible Federal or State agency, the facilities (including roads, airstrips, and wharves) should not be used by persons other than AAGPC personnel and Federal and State representatives. All such areas should be adequately posted and notice of closed airstrips should be submitted for publication in FAA publications used by pilots.

Provide alternative routes for existing roads and trails as determined by the regulatory agency, whether or not these roads or trails are recorded.

The Applicant should inform work forces of all applicable laws and regulations relating to hunting, fishing, trapping, or camping.

Mitigation of the Impact on Wilderness

Proposed by Applicant

Limit the preconstruction, construction, and operation and maintenance activities so that the smallest possible impact is made on land and water resources. Restrict construction to winter months, limit over-flights, and restore revegetation.

Analysis and Conclusion

The project will require mechanical equipment, both permanent and temporary human occupancy, and construction activities foreign to a wilderness.

The steps proposed will help to lessen impact but cannot prevent making a substantial area unsuitable for wilderness designation. The buried pipeline, the mound of left-over material, the physical buildings, posts, airfields, and communication towers all will lessen the wilderness values. There is no way to eliminate this impact on the wilderness character of the Arctic coastal area across the Arctic National Wildlife Range.

Additional Measures

Selection of another route would eliminate the impact on the wilderness characteristics of the Arctic National Wildlife Range.

Utilization of a route either offshore or close to the coastline would have a lesser impact on wilderness than the proposed route.

<u>Mitigation of the Impact on Land Ownership</u>

Proposed by Applicant

Compensate any private landowner for use of his/her lands for project purposes.

Conclusion

Due to the uncertain actions regarding the pending Native allotment applications by the Department of the Interior, it is not possible to draw conclusions as to the effect of the Applicant's proposal on private land ownership or to suggest additional mitigation measures.

4.1.1.12 Historic, Archeological, and Unique Values

<u>Mitigation of the Impact on Historic Values</u>

Proposed by Applicant

No specific measures were proposed to mitigate impacts on the historic resources involved in the proposed project.

Analysis and Conclusion

Leffingwell Camp on Flaxman Island is the only site closely associated with the proposed project which is in the National Register of Historic Places. There appears to be little likelihood of serious impact on the Flaxman Island sites as a result of the proposed project.

Additional Measures

Provide close supervision of its personnel to prevent vandalism at the Leffingwell Camp on Flaxman Island.

<u>Mitigation of the Impact on Archeological Values</u>

Proposed by Applicant

Potentially productive archeological sections and locations have been identified along the route and classified as being high, medium, or low priority. Archeological survey of selected high priority sections and localities will be carried out ahead of construction activities. Archeological crews will accompany ditching and other construction or excavation activities to provide surveillance of any archeological sites exposed at that time. Sites discovered before construction will be avoided or will be salvaged in advance of construction wherever possible. Sites discovered, but not otherwise affected by construction, will be clearly marked and identified for future investigations. Sites discovered during ditching or other excavation will be flagged for salvage.

The importance and identification of artifacts will be included in the environmental training program for construction personnel. Procedures for reporting discoveries to archeologists will be implemented. The Applicant will arrange for artifacts to be deposited in appropriate public repositories and expects that most of them will be placed in suitable northern museums.

Analysis and Conclusion

Preceding construction, an on-the-ground survey by professional archeologists should be conducted by the Applicant to locate archeological and historical sites in accord with provisions of the National Historic Preservation Act of 1966.

The results of the preliminary surveys conducted by the Applicant will be evaluated by the Federal or State agency having jurisdiction over the lands involved. In compliance with Executive Order 11593, "Preservation and Enhancement of the Cultural Environment," those sites meeting established criteria will be nominated to the "National Register of Historic Places." If it is found that eligible sites will be affected by a construction segment, compliance procedures adopted under Section 106 of the National Historic Preservation Act of 1966 will be instituted, under which the Applicant will undertake excavation of the representative sample of the archeological sites endangered by the project. State laws and regulations will govern actions on State lands. These investigations should be performed by professional archeologists acceptable to the State and Federal Departmental Representatives. Preparation of comprehensive scientific reports (suitable for publication) on the results of the excavations will be undertaken.

Additional Measures

Immediately notify the State and Federal Departmental Representatives if paleontological, archeological, or historical sites are encountered. Should any individual item(s) of paleontological, archeological, or historical value be discovered, the Applicant should be required to insure that such item(s) are adequately identified as to discovery, location, date, and any other pertinent data relating to the item(s). Such item(s) should immediately be remitted to the Representatives. The Representatives should have authority to suspend that portion of Applicant's operations necessary to preserve evidence pending investigation of the site.

Mitigation of the Impacts on Unique Areas

Proposed by Applicant

No specific measures proposed.

Conclusion

The most critical issues revolve around the use of water from Sadlerochit Spring and the impact on Jago River from construction activities. There may be measures to mitigate water quality to protect the

Beaufort Lagoon and the fish and wildlife using the critical areas near Demarcation Bay. (See Water Resources, 4.1.1.5.)

Additional Measures

To avoid destruction of the natural area values of Sadlerochit Spring, it will be necessary to prohibit the use of water from the spring for ice road construction during the winter. Select a route that does not cross the Jago River. Special recommendations concerning the protection of water quality in streams flowing into the Beaufort Lagoon are covered in 4.1.1.5, Water Resources. Additional Measures for the protection of fish and wildlife values of the Demarcation Bay area are contained in 4.1.1.7, Wildlife.

4.1.1.13 Recreational and Esthetic Resources

Mitigation of the Impacts on Recreational Resources and Use

Proposed by Applicant

No specific mitigation measures.

Analysis and Conclusion

There has been and will continue to be an increase in outdoor recreational use of most areas of the United States. The present use of the arctic coastal area is very light, and users are attracted to this area for its wilderness and primitive values. There will be an increase in the accessibility to the area due to construction and operation of the Applicant's new airfields.

The opening of the new highway north of the Yukon River to the Prudhoe Bay area will increase appreciably the number of sightseers and hikers to the initial terminal area. Such potential increases would not be attributable to the Applicant's project, but rather to the oil pipeline project.

The Arctic National Wildlife Range is the major focal point for most of the present use. The arctic coastal area is used by wilderness hikers who make trips across the Wildlife Range.

It appears there is no immediate need to make special provisions for increased recreational use during the project construction period. The Applicant will provide recreation facilities for its work force, and since most workers will be in the area during the winter, the need to mitigate the impact on outdoor recreational resources is negligible.

Mitigation of the Impacts on Esthetic Resources

Proposed by Applicant

Will design construction, and operation procedures to minimize disturbance to the terrain and maintain the integrity of the pipeline. Natural and fill surfaces will be stabilized by carefully planned revegetation and maintenance measures which will achieve an esthetically acceptable result.

Analysis

The pipeline will, because of its profile, be visible mainly from the air. The line will be located in a remote area, seldom seen by people.

In light of the huge potential reserves of gas in the Alaska Arctic, it is highly probable that the Applicant's pipeline, once installed, will be operative for many decades.

When abandonment becomes an issue, the buried pipe could be left in place or removed and salvaged. If left in place succession of vegetative growth would continue on the right-of-way and eventually, visual evidence of the pipeline would disappear. The line would be in stable surrounding soil and would remain "frozen in" in permafrost soil.

Surface facilities which were not found to be desirable for continued human use would be removed and salvaged. The remaining sites would be restored and returned to nature or to other human uses.

Conclusion

During the several years of active construction, the visual impact will be of major proportions. The structures which remain will be visable for miles, similar to structures on the Great Plains of the U.S. The color, shape, and form will affect the final "look" of the area. It is expected that cleanup of the construction area will be accomplished to a degree satisfactory to the land administrators of the State of Alaska and the Federal government. It is not possible to fully mitigate all visual impact on the area if the project is constructed. The revegetation aspect and slope control of borrow area are covered in other parts of this EIS.

Additional Measures

Submit detailed designs for approval to the authorized officer of the Federal government. This will allow full consideration of the esthetic quality of structures, color of paint, and construction procedures. The cleanup of the various areas and rights-of-way should also be carefully monitored at all stages.

4.1.1.14 Air Quality

Mitigation of the Impact on Air Quality

Proposed by Applicant

The fuel (natural gas) used by compressor stations will be clean burning. Combustible waste will be burned in high temperature incinerators to provide complete combustion and reduce particulate emission. The required air-pollution control devices on vehicles and on stationary sources will be used.

Analysis and Conclusion

The short-term effects of construction on air quality cannot be mitigated reasonably. Compressor station emissions will degrade air quality locally.

Additional Measures

Methods for further reduction of NO_x emissions should be investigated. The amount of SO_2 entering the pipeline should be strictly limited and continually monitored.

4.1.1.15 Environmental Noise

Mitigation of the Impact of Construction Noise

General sound-pressure level measurements will be taken during the construction phase as part of the construction-monitoring procedure. Mechanical machinery which produces unnecessary noise will be identified and corrective measures taken for protection of the hearing of construction workers. Obvious corrective measures such as replacement of mufflers will be standard procedure.

Wildlife

Winter construction will avoid serious disturbance to grizzly bears and caribou by personnel, machines, blasting and overflights during the October-May period. Winter construction activity, such as blasting of borrow areas near occupied dens, will be restricted.

The pipeline route will keep clear of known den sites of foxes, wolves and bears, and sites near the route will be clearly marked prior to construction to avoid inadvertent disturbances.

Special precautions will be taken to ensure that the least possible disturbance of muskox occurs, and to provide mitigation against adverse results from any disturbance which occurs.

In commenting on the Draft Environmental Impact Statement, the Applicant stated that "there will be further detailed preconstruction surveys, and environmental inspectors will be marking any denning areas on or adjacent to the pipeline right-of-way."

Analysis

Scheduling construction in the winter will minimize construction disturbance to wildlife, as many wildlife species have migrated south of the pipeline for this season.

Conclusion

The definition of "unnecessary noise" from construction equipment should be stated. Some caribou and Dall sheep will be in the vicinity of the pipeline route during the winter season.

Additional Measures

The sound levels of construction equipment should be attenuated to reduce the impact of noise emissions on the animals remaining along the pipeline route during winter. The primary noise impact is sound emitted by engine powered heavy equipment, thus the primary mitigating measure should be mufflers. Since the U.S. Environmental Protection Agency has recently adopted noise standards for trucks used in interstate commerce, these standards should be applied to all offsite diesel engine powered trucks by specification with the construction contractors. Pipehauling should be restricted to daylight hours in the more populous areas. Air compressors should meet U.S. Environmental Protection Agency standards.

Technically feasible sound levels for retrofitted construction equipment, identified by the Construction Engineering Research Laboratory (Technical Report E-53) of the Army Corps of Engineers, are listed below:

Immediate Potential Sound Levels
for Retrofitted Construction Equipment

Equipment	Sound Level in dB(A) at 50 ft. Present
Earth Moving	
Front Loader	79
Back Hoes	85
Dozers	80
Tractors	80
Scrapers	88
Graders	85
Truck	91
Paver	89
Materials Handling	
Concrete Mixer	85
Concrete Pump	82
Crane	83
Derrick	88
Stationary	
Pumps	76
Generators	78
Compressors	81
Impact	
Pile Drivers	101
Jackhammers	88
Rock Drills	98
Pneumatic Tools	86
Other	
Saws	78
Vibrator	76

Since blasting results in environmental noise of serious natural and ground vibration of large magnitude, control of explosives used is important. An explosives management plan is to be submitted to the cognizant agency when detailed knowledge of the need for and the potential adverse effects of any blasting is known. The plan should set forth policy and include blasting techniques, blasting locations, methods for avoiding rockfalls, landslides, and damage to structures, people, and wildlife, particularly aquatic. Minimizing charge size and blasting only during the day should be required.

Mitigation of the Impact of Gas Compressor Station Noise and Blowdown Noise

Proposed by Applicant

No specific measures are proposed.

Conclusion

No mitigation is required for humans.

Even though some wildlife tend to react to station noise at great distances, the estimated land area in which reduced wildlife is predicted to occur may be small in respect to the total land areas available to the wildlife. One exception may be the snow geese, which display extreme sensitivity to station noise.

The reaction of wildlife to blowdown noise has not been investigated, so no explicit mitigative analysis can be made. Since wildlife has been observed to react at great distances to station and aircraft noise, which are both less intense noise sources, it may be estimated that wildlife will react to blowdown noise at similar or greater distances.

Additional Measures

Reaction distances of caribou, sheep, red foxes, and lapland longspurs could be reduced to approximately 1,850, 3,800, 3,800, and 2,600 feet, respectively, by reducing station noise by 8 dBA. This reduction could be realized by acoustically treating the compressor building and by treating the turbine intakes and exhausts with additional silencing equipment (beyond the standard manufacturer's measures).

An effective means of reducing station noise impact on snow geese would be to prohibit aircraft flights into station airstrips during their premigratory staging period (August 15 to October 1). (Studies have demonstrated that snow geese initially deserting areas within 3 miles of stations, will eventually return to within 1 mile, if no aircraft landings occur in the vicinity.) If aircraft landings are avoided in station airstrips during snow geese premigratory staging and the station noise is reduced by 8 dBA, then snow geese reactions to station noise would be predicted to occur at 3,800 feet.

Blowdown vents should be equipped with mufflers that do not permit the gas to pass straight through. Whenever possible, blowdowns should be avoided during snow geese premigratory staging, caribou calving, caribou post-calving aggregation, and other periods of potentially sensitive wildlife activities.

Mitigation of the Impact of Aircraft Noise

Proposed by Applicant

Aircraft movements during construction and operation and maintenance of the pipeline will be controlled as to flight lines and altitude in order to avoid unnecessary disturbances of birds. Monitors will determine sensitive areas.

No raptor nests have been found along the pipeline right-of-way, and only a few nests have been located in the vicinity of the route. In those few cases, a buffer zone of about two miles will be maintained around known nesting sites, to protect these birds from disturbances. Special precautions will be taken to ensure that aircraft movements avoid known or subsequently identified raptor use areas, especially during critical nesting periods. These areas will be identified by environmental inspection personnel.

Because of the sensitivity of snow geese to aircraft disturbance, flights will be curtailed over the premigratory staging areas between August 15 and September 30. Necessary overflights during this time will maintain a 2,000-foot minimum altitude and will avoid areas of heavy snow goose concentration.

In commenting on the Draft Environmental Impact Statement, the Applicant stated that "Arctic Gas' policy, in accordance with appropriate Federal and State regulations, requires that flights be at an altitude of 2,000 feet or greater. This is well above the levels which are known to cause disturbance of caribou." The Applicant states that they have "already effected aircraft altitude flight regulations which will mean that aircraft will be flying above altitudes which have been shown to cause disturbance to sheep."

Applicant further stated that

> "during certain time periods, specific areas and species of wildlife along the Arctic Gas pipeline are particularly sensitive to disturbance from low-flying aircraft. Such areas are listed below, and should be avoided to the greatest extent possible. If these areas must be traversed, flight time should be kept to a minimum, and flight levels kept in excess of 2,000 feet AGL to the extent practical. Harassment of wildlife is strictly prohibited."

PRUDHOE BAY REGION

Area	Wildlife Use	Time	Alternative Route
Canning River-Alaskan Border (Arctic National Wildlife Range)	Extensive nesting and migrating waterfowl; migrating and calving caribou	May 15-Oct 15	More than 1/2 mile offshore; along foothills of Brooks Range

Analysis

The requirement that flights, other than pipeline surveillance flights, maintain a minimum of 2,000 feet altitude should be adequate to protect caribou, moose, grizzly bears, black bears, wolves, and arctic terns from disturbance. The special alternative flight route during the caribou calving and bird breeding should be sufficient to protect common eiders and glacous gulls from nesting disturbance and caribou from disturbance during calving.

Though no studies investigated the distances at which raptors are disturbed by aircraft flights, a 2-mile-wide berth should be sufficient, judging from the reaction distances of most other birds studies (snow geese not included).

Conclusion

Dall sheep, snow geese, Canadian geese, waterfowl, and black brant may be disturbed by non-surveillance flights at an altitude of 2,000 feet. Pipeline surveillance flights at an altitude of 500 feet may disturb caribou, Dall sheep, moose, grizzly bears, black bears, snow geese, waterfowl, black brants, common eiders, glaucous gulls and arctic terns.

Additional Measures

If major bird nesting and migratory staging areas were given a 2-mile berth, as suggested by the Applicant for raptors, by non-surveillance aircraft between May 15 and October 15, then all species would be protected from disturbance with the possible exception of the snow geese. The snow geese may be disturbed by flights up to 5 miles away at altitudes of 2,000 to 5,000 feet. If non-surveillance flights near snow geese premigratory staging areas, between August 15 and October 1, were flown at altitudes from 7,000 to 10,000 feet around the periphery of the staging areas, no disturbance would be predicted.

Surveillance flights should be kept to an absolute minimum and flown at the highest altitude practical during breeding, nesting, molting, pre-migratory staging, calving, post-calving aggregative, and other periods of potentially sensitive wildlife activities in order to minimize disturbance.

4.1.1.16 Pipeline System Repairs

Mitigation of the Impact of Emergency Repairs of the Proposed System

Proposed by Applicant

The Applicant has provided general information on how pipeline repair would be done. (See Section 1.1.1.7 for discussion by the Applicant on Emergency Contingency Plans.) In addition, the Applicant intends to prepare a detailed pipeline repair procedure plan at some future date.

The Applicant's Mainline Break Plan (a part of the proposed Operating Manual) will consider the types of terrain, location, and weather conditions which will be encountered. It will preplan methods of repair, materials, equipment required, and will include an estimate of time needed for a major line repair.

The Applicant indicates pipeline repair disturbance will be restored in the same way that surfaces will be restored and revegetated following the initial construction of the line.

Equipment to be used includes a large air-cushion vehicle still under test, low ground-pressure vehicles up to 40 tons, helicopters, and miscellaneous large and small equipment which can be transported.

The Applicant's stated major engineering, geotechnical, and wildlife concerns and considerations which will influence pipeline maintenance with respect to off-road vehicular traffic are as follows:

(1) The Applicant recognizes that it must preserve and, when damaged, repair the active surface layer. This requires the minimizing of vehicular traffic when the terrain is vulnerable to damage, the selection of equipment which will impose the minimum unit weight on the ground surface, and the implementation of an on-going surface repair and revegetation program to restore ground cover if damage does occur.

(2) The right-of-way will be monitored for evidence of active layer damage to effect early repairs.

(3) Aircraft, fixed wing and helicopter, will be used to minimize ground traffic over sensitive areas.

(4) Approved types of heavy construction and transport equipment will be stationed at locations selected so as to avoid long hauls in sensitive terrain areas and isolated sections of the system.

Analysis

It is not reasonable to assume that major emergency repairs will be postponed until ideal environmental conditions exist because large numbers of people will be dependent upon a reliable gas delivery schedule and because of the large monetary investment required for the gas pipeline system.

Initial construction is to be conducted from snow/ice roads prepared in advance. Emergency repairs, when the pipeline is in operation, will be made without the benefit of all season roads. Winter repair will result in damage to the environment more severe than that from initial construction because of lack of accessibility. Pipeline repair in the spring, summer, and fall would result in substantial disturbance or destruction of vegetation, soil, permafrost, water quality, and some wildlife.

In describing projected repair procedure during the summer period, the Applicant does not address the consequences of the excavation of subsequent soil conditions on the ditch affecting pipeline integrity. These problems regarding local thawing, flooding, and subsequent refreezing should be detailed.

Movement of heavy equipment for summer repairs would be carried out by air vehicles to be based at compressor station sites and this requires prior "proof of concept" development and demonstration.

The Applicant also emphasizes use of helicopters and short takeoff/land (STOL) aircraft for both routine and emergency maintenance, but he does not indicate the number or type of such aircraft he would base at Prudhoe Bay. Two pilots and two flight engineers are assigned to Operations Headquarters, which may be indicative of the quantity of aircraft. Some discussion is needed of (1) the number and size of aircraft, (2) load capability, (3) airborne ambulance facilities mentioned, and (4) the availability of additional aircraft for charter in case of a major emergency.

An emergency condition that the Applicant has not mentioned is a failure in the producer's refrigeration equipment or compressor station.

The best way to prevent environmental damage from repairs is to design and construct a pipeline system with high reliability against failures. It is recognized that this application did not include final design. However, voids in the design criteria must be filled before final design and construction is approved. The following items are not to be considered all inclusive, but they need to be addressed. They are within the realm of engineering feasibility.

Pipe Safety Factor--The pipe is designed at present only for hoop stress (not including gas surge pressure) with the lowest safety factor (0.72) allowed by Federal regulations. This approach tacitly assumes that any external loads imposed on the pipe by forces such as frost heave or mass wasting are insignificant. Such an assumption may not be warranted and requires verification under the predicted worst conditions, with the pipe in both nonpressurized and pressurized modes.

Pipe Toughness As a Key Element Preventing Failures--The fracture toughness of the API X-70 steel at low operating temperatures is now specified by a minimum average of three toughness measurements. The specification of a minimum value for each measurement will yield more stringent quality control. However, he has proposed the use of external bands as crack arresters for mitigating measures. Performance data for steel at low temperatures have not yet been fully developed by industry. The toughness problem would become more acute in welded portions of the pipe, especially field welds. Field procedures and equipment for flaw detection for all field welds should be defined. Experience gained with the use of more forgiving steels such as API X-42 or X-52 cannot be taken at full face value for X-70 steel.

Unchilled Pipe-Thermal Problems--The Applicant has addressed the possibility of the buried pipeline having an inactive period up to one or more years after construction. The buried pipe would not be flowing gas during this period and would seek the temperature of the surrounding soil.

The main problem with the unchilled pipe would be ground settlement in the right-of-way and in the berm. This is attributed to disturbance of the organic layer and the composition of the backfill. Possible accumulation of water in the ditch could induce drainage and erosion problems which may be alleviated but not eliminated with ditch plugs.

Another potential problem is severe berm erosion. Such erosion could compromise the effectiveness of the berm as a mitigating measure for bouyancy and frost heave effects.

Methods which can be taken to mitigate these effects include aboveground construction, anchoring the pipe, passing chilled air through the pipe during the inactive period, use of surface insulation or berm reinforcement and through the addition of an additional layer to compensate for the berm erosion. In addition, plugs can be used which act to arrest the flow of water along the berm in a manner analogous to the use of ditch plugs.

Summer Repair and Maintenance Concept Viability Questioned--As an all-season road to the route site has not been proposed, summer repair and maintenance, if not conducted properly, could have a major effect on the environment. The proposed solution is the use of aircraft, air cushion vehicles, and low ground pressure vehicles. The availability of machines is under investigation by the Applicant, but it will be necessary to prove (low footprint) concept feasibility prior to pipeline construction and to conduct field trial demonstrations prior to pipeline operation, to ensure that the summer repair and maintenance procedures are adequate.

Pipeline Mechanical Design Criteria--The comprehensive design criteria formulated by the levels Applicant permits unconservatively high stress and strain levels to develop in the pipe under certain combinations of external loadings. These levels are in excess of the express and implicit allowable stress levels described by Part 192, Title 49 of the Code of Federal Regulations.

Measures which can be taken to mitigate this discrepancy between design approach and interpretation of Part 192, Title 49 of the Code of Federal Regulations, includes increasing the wall thickness of the pipeline, decreasing the operating pressure, or involving to a greater degree the measures already proposed to reduce geotechnic loads to the pipeline.

Frost Heave Effects--As the gas will be chilled to prevent thawing of the permafrost throughout the regions traversed, the chilled pipe will tend to freeze or refreeze areas with frost-susceptible soils. Inadvertent thaw conditions may occur during construction, during prolonged shutdown, or during the up to one or more years which may elapse between construction and establishment of chilled gas flow in the completed pipeline. The consequent frost heave forces are to be mitigated by mounding the backfill trench (surcharge) over the pipe to increase down pressure to above critical levels. The ability to provide sufficient surcharge pressure above the critical level is questioned, particularly as limited by berm height during the inactive period, berm erosion, and river scour considerations. In addition, the accuracy of the methods proposed to determine frost heave rate and, indirectly, berm surcharge requirements, is not defined for the range of soils along the right-of-way, as complete soil surveys have not been accomplished.

In summary, there is uncertainty about the amount of overpressure (surcharge) required to arrest frost heave forces because of soil variation, river scour, erosion, and subsidence effects, the latter becoming more pronounced with the unchilled pipe in the ground. A detailed analysis of the worst expected conditions is required by the Applicant to minimize potential frost heave and pipe overstressing hazard.

Measures which can be taken to mitigate frost heave effects include anchoring the pipe, increasing the berm height (surcharge) to add a factor of safety to the analytically determined surcharge requirements, aboveground construction, or combinations of these techniques.

Effect of Mass Wasting on Pipeline Integrity--Although the Applicant has shown a sound understanding of the potential effects of mass wasting on the pipeline integrity, this remains a major design issue. The effects of mass wasting on pipe external loads, particularly in the case of undercut slopes, should be evaluated in detail for the case when pipe may remain inactive and unchilled for one or more seasons, or when the pipe is chilled. The unchilled pipe also introduces a problem of subsidence in the right-of-way, and a change in the drainage pattern with associated berm channeling and ponding. This problem requires carefully planned mitigating measures to minimize the environmental impact.

Measures which can be used to mitigate the effect of mass wasting include erosion control measures, such as avoidance of slopes with marginal stability, drainage control, and slope reconstruction.

In order to be able to assess the mass wasting problem, pipeline movement monitoring equipment should be provided at critical locations along the route.

Protection of Pipe at River Crossings--During thaw periods, ice dams could form in the river above the chilled pipeline. If such dams were to break, the resulting channeling and bank erosion could significantly affect scour depth and bank profile and perhaps expose the pipe. The Applicant stated that the problem of ice jam during the breakup is unlikely because most of the crossings are at braided river sections with low banks. Nonetheless, several channeled rivers (examples: Hulahula, Aichilik Rivers and others) will be crossed and the problem posed by ice jams and deep scouring and bank erosion must be considered.

A measure which can be used to mitigate these factors is deep burial at approaches to the river as well as under the channel.

Snow Roads and Work Pads--Snow roads and work pads are a point of concern from the aspect of timely availability of large amounts of snow and water through the winter period. Extensive use of snow fences to bank snow along the proposed right-of-way, plus the manufacture of snow (from water), may allow pipeline construction to be started in October. However, the ability to end the construction season past late May is questionable, due to melting and degradation of the snow road at the start of the summer following the construction season. Early melting compounds another problem which consists of the aftereffects of snow roads on the tundra. While the Applicant performed a series of useful experiments on the feasibility of snow roads, the problems cited above have not been completely answered for the arctic tundra.

Measures which can be used to mitigate these factors include accelerations of the construction schedule by use of more than three construction spreads, by using low ground pressure vehicles extensively at the end as well as the beginning of the construction season, or through provision of sufficient all-seasons road to support the construction period.

Leak Detection--The hostile environment and inaccessibility of the pipeline would make small leak detection extremely difficult utilizing current technology. Means should be defined and procedures set for detecting gas leaks under frozen ground with and without thaw layer, under rivers and under ice. A research program directed at remote leak detection systems should be undertaken.

Effect of Leaking Gas--Effects on the environment of the gas leak and loss in the case of pipe fracture should be investigated. Assuming the gas trapped between two sets of block valves 15 miles apart were to be released, approximately 180 million scf (standard cubic feet) of gas would be discharged into the atmosphere.

Seismic Monitoring--Seismic instrumentation provided along the pipeline route in the vicinity of Flaxman Island, which has a history of seismic activity, should be considered. If any indication of seismic activity is recorded, the pipeline should be carefully re-inspected for leaks via the leak detection system previously recommended.

Operations, Emergency, and Contingency--Operations and emergency and contingency planning are necessary and the Applicant proposed to perform this task as a part of the final design of the pipeline system. Procedures should be defined for hydrotesting, including the water/methanol disposal, emergency repairs, and health and safety of the personnel.

Subsurface Conditions--A major limitation in the ability to assess the proposed project is the lack of ground truthing. In one case, there are no soil data for 45 miles. The presence of large percentages of ice coupled with normal small sample unreliability make it impossible to judge route and site adequacy in detail.

Schedule Feasibility--Feasibility of constructing the pipeline in permafrost is dependent upon the ability to meet a schedule of construction in one winter season. The hostile environment on the North Slope requires that water is available to maintain snow/ice roads after "freeze up", ditching techniques are thoroughly developed, work bed and backfill materials are identified and in abundant supply, and that all critical pipeline components are "in hand" prior to the commencement of construction.

Conclusion

The Applicant recognizes the serious consequences of emergency repair. The proposed preplanning for mitigation of wintertime damage is considered adequate. Disturbances caused by pipeline repair in the spring, summer, and fall are not well enough defined to properly analyze. Therefore, mitigation of damage caused by summertime repair is not adequate as proposed.

Additional Measures

a) Analyze the effect of summer pipeline excavation on subsequent local soil conditions and pipeline integrity and incorporate findings in the proposed operating nanual.

b) Institute precautionary measures to be employed during periods in which the ground is covered by a thin ice or a thinly thawed ice layer.

c) Describe in detail air-cushion vehicle operation and type and number of aircraft required for summer repairs.

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5 ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

5.1 ARCTIC GAS PIPELINE PROJECT

5.1.1 Alaska Arctic Pipeline

This section discusses the adverse effects that will remain if the proposal is implemented and the effective mitigating measures discussed in Section 4.1.1 are applied.

5.1.1.1 Climate

Unavoidable Adverse Impacts on Climate

The pipeline project will cause no measurable change in the climate.

Unavoidable Adverse Impacts of Climate

The climate will affect the proposed AAGPC pipeline system by increasing the probability of pipeline failure and impeding chances of meeting the proposed construction schedule. Should failure occur the unavoidable impacts created by repair being done during the thaw period (assumed to be worst case conditions) are discussed in Section 5.1.1.16, Repair.

The intense cold temperature and low chill factor coupled with the darkness of arctic winter could cause some delays in the proposed construction schedule which in turn could trigger a wide range of effects as listed in subsequent parts of this section. Even with proper training, insulated clothing and heated cabs, construction workers are endangered by frostbite.

5.1.1.2 Topography

The berm over the pipeline will persist for several seasons as will scars at the approaches to the river crossings. In the foothill area some scarring will remain after the project is completed. These changes in topography are unavoidable and are in direct conflict with the wilderness values of the Arctic National Wildlife Range.

5.1.1.3 Geology

Unavoidable Adverse Impacts on Bedrock

There will be no adverse impacts of the proposed pipeline system on bedrock.

Unavoidable Adverse Impacts on Permafrost

In the context of total surface area underlain by permafrost, the project involves a very insignificant portion. However, the 195 miles of line could be considered of major consequence due to its linear nature even if restricted to the local right-of-way.

No mitigating measures including those proposed by the Applicant and other measures discussed in 4.1.1 could prevent all degradation of the permafrost and thermal degradation under all conditions of pipeline operation. Should permafrost degradation occur, a chain of events could be initiated (such as water ponding, development of rills and gullies, and accelerated erosion) that would cause loss of habitat to wildlife, birds, and fish, loss of esthetic values, and topography change. During the construction and operation of this system, thawing of ice-rich, fine-grained permafrost materials could result in serious unavoidable impacts such as liquefaction, slope instability, differential settlement of the ground surface, disruption of drainage, and accelerated erosion along the pipeline system. Areal loss of permafrost is considered negligible. It is the secondary impacts that need to be considered.

Unavoidable Adverse Impacts on Slope Stability

Careful implementation of the mitigating measures proposed by the Applicant could mitigate adverse effects on slope stability.

Unavoidable Adverse Impact of Permafrost, Slope Instability, Frost Heave, Buoyancy, and Seismic Activity

The Applicant has identified all potential significant sources of loading which may influence the pipeline mechanical design and has demonstrated a capability to properly perform engineering analyses to predict the internal stresses and strains resulting from the various loading conditions.

However, the design criteria proposed by the Applicant do not meet the implied requirements of Part 192 of Title 49 of the Code of Federal Regulations and the Applicant has not shown conclusively that all geotechnic loadings are insignificant.

The risk of failure of the pipeline during operation designed to the Applicant's criteria is greater than the level that would exist for a pipeline designed in strict accordance with Part 192 of Title 49.

Lack of a contingency plan for checking for the re-establishment of pipeline integrity could compound the resulting environmental consequences.

Failure of this pipeline would negate delivery of gas on a continuous basis without line repair or replacement. Without a reliable delivery system, expected benefits will not be achieved and will be compounded by adverse environmental impacts caused by repair or replacement. Therefore, the unavoidable impact will be loss of a non-renewable resource (natural gas) to the atmosphere and the lack of service to the consumer.

5.1.1.4 Soils

Mixing the Soil During Excavation and Backfilling

Soil will be mixed during the excavation and backfill procedures. While the impact from this may be considered minor, it could influence the revegetation of disturbed areas.

The success of tundra mat replacement is questionable, therefore loss of the mat is considered irretrievable on a short-term basis (1 to 5 years).

However, fertilization and revegetation can be expected to re-establish the surface mat, but success depends on repeated applications.

Excess Spoil Material Disposal

The loss of native vegetation through burial is irretrievable.

Spills of Fuels and Lubricants

The possible loss of soil productivity through contamination is considered likely to be slight but will occur.

Soil Temperature Changes and Consequent Lower Nutrient Availability in the Pipeline Berm

Soil temperatures over the pipeline will be altered from the normal regime due to the chilled gas in the pipeline. Such changes are considered unavoidable.

5.1.1.5 Water Resources

Unavoidable Adverse Impacts on Water Quality

1) There will be no adverse effects on water quality if the sewage treatment and effluent discharge are controlled and operated within Federal and State requirements. There will be adverse effects if the system fails. The effect will be the lowering of available dissolved oxygen for aquatic life. Extent of this impact is unknown because it depends on time of year, quantity of discharge, and cleanup activities. Addition of effluent nutrients to the water will have a secondary impact to vegetation and will cause a change in plant species composition and type.

2) Suspended sediment entering streams from melting of ice in the spoil disposal material when water is normally clear will reduce esthetic qualities and may harm aquatic life by reducing water quality. Extent of damage to the esthetics is unquantifiable; silt could smother incubating eggs and aquatic invertebrates. Extent of damage to aquatic life is unknown because specific areas of the disposal sites, spawning areas, and aquatic invertebrates have not been identified.

3) Suspended sediment from gravel extraction is expected to create an unavoidable impact, since silt entering streams will lessen the natural water quality.

4) Sediment resulting from pipeline construction activities will significantly affect water quality, which in turn will have a serious impact on aquatic life, reducing fish habitat, smothering incubating eggs and invertebrates, reducing light penetration in lagoonal areas where light is required for growth of the bottom fauna and micro-organisms important to the marine food chain. Extent of loss of fish, birds, and marine life by degradation of their environment due to loss of water quality is unknown.

The frost bulb created by the chilled pipeline will affect the movement of both surface and subsurface water flows. This could cause additional imbalance in water availability to plant life above and below the pipeline.

In addition, upshore ponding along the pipeline could create thixotropic soil conditions making the pipeline more vulnerable to seismic disturbance; could create surface ice along pipeline; and, through channeling, could accelerate surface erosion, requiring extensive maintenance activity with resultant increase in traffic over the tundra.

5) Spills from use of hydrostatic testing fluid and other toxic materials could have a long-term adverse effect on vegetation, wildlife, and aquatic life. Acres of habitat and numbers of wildlife or aquatic life affected would depend on the size and location of spill.

In addition, a leak occurring during hydrostatic testing, even after repairs, will compromise the integrity of the pipeline through saturation of the trench walls, bottom, backfill, and bedding with the test fluid.

6) Accidental fuel spills can be mitigated by emergency procedure planning. The impact on water quality could be serious if a spill occurred and reached the Beaufort Sea estuaries. Worst conditions indicate that a fuel spill in an estuary would harm populations of oldsquaws and eider ducks.

Unavoidable Adverse Impacts on Ground Water, Rivers and Streams, and Other Surface Drainage

Careful implementation of the Applicant's proposal could mitigate all of the impacts discussed in 3.1.1.5.

Unavoidable Adverse Impacts on Water from Borrow Material Excavation

Mitigating measures proposed by the Applicant are adequate to prevent adverse effects discussed in 3.1.1.5.

5.1.1.6 Vegetation

There will be a number of changes to the tundra plant communities which cannot be avoided. In areas which will be overlain with gravel there will be little chance of ever completely restoring vegetation. The loss of net primary productivity is considered irreversible and permanent.

Changes in the plant communities caused by disturbance of vegetation from construction of snow and ice roads and changes in drainage will be unavoidable. Some changes such as those associated with drainage will be permanent; in other cases exotic plant communities will no doubt be replaced by native plants through plant succession, but this will take many years.

The disturbance of 12,500 acres of vegetation and killing or tearing of root systems opens the soil surface to erosion. This is unavoidable and it may take years to stabilize.

Methanol and fuel and lubricant spills will kill some plants. The amount of damage will depend on how well spills can be cleaned up. Because these materials act as soil sterilants, effects will last for many years.

5.1.1.7 Wildlife

Mammals

Caribou

The mitigation methods proposed by the Applicant will help reduce adverse impacts on the Porcupine Caribou Herd. Increased access, disturbance by aircraft and ground vehicles on the calving ground, summer borrow activities, and shipping activities all will act adversely on the herd. Disturbance factors associated with material staging, construction, and operation of the compressor stations will add to the adverse, long-term impact on the herd. It is probable that these impacts will result in some reduction in herd numbers. If the animals abandon the traditional calving grounds and portions of their summer range, a major reduction (more than 50 percent) in herd size could result.

Musk Ox

Musk oxen are shy and of great sightseeing interest to humans. They are also very sensitive to disturbance. Most of the North Slope population of musk ox live near the project area. Project activities, loss of habitat, and increased access will permanently reduce musk ox numbers.

Dall Sheep

Some parts of sheep winter range and perhaps lambing areas will be affected by construction and operation of communication towers. This could result in range abandonment by some of the animals and a reduction of numbers, because sheep winter range and lambing grounds are limited on the North Slope of the Brooks Range.

Wolf

The Applicant's mitigative measures will lessen project effects on wolves. Because of their special interest to humans, however, and the probable necessity to use some denning areas as borrow sites or pipeline right-of-way, there will be a reduction in wolf numbers on the North Slope. If caribou numbers decrease, wolf populations will be further reduced.

Arctic and Other Foxes

The project may cause a short-term reduction in fox population.

Grizzly Bear and Wolverine

Because these animals are less tolerant of human activities and facilities, populations will be reduced by project development. Magnitude of this reduction is unknown but could exceed 50 percent. There is no way to mitigate this impact except to locate the line elsewhere.

Polar Bear

The coastal area near the project route contains some of the known denning sites for polar bear in Alaska. There will be an unavoidable reduction in numbers of polar bear that den on land near the project. Whether or not this will reduce total population numbers is unknown, but it is considered likely. The only feasible mitigation measure is to leave the area in its natural state.

Other Marine Mammals

There will be an unknown effect on sea mammal populations from project associated activities.

Fuel spills affecting the marine water could cause the immediate death or change in behavior of individual marine mammals or an alteration of population dynamics through a modification of habitat or a change in food source. These impacts could be long lasting.

Birds

Swans

Project related activities will cause an unavoidable reduction in swan numbers. Extent of this reduction is unknown but in the case of trumpeter swan population (two breeding pairs) loss may be total. Because of a wider range of breeding habitat and large numbers, the whistling swan population will not be as adversely affected.

Geese

Project-related activities will have adverse unmitigable effects on geese. Snow geese while on the fall staging and feeding areas will be affected more than other geese species. If disturbance is severe and long term, it could cause the geese to seek other less suitable areas for staging and feeding. In any case, the population of snow geese will be reduced.

Other species, such as black brant and Canadian geese, will also be affected but not to the same extent as snow geese because they appear to be less sensitive to disturbance.

Ducks

The primary impact on ducks will occur during their molt period. Large numbers of ducks are then concentrated on relatively small areas of water, and because of high energy demands during this period they are extremely sensitive to disturbance.

Disturbance of ducks, especially sea ducks, during the nesting period will increase predation of eggs and young birds, thus lowering total brood numbers.

Project-related activities will reduce duck populations. This effect may be short-term and quickly recoverable if disturbance ceases or is reduced after completion of the equipment staging and construction periods.

Peregrine Falcons

Not enough information is available to determine if project-related impacts on peregrine falcon feeding areas are completely unmitigable or how adverse the impacts will be.

Other Birds

There will be some reduction in population of song and other tundra-dwelling birds because of habitat destruction caused by fuel spills and other related facilities. Populations of hawks, owls, etc., may also be lowered because of the reduction in the numbers of their prey species. These losses, although likely to be small, are unmitigable.

Fish

If the Applicant's mechanical procedures to arrest erosion prior to the time vegetation is restored and formation of the frost bulb around the pipe does not change drainage patterns, stream channels, and water temperature regimes, project-caused effects on fish populations will be minor and short term. Failure of the mechanical erosion measures (which will cause long-term sediment deposition), changing of stream channels, and altered water temperatures could reduce fish populations to a very low level. Because research into effects of methanol on fish fertilization success is not sufficient, a method of disposal could be used which could adversely affect egg fertilization and further reduce fish populations. Cumulative effects over a 1-year period of increased sediments in streams, possible reduced winter flows, increased mineral content of water because of water withdrawals for snow roads, and the disposal of methanol and other project-related fluids into streams, reducing available oxygen, will act to reduce fish populations of the area. If these effects are short-term, populations will return to normal. If, however, any are chronic, populations will remain low.

Unavoidable Secondary Adverse Impacts on Mammals, Birds, and Fish

There will be a general long-term, wide-ranging degradation of the wildlife resource base with continued development of the area. Eventually, resistant species will reach the population level commensurate with development, and sensitive species will abandon the area. The way stipulations for development are to be carried out will determine the loss levels and species.

Invertebrates

Unavoidable effects of the project on aquatic invertebrates will be the same as those listed for fish species. Water quality degradation and increased sedimentation will reduce the number of species and their populations. Land invertebrates should suffer little disturbance. Because of habitat loss, there will be some population decrease which is unmitigable.

5.1.1.8 Ecological Considerations

Since, in the ecosystem context, everything is connected, all of the adverse effects on air, water, soil, vegetation, and wildlife which cannot be avoided should the proposed project be implemented will also have unavoidable adverse effects on the Arctic Slope ecosystems.

Probably the most serious unavoidable impact on the integrity and functioning of local ecosystems in northeastern Alaska is the implication that more development and disturbance activities will likely follow this pipeline. While the unavoidable impacts of this first development may be manageable and even insignificant in terms of regional ecosystem functioning, successive developments will "whittle" away various components of the ecosystem until the system is unable to recover from some as yet undetermined increment of change. Total loss of each plant or animal species will reduce the diversity of interactions and lead to lowered overall stability.

In an ecosystem characterized by low heat budgets and short growing seasons, recovery from disturbance is extremely slow, and therefore any destruction to the ecological regime must be considered irretrievable and possibly irreversible within our lifetimes.

5.1.1.9 Economic Factors

Employment and Unemployment in Alaska

If this project is not timed to immediately follow the trans-Alaska oil pipeline project, it is expected to create unemployment patterns similar to those of all large or remote construction projects. Fewer people will come to Alaska, expecting to find employment, than came with construction of the oil pipeline because: potential in-migration will anticipate that many AAGPC jobs will be taken by former Alyeska workers; the high post-Alyeska unemployment rate will operate to discourage in-migration; the AAGPC pipeline project will not be nearly as "visible" as the Alyeska, since only 195 miles will be built in Alaska; and this 195-mile section will be built in an extremely barren and remote section of Alaska.

5.1.1.10 Sociological Factors

Solid Wastes

The project will cause an increase of windblown and scattered litter. Litter will be more noticeable if left on the Arctic National Wildlife Range than in the oil-developing area of Prudhoe Bay.

Cleanup procedures in the Arctic National Wildlife Range can have more adverse effects on wildlife and vegetation than leaving the litter. The impact will be long-term and visually and esthetically displeasing.

Transportation

There will be an unavoidable increase in competition for transportation of goods, with food stuff, clothing, and other consumer goods having lower priorities than project-related goods. This will be of short-term duration.

Subsistence

Implementation of the proposed project will be one more facet in a series of development activities that are diminishing the subsistence culture of residents of the North Slope and elsewhere.

This appears to be an irreversible process and although mitigation methods can be devised to offset this change in lifestyle, some change is inevitable. This project will affect a portion of Alaska that has already seen development activities. Impacts on the village nearest the project will be less severe than impacts on villages where no development has taken place.

5.1.1.11 Land Use

Land Use Planning

The Applicant has not indicated any mitigating measures to be undertaken to lessen the impact on several planning programs dealing with land use in the Arctic. The Joint Federal-State Land Use Planning Commission, charged with statewide planning and a policy for the Arctic, the State of Alaska, the Coastal Zone Management program, and the North Slope Borough all have programs to study land use. It does not appear that any of the planning agencies will have completed a specific, comprehensive land-use plan dealing with transportation, population distribution, and resource development before construction of the proposed project if authorized. Therefore, the adverse impacts which cannot be avoided relate to the fact that project-related commitments will be made to establish long-term transportation corridors, population distributions, and resource developments before land use plans or a policy for the Arctic have been formulated and completed. This would be contrary to the Joint Federal-State Land Use Planning Commission's recommendation that land use planning determine transporation patterns. Large areas of the Arctic, extending from Petroleum Reserve No. 4 all the way to the Canadian border could be actively explored for oil, gas, and other energy fuels. If large discoveries are made, subsequent development and transporation systems may affect most of Alaska's Arctic.

The land use plan for the Arctic National Wildlife Range is to protect unique wildlife, wilderness, and recreational values. If the proposed project is authorized, it would have major and adverse impacts on land use planning for the Range. The likelihood of additional exploration and subsequent development of both onshore and offshore areas within the Range will also conflict directly with the proposed land use plan for the Range.

Current Land Use

The Applicant did not specifically indicate mitigating measures. The proposed project will affect existing land uses which include production of oil and gas, waterfowl production, large animal habitat, subsistence uses, wilderness, hiking, recreation, and national defense. This project, if implemented, will produce the impacts identified in 3.1.1.11. None of these, with exception of those affecting wildlife, are likely to be mitigated and, therefore, are considered unavoidable.

Wilderness

That portion of the project which is located within the Arctic National Wildlife Range would have significant impacts on the wilderness values if construction is undertaken. Significant areas, such as those near the ports, compressor stations, aircraft landing fields, communication towers, and borrow areas, will not qualify for wilderness designations. The pipeline right-of-way, despite the buried line and lack of a construction road, will decrease the value for wilderness of a large part of the Arctic Coastal Plain. There is no way to mitigate these impacts and they are considered unavoidable.

Land Ownership

There could be impacts on Federal lands which may be patented as a result of Native allotment applications. The proposed project, if authorized, could affect the traditional use of such areas. Uses include hunting, fishing, berrypicking, trapping, and other subsistence activities. Such impacts cannot be avoided.

5.1.1.12 Historic, Archeological, and Unique Area Values

Historic Values

It is unlikely the proposed route would affect any known historic sites.

Archeological Values

The Applicant has indicated that measures will be taken to lessen the project's impact on the archeological values of the project area, including sites which may be discovered during the phases of project development. Some impacts not to be mitigated by the Applicant will include the difficulty of identification of small items during winter pipeline construction with low temperatures and almost complete darkness. Some artifacts, and perhaps entire sites, could be completely destroyed despite attempts to prevent these losses.

There also is a possible unavoidable impact resulting from archeological values upon the project -- this would occur when an important discovery is made and the project is delayed until the excavation is completed. This could result in various spinoff impacts, such as wildlife losses and thermal erosion due to the open ditch if such a delay lasted until the summer thaw season. See Sections 3.1.1.2 and 3 for more information.

Unique Areas

If the proposal is implemented as planned, the following unique areas would be affected to the degree that they would no longer retain all values for designation as unique areas, research areas, or National Landmarks: Sadlerochit Spring, Jago River, Beaufort Lagoon, and possibly Demarcation Bay.

5.1.1.13 Recreational and Esthetic Resources

If the proposal is implemented there will be unavoidable impacts on the esthetic value of the project area, as buildings, airports, communications towers, docks, material stockpile sites, and other facilities will be located in an area now devoid of such objects. The pipeline mound will remain visible from great distances to those hiking in the foothills and mountains south of the line. The visual impact of these things cannot be avoided, despite strict control measures.

The implementation of this proposal can also stimulate the early development of other resources in the general area, which may have an even greater impact on the visual aspects than the project itself.

5.1.1.14 Air Quality

Future compressor stations will unavoidably add ice fog, nitrogen, and small amounts of sulfur oxides to what is now pure air. Therefore, should the proposal be implemented there will be an unavoidable decrease in air quality. When averaged over large areas that decrease would be small.

5.1.1.15 Environmental Noise

Even if all suggested mitigation measures are implemented, increased noise levels would still occur as a result of the proposed action.

Retrofitted construction equipment will produce high sound levels in the vicinity of the construction site, ranging from 76 to 101 dBA, but it is presently economically impractical to quiet them further. Assuming trucks are brought into compliance with the recently promulgated EPA regulations, they will still produce sound levels between 86 and 90 dBA at 50 feet (depending on their speed) in otherwise quiet areas.

The pipeline construction noise will affect animals wintering along the proposed route. There are no major winter ranges in the vicinity of the pipeline route, but caribou do occur along 46 miles off the route in winter and the pipeline passes near a sheep winter range in the Sadlerochit Mountains. The impacts will be spread over the entire route and period of construction.

With an 8 dB reduction in predicted gas compressor station noise emissions, the stations will probably cause reduced usage of habitat areas within 1,850, 3,800, and 2,600 feet of stations for caribou, Dall sheep, red foxes and lapland longspurs, respectively. If aircraft landings are avoided in station airstrips during snow geese pre-migratory staging and the station noise is reduced by 8 dBA, then snow geese reactions to station noise would be predicted to occur at 3,800 feet.

The impact of non-surveillance aircraft noise on wildlife could be completely mitigated; whereas the impact of noise from pipeline inspection flights cannot.

5.1.1.16 Pipeline System Repairs

Emergency repairs during the thaw period will have adverse effects which cannot be avoided. Damage to the organic mat by low ground-pressure vehicles and pipeline laying equipment is inevitable. Noise and physical disturbance of pregnant animals and nesting birds from increased vehicular and aircraft traffic cannot be completely avoided, no matter how much care is exercised.

Damage to the tundra will be reduced if maximum precautions are taken during thaw periods and detailed advanced planning is made for these environmentally sensitive periods. The impact from repairs is considered likely to create losses, but it is impossible to quantify these.

REFERENCES

Alaskan Arctic Gas Pipeline Company. 1974a. Environmental report of Alaskan Arctic Gas Pipeline Co. (Ch. V published separately.)

Alaskan Arctic Gas Pipeline Company. 1974b. Environmental report Exhibit F (maps and alignment sheets) and Exhibit G (plan diagrams). Alaskan Arctic Gas Pipeline Company.

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Alaskan Arctic Gas Pipeline Company. 1975. Responses to questions of the Joint Environmental Study Group of the Federal Power Commission and Department of the Interior. Unpublished.

(See also References for Sections 1, 2, and 3 of this Statement.)

6 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

6.1 ARCTIC GAS PIPELINE PROJECT

6.1.1 Alaska Arctic Pipeline

6.1.1.1 Definition

In general, "short-term" is used to mean the useful lifetime of the proposed pipeline system, but some even "shorter-term" uses and effects are considered. "Long-term" is used to mean that time beyond the lifetime of the pipeline system. These terms are relative and differ from one environmental component to another.

The assumed life of the proposed pipeline is estimated to be from 20 to 50 years. This is the time frame that is considered as representing short-term use of the environment for purposes of this statement, although such a period of time would certainly be considered long-term in the context of an individual's life planning.

Most of the environmental impacts discussed in Section 3.1.1 and the mitigating measures discussed in Section 4.1.1 relate to short-term use. Section 6.1.1 discusses environmental values, future options, and benefits of the proposed action.

6.1.1.2 Environmental Values Affected By The Proposed Action

Health and Safety

The major human health and safety problems would be encountered during the relatively brief construction period and during major repairs. All work around heavy construction machinery is hazardous, and the arctic environment, with its extreme cold, slippery surfaces, and long periods of darkness, will present an additional hazard to health and safety during construction. After the construction period, some hazards would continue to exist for the small group of persons involved in operating and maintaining the pipeline across the Arctic.

Potable water supply and sewage disposal for the construction force of more than 2,000 persons would be short-term problems which should have no long-term impacts on human health and safety in the area.

The arctic environment, and not the pipeline system itself, is likely to exert the greatest long-term influence on human health and safety along the route.

Development of employment for wage opportunities would contribute to altering the lifestyles of Native Alaskans. It is unlikely that many would return to a wholly subsistence-based existence when pipeline construction is complete. The lives of Alaskan residents in Anchorage, Fairbanks, and other communities would be affected by short-term social disruptions related to the pipeline. How long the effects of these disruptions and their cost in both social and economic terms cannot be evaluated now.

Air and Water Quality

Since the proposed gas pipeline route is through an area primarily in a wilderness state, construction and operation of the pipeline system would degrade the pristine quality of the air and water resources. The most acute effects would occur during construction when workers and machines would be concentrated at the three port sites and construction camps.

The four future compressor stations to be constructed, and other transportation and operation equipment, would have a longer-term effect on the quality of the air along the Arctic Slope. The most noticeable effect would be the ice fog formed around each station in very low winter temperatures.

The proposed pipeline would cross streams at 120 locations between Prudhoe Bay and Canada, and its construction would affect innumerable lakes and ponds. An increase in suspended and bedload sediments in surface waters would be a short-term effect of construction in and near streams, and should have no long-term effects on water quality or aquatic organisms. If, however, thaw consolidation and erosion of permafrost are not controlled, the effects on surface drainage patterns, water quality, and aquatic life could be long-term and detrimental to the productivity of the arctic aquatic ecosystems. The Applicant's studies concerning fish included 49 lakes. Additional studies are needed to identify fish and other aquatic life species that could be affected on short-term and long-term leases by the proposed project.

If abandonment procedures include attempts to retrieve the pipe and restore the ditch to its original level and covering vegetation, changes could continue for up to 5 years after abandonment is completed.

Noise and Esthetics

Noise from construction activities including transportation of workers and materials would be greatest during the 3-year construction period and would become most acute in the one winter during which pipe is strung.

Pipeline system buildings, airfields, and other facilties would continue to alter the esthetic quality of the Arctic Slope during the life of the pipeline. Regular aircraft patrol flights would be seen and heard by people who might not otherwise notice the pipeline operations.

These are generally short-term effects, but the pipeline would be a discordant element in the tundra vegetation for many years and could show up forever as a 195-mile long, line with a color and texture different from those of the surrounding landscape.

The gas may be transported by several different routes, but the wilderness can be neither created nor transported. Loss of the wilderness character of that area with its unbroken continuum of biotic communities within the Arctic National Wildlife Range would be a long-term loss of the productivity and values of that resource.

Archeological and Historical

The proposed construction would have a short-term impact on archeological resources through the accidental destruction of sites before they could be identified and protected.

Sites discovered and properly investigated before construction would add to the long-term production of knowledge of our heritage. Once an archeological, paleontological, or historical artifact is discovered in place, its long-term productivity is just beginning. During construction, some sites might be located that could have enough interest and significance to warrant permanent protection and become points of interest and public attraction. The most important value, however, in relation to long-term productivity, would be the information gained which could lead to the location of other sites and the advancement of knowledge of early man and his history.

Diversity and Productivity of Biotic System

Mixing of the thin tundra topsoil with subsoil and parent material would result in a long-term loss in soil productivity along the 195-mile long pipeline ditch mound. This soil change would also influence the diversity and abundance of plants able to grow on the disturbed sites. Applications of grass seed and fertilizer to revegetate the disturbed soils would bring about short-term increases in plant primary production, but both this short-term increase and the long-term loss of productivity are insignificant in relation to the total primary production from the tundra ecosystems in northeastern Alaska.

Modification of surface and subsurface drainage by the refrigerated gas pipeline and its covering mound will bring about long-term changes in the mosaic of plant communities along the route. Plants better adapted to changed soil moisture, temperature, and fertility will replace those species originally found on the site, and a new equilibrium will gradually be achieved. Either abandonment of the line or its removal and salvage will bring about new conditions with further long-term effects in the tundra soils and vegetation.

One rare and endangered plant species and one Eurasian willow species are found in the area traversed by the proposed pipeline, but long-term effects of the pipeline system on those species cannot be predicted until their abundance and distribution with respect to the pipeline system facilities are known. Two species of rare and endangered whales are present in the Beaufort Sea waters offshore from the proposed pipeline, and neither species should suffer long-term impacts as a result of the gas pipeline operation. The peregrine falcon, an endangered bird species, which exists today in precariously low numbers (about 25 falcons) is known to use the right-of-way during summers. Some of these could be disturbed by aircraft and other intrusion on its cliff nesting sites.

The pipeline presence and operations activities would also have adverse impacts on the long-term productivity of the Porcupine Caribou Herd, the magnitude of which would depend on how well the animals can adapt to the intrusion on their traditional calving ground. Reduction of caribou numbers would have secondary long-term effects on subsistence hunting by Alaskan and Canadian residents of the Porcupine River drainage.

Economics and Liabilities

The short-term use of the Arctic Slope environment for a natural gas transportation system would carry with it shorter-term economic impacts and benefits in Alaska. Employment, wages, and materials for the proposed construction would have a minor effect on the economy of Alaska, and the small operating work force would have an even smaller impact. Taxes and royalties, however, would make a significant contribution to State and local government revenues and can be of long-term benefit to a State which is just beginning to realize its potential productivity.

6.1.1.3 Restrictions to Future Options and Needs

Land Use

Installation of the proposed AAGPC natural gas pipeline system would have significant long-term impacts on the use of the land of the Arctic Slope. The pipeline could preclude the designation of a portion of that area as a unit of the National Wilderness Preservation System. The aggregate impact from development of additional natural gas sources could further lessen wilderness potential parts of the Arctic National Wildlife Range. Potential natural areas which could lose their long-term value as productive contributors to our knowledge of tundra ecosystems include Jago River and Beaufort Lagoon, as well as others nominated as National Landmarks by the National Park Service.

If additional supplies of gas are discovered and developed in the Marsh Creek Anticline or under the Beaufort Sea, the proposed pipeline would be in a good position to enhance the production from such finds. This would lead to more feeder pipelines, pump stations, roads, and other structures which would completely change the character of land use.

Acquisition of Mineral Resources

Production and transport of natural gas from the Prudhoe Bay field would consume the resource in about 30 years and preclude any longer-term productive use of the gas for energy or industrial chemical purposes. The construction of the proposed pipeline system could prompt exploration and development of nearby areas thought to contain economically available gas reservoirs. Most of these areas are on State lands, and the State of Alaska would derive revenues from taxes and royalties.

The Arctic Slope of the Arctic National Wildlife Range is considered likely to contain significant petroleum reserves in the Marsh Creek Anticline, the development of which would limit future options for management of that wildlife range and cause a loss of long-term productivity of the non-mineral resources it was established to protect.

The most important non-energy minerals on the Arctic Slope are sand and gravel. All roads and airfields, storage areas, camps, and drilling pads must be built on gravel embankments 5 feet or more thick. This requires a large amount of sand and gravel (Applicant's proposal is for 2.4 million cubic yards for construction of pads, air-fields and related facilities). The total quantity of the resources available is unknown, but the demand is great. Short-term use now could be removing much of the resource from future consideration.

Short-term use of the route for a pipeline system should not affect the long-term availability of other natural resources.

Availability of Fuel

Use of the 47,000 tons of fuel and lubricants required in construction of the pipeline system in Alaska is a significant short-term diversion of petroleum products from other uses.

The operation of the pipeline system compressor stations would consume some of the gas for turbine fuel and some would be released during routine maintenance. This use would be insignificant for the 195-mile line in

Alaska. Such use constitutes a long-term loss of a nonrenewable resource which might at some future time be used nearer its source.

6.1.1.4 Benefits of Energy Supply Made Available as a Result of the Proposed Action

The project would provide a short-term supply of 2.25 billion cubic feet per day, initially, with increases to 4.5 bcf/d to markets in the lower 48 states.

REFERENCES

Alaskan Arctic Gas Pipeline Company. 1974a. Environmental report of Alaskan Arctic Gas Pipeline Co. (Ch. V published separately.)

Alaskan Arctic Gas Pipeline Company. 1974b. Environmental report Exhibit F (maps and alignment sheets and Exhibit G (plan diagrams). Alaskan Arctic Gas Pipeline Company.

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(See also References for Chapters 1, 2, and 3 of this Statement.)

7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES IF THE PROPOSED ACTION IS IMPLEMENTED

7.1 ARCTIC GAS PIPELINE PROJECT

7.1.1 Alaska Arctic Pipeline

7.1.1.1 Damages to the Pipeline System and Environmental Damage from Natural Catastrophes or Man-Caused Accidents

The dispersed and low level of human activity in the pipeline vicinity would reduce the possibility of pipeline damage from man-caused accidents. Constant monitoring of pipeline performance and routine surveillance should further minimize man-caused accidents.

Pipeline failures could occur from metal fatigue, corrosion, or a material failure caused by excessive geotechnic loadings which could result in either a slow leak or sudden release of a large quantity of gas (see Section 3.1.1.16 for design factors affecting pipeline integrity).

In addition, reports obtained from three major Canadian gas transmission systems operating approximately 7,000 miles of 30-inch to 42-inch pipeline for a period of 17 years show a total of 10 ruptures, equating to a probability of 0.084 ruptures per year per 1,000 miles.

Based on the average statistics of 0.084 ruptures per 1,000 miles per year, the proposed portion of the pipeline along the prime route in Alaska (195 miles) might experience approximately one break every 61 years:

$$0.084 \times \frac{195}{1000} = 0.016 \text{ breaks per year.}$$

However, as stated in Section 3.1.1.16, "Experience gained with the use of more forgiving steels cannot be taken at face value for X-70 steel" and, therefore, frequency of pipeline failure of X-70 steel designed to the criteria specified by the Applicant can be expected to be greater than the above figure.

In the event that pipeline rupture were to occur, natural gas would be released to the atmosphere. Automatic activation of the mainline block valves with loss of pressure would isolate the break area. If rupture were to occur between two block valves 15 miles apart, a large volume of natural gas will exhaust to the atmosphere.

The gas could ignite resulting in fire. Such a fire could burn for approximately two days (40 hours), and could damage vegetation out to a 2,000-foot radius, with complete destruction of the vegetation possible to 1,500 feet.

Vegetation recovery from fires in tundra areas generally requires two to three years.

In the event of a major pipeline emergency, the need for rapid access to the line would require vehicular passage over unprepared tundra surfaces to move heavy equipment to the location. Passage of vehicles over unprepared surfaces in the winter would have less impact than in the summer, but subtle irreversible changes in the tundra ecosystem are possible. The primary source of irreversible and irretrievable impacts on the Arctic Slope environment would probably be activities associated with emergency control and repair of a failure during the spring and summer.

The intensity and extent of such impacts on the local flora and fauna depend on the time of year and the extent to which the permafrost and soil temperature regime are disturbed. It is not anticipated that the actual failure of the pipeline would have irreversible or irretrievable effects on plant or animal populations.

The effects of loss of fuel and methanol through spills would depend on the speed and efficiency of cleanup procedures. Soil and water contamination and vegetation and wildlife could be irreversible and irretrievable, with loss determined by amount and extent of spillage and success of cleanup. See Sections 3.1.1.4, Soils, 3.1.1.5, Water, 3.1.1.6 Vegetation, and 3.1.1.7, Wildlife.

7.1.1.2 Structures Where it is Unlikely that Removal of Project Features Would Take Place

It is uncertain whether the Applicant would abandon the pipe and leave it in the ground when there is no more gas to transmit or remove the pipe. Abandonment would result in a commitment of some 210,000 tons of steel which could otherwise be salvaged and utilized for scrap.

Applicant proposes to remove and salvage the compressor stations and other aboveground structures. If the gravel embankments used for compressor station pads and airstrips were also removed, some 2,000,000 cubic yards of valuable sand and gravel could be salvaged. See Section 1.1.1.8, Future Plans.

7.1.1.3 Resource Extraction

When the proposed AAGPC pipeline system reaches its design capacity of 4.5 bcf/d, less than one percent of that volume would be consumed as compressor turbine fuel to transmit the gas 195 miles.

An unspecified quantity of coal, oil, and natural gas would be irreversibly and irretrievably committed to the manufacture of the 48-inch steel pipe and transporting it to the Arctic Slope. Also the 22.5 trillion cubic feet of natural gas taken from the Prudhoe Bay reserves will be irretrievably committed to energy generation.

The Applicant proposes to use 47,000 tons of fuels and lubricants in the vehicles required for project construction. This would constitute an irretrievable commitment of fossil fuels which would thus be unavailable for other uses.

Six thousand tons of methanol would be irretrievably committed for use in hydrostatic testing of the completed pipeline.

Some 3,100,000 cubic yards of sand and gravel would be extracted from the Arctic Slope terrain and committed to construction of various project structures. As much as two-thirds of these scarce arctic construction materials may be retrievable after use of the facilities terminates, but the balance would be irretrievably lost.

Some 5,328,000 barrels of water could be used in snow road construction, pipeline hydrostatic testing, and camp operations. Virtually all of this would be returned to the surface water drainage and remain available in the natural hydrologic cycle.

7.1.1.4 Erosion

Loss of Topsoil and Surficial and Organic Matter from Denuded Areas

Construction of this project would result in irreversible and irretrievable losses of surface soil by both water and wind erosion. Most of the soil erosion would be caused by water.

Materials carried off would be mostly from newly denuded or disturbed areas including borrow sites, the pipeline mound, and areas damaged by snow and ice roads. Emergency repair procedures can be expected to provide new sources for erosion.

Sediments carried away would be a combination of surficial materials and the organic peat which normally occurs in both the surface and surficial materials.

Effects on Aquatic Ecosystems and Water Quality

The total amount of runoff is not expected to change. Drainage patterns would change, however, with water blockage causing new wet and dry communities.

During construction, and until disturbed surfaces have stabilized or revegetated, there would be turbidity and siltation levels greater than existed prior to disturbance. As surface restoration gradually takes effect, these factors should generally return to near preproject levels.

Erosion and the resulting sedimentation of streams would destroy or make less productive some fish spawning and hatching areas. An active and effective revegetation and rehabilitation program could keep this loss of habitat at a minimum, especially in larger streams.

Loss of spawning areas in small streams may be a far greater problem. Arctic grayling are known to spawn in very small streams that have low water-flow characteristics. Because of the low rate of flow, sediments may never be washed away or the spawning bed cleaned. This could adversely affect grayling populations over a wide area. In the Arctic this effect could be irreversible.

Petroleum products and other chemicals that adversely affect aquatic habitats will be used during all phases of the proposed project. Accidental spills of these materials are likely to occur and some of the spilled material would reach streams. The extent and duration of drainage depends on the quantity spilled and the effectiveness of cleanup and renovation.

Chronic low-level pollution could be more damaging to aquatic habitats than large-scale, short-term pollution. If either type of pollution is severe enough, the aquatic habitats will be lost irretrievably.

Chronic erosion that causes increases in suspended sediment and turbidity of sport fishing streams will reduce the catch per unit of fishing effort and reduce the esthetic enjoyment of the fishermen. If this continues for a long period of time, fish populations will be drastically reduced and fishermen will avoid the area and concentrate on more attractive and productive streams. This, in turn, could reduce the numbers of fish in non-turbid streams to a point where the reproductive rate could not sustain the catch rate. This would discourage sport fishing.

There are no commercial fisheries in the area of project influence nor is it likely that any will develop.

7.1.1.5 Destruction of Archeological, Historic, Paleontological Sites and Esthetic or Scenic Resources

Destruction of Archeological, Historical, and Paleontological Sites and Paleontological Sites

Archeological, paleontological, and historical sites are nonrenewable resources. It appears inevitable that some of these values would be destroyed by project installation. No survey over such a vast stretch of territory can hope to identify each and every site which would be affected.

Esthetic and Scenic Resources

Some esthetic and scenic features scarred by pipeline activities can be restored and are not necessarily permanently destroyed, although they are considered to be permanently compromised by some purists. Other such features would bear permanently (at least for many lifetimes) the marks of man's technology. Wilderness resources may be similarly irreversibly and irretrievably committed. It is difficult to determine the length of time necessary for this area to return to its natural state after abandonment of the pipeline project. The removal of buildings, airports, towers, pumping stations, and other facilities would improve the area scenic and wilderness quality but would not fully restore it for generations to come. (See section 3.1.1.11, Land Use.)

7.1.1.6 Elimination of Endangered Species' Habitats

Three animal species listed by the U.S. Department of the Interior as endangered inhabit the area involved with this proposed project during a portion of the year. These are the gray whale and bowhead whale that are present during the 6- to 8-week period of open water in late July to September and the arctic peregrine falcon that hunts over the pipeline area during the spring through early fall.

Loss of Cover in Resting, Feeding, or Breeding Areas

The cover associated with the Arctic North Slope area is low, with the river bottom willows the tallest vegetation. Pipeline construction activities could destroy some of the cover but effects could be minimized and restricted to the feeding or hunting area of the falcon.

Pollution of Aquatic Habitats

A large proportion (±70 percent) of the peregrine's food items are water-oriented birds, e.g., waterfowl, shorebirds, and gulls.

Loss from pollution of aquatic habitats of these prey species would reduce their numbers, thereby reducing the amount of available food. A massive water pollution event in a year of normally low bird populations could be disastrous to the arctic peregrine falcon populations.

The whales are present only during that period when the polar ice pack is away from shore. This is also the time when shipping and material transfer would be most prevalent. A pollutant spill at sea or in an estuarine area could reduce the whales' food supply and could kill individual whales that come in contact with the pollutant.

Effects of Noise and Air Pollutants

Noise associated with the operation of compressor stations, maintenance checks at communication stations, and general aircraft traffic can affect the breeding and feeding habits of the falcon.

Their breeding areas are removed from the pipeline construction area, and the birds are not in the area during the winter, but summer activities could have a detrimental effect on the birds.

Shipping noise should have little effect on the whales' feeding habits.

Many plant species are sensitive to airborne pollutants. Construction equipment and compressor stations would release oxides of nitrogen, sulfur dioxide, carbon monoxide, unburned hydrocarbons, water vapor, and suspended particulates into the air. This could have an adverse effect on the endangered plant species because of change of habitats or intolerance of the species to one or more of the pollutants.

Use of Herbicides, Burning, and Bulldozing for Right-of-Way Maintenance

AAGPC would use no herbicides, and there would be no burning of vegetative material in Alaska. Bulldozing would not be used in right-of-way maintenance.

Influx of People into Sensitive Breeding and Nesting Areas

The arctic peregrine falcon is extremely sensitive to people in its breeding and nesting areas. It is extremely important that movement in and around nesting areas be restricted during sensitive (April 15 to August 15) periods and maintained during the entire time the birds are present.

The whales do not use the adjacent marine area for breeding.

Creation of Barriers

No land barriers have been proposed for this section of the project. Satellite communications are being considered in lieu of communication towers. If such towers are associated with the project, however, they could be serious obstacles to free flight. Many birds are wounded and/or killed each year when they strike towers and tower support wires.

The Applicant has proposed to construct two dock areas in or near Camden and Demarcation Bays. Preliminary plans call for a long approach from land to the lighter unloading area. Precise length of this approach is not known, so an analysis of impact on the whales' feeding habits cannot be made.

7.1.1.7 Irrevocable Changes in Land Use

Changes in Zoning (Agricultural to Industrial)

There is only one broad zoning effort in effect along the route of the proposed pipeline in Alaska. This is the classification of the State of Alaska lands (M.P. 00 to M.P. 61.45) as resource management lands. This proposed project would not conflict with that classification.

Preparation for a zoning system by the North Slope Borough is in early stages, and the zoning impact is unknown at this time. Therefore, irrevocable changes that may occur cannot be identified.

Increased Housing and Other Construction (Rural to Urban)

Irrevocable changes would occur in two areas not geographically close to the proposed pipeline; Anchorage and Fairbanks. Both cities have substantial areas of open space that may be looked upon as a resource to accommodate the project-related commercial and residential needs. Neither city has developed in advance the required utility or transporation systems, so additional land would be used for those purposes.

Conflicts with Recreational or Other Future Land Use Plans

The recreational experiences of individuals who use the pipeline area would be irreversibly and irretrievably affected by association with the pipeline. Whether this is a negative or positive effect will be the opinion of the individual recreationist. (See above for commitments relating to proposed wilderness designation.)

Land-use planning by the State of Alaska in the Prudhoe Bay area is in its early stages. The State, however, has been encouraging the development of the oil and gas reserves in that area so it is improbable that the concept is in conflict. The Governor-appointed special task force to study the transportation of the Prudhoe Bay gas has recommended that natural gas be transmitted south through Alaska instead of east across the Arctic Slope.

The approval of the AAGPC proposal would preempt the planning process of the Joint Federal-State Land Use Planning Commission and the State planning efforts, since it will essentially commit future land uses such as transportation corridors and the proposed policy for the Arctic. Future activities that are likely to follow also will affect future land-use planning efforts in the area.

Increased human activity, if required over a period of years, could also lead to the need for permanent roads or even small communities in areas now entirely devoid of such things.

Conflicts with Native Subsistence Land Use

Any permanent damage to the Native subsistence hunting and fishing areas will be an irreversible commitment of this resource. Loss of fish and wildlife habitat can result in decreases in game populations which will be irretrievable.

7.1.1.8 Commitment of Materials and Human Resources

Construction Materials (Pipe, Concrete, Lumber, Fabricated Materials)

Materials used to construct the pipeline (steel, concrete, etc.) would be unavailable for the lifetime of the pipeline. It is possible that some of this material could be reclaimed, if desired, upon abandonment of the pipeline or later. The conditions of abandonment would be determined in conjunction with the responsible public agencies prior to that time. Environmental and economic considerations, and the state of technology, all would be considered in the final resolution. Approximately 215,000 tons of steel would be incorporated in the 48-inch pipeline and its ancillary facilities. Pipeline weights which would be utilized in construction would be composed of cement, rebar, sand, and gravel. Other gravel will be used for pad construction.

Use of Labor Force

Construction in Alaska would involve about 1,500 man-years of work. Maintenance and operation activities will require about 40 man-years per year through the fifth year of the pipeline's operation. The work force committed to the project would not be available for projects requiring its skills elsewhere. See Sections 1.1.1.6 Construction and 3.1.1.10 Sociological Factors. An unidentifiable number of workers may abandon jobs in which their skills are needed to work more profitably on the pipeline. For instance, a teacher might be employed as a laborer. His skills as a teacher would be irretrievably lost to students during the time he worked at pipeline construction.

REFERENCES

Alaskan Arctic Gas Pipeline Company. 1974a. Environmental report of Alaskan Arctic Gas Pipeline Co. (Ch. V published separately.)

Alaskan Arctic Gas Pipeline Company. 1974b. Environmental report Exhibit F (maps and alignment sheets) and Exhibit G (plan diagrams).

Alaskan Arctic Gas Pipeline Company. 1974c. Response to questions of the Joint Environmental Study Group of Federal Power Commission and Dept. of the Interior. (54 questions submitted to AAGPC 11/22/74; answers unpublished or in preparation).

Alaskan Arctic Gas Pipeline Company. 1975. Responses to questions of the Joint Environmental Study Group of the Federal Power Commission and Department of the Interior. Unpublished.

(See also References for Chapters 1, 2, and 3 of this Statement.)

8 ALTERNATIVES TO THE PROPOSED ACTION

8.1 ALTERNATIVE GAS PIPELINE ROUTES

8.1.1 Alaska Arctic Pipeline

Introduction to Alaskan Alternative Pipelines

The preceding portions of this Part evaluated expected impacts associated with the proposed AAGPC pipeline system. This section evaluates alternative pipeline routings through Alaska which could be selected.

Alternative schemes for transporting natural gas from Prudhoe Bay, such as by railroad or submarine, are discussed in Alternatives. Also included in Alternatives is a discussion of an alternative method for transporting Alaskan gas through a combination of pipeline-ship-pipeline. That alternative system involves the conversion of natural gas to liquified natural gas (LNG) for transportation in cryogenic (cold) containers and then reconversion to natural gas. The LNG alternative system involves pipeline routings from Prudhoe Bay to an Alaskan coastal area where the gas would be converted to liquid. The LNG systems are summarized in Overview for comparison with those discussed in the Applicant's proposal. The reader should note that the Federal Power Commission has pending an application to construct and operate an LNG transportation system and has prepared a draft environmental impact statement.

In the selection of the applied-for pipeline route across the Arctic National Wildlife Range, the Applicant studied and considered four alternative pipeline routings from Prudhoe Bay to the United States-Canada border. The Applicant, in his application to the Department of the Interior and the Federal Power Commission, implied that the Interior alternative pipeline route would be proposed in the event that the applied-for AAGPC pipeline route is not available.

Because the Interior alternative pipeline route is primarily within a Federal utility corridor established by the Secretary of the Interior in March 1972 for construction of oil and gas pipelines from Prudhoe Bay, the Applicant submitted data and plans for pipeline construction in the Interior route nearly as detailed as those of the Applicant's preferred routing. Only generalized data were assembled by the Applicant on the remaining three routes (Offshore, Fort Yukon, and Fairbanks Alternatives). These and the following alternative pipeline routings in Alaska are shown on Figure 8.1.1-1 and in Table 8.1.1-1.

Since discovery of the Prudhoe Bay field in 1968, considerable attention has been given to identifying the best method and route for transporting oil and gas from remote areas of Alaska to domestic markets in the conterminous United States. Studies included the environmental impact statement prepared for the trans-Alaska Oil Pipeline System (SITF, 1972); the Bureau of Land Management (1973); the Applicant (1974); El Paso Alaska Company, (1974); and the Bureau of Land Management (1974). Resource values associated with these various schemes and routings have been studied by the Joint Federal-State Land Use Planning Commission for Alaska, the Department of the Interior, and the State of Alaska (1974, 1975).

Pipeline routings in Alaska from Prudhoe Bay considered as part of the trans-Alaska oil pipeline system (SITF, 1972) included oil terminals at:

1) Cook Inlet

2) Whittier on western Prince William Sound

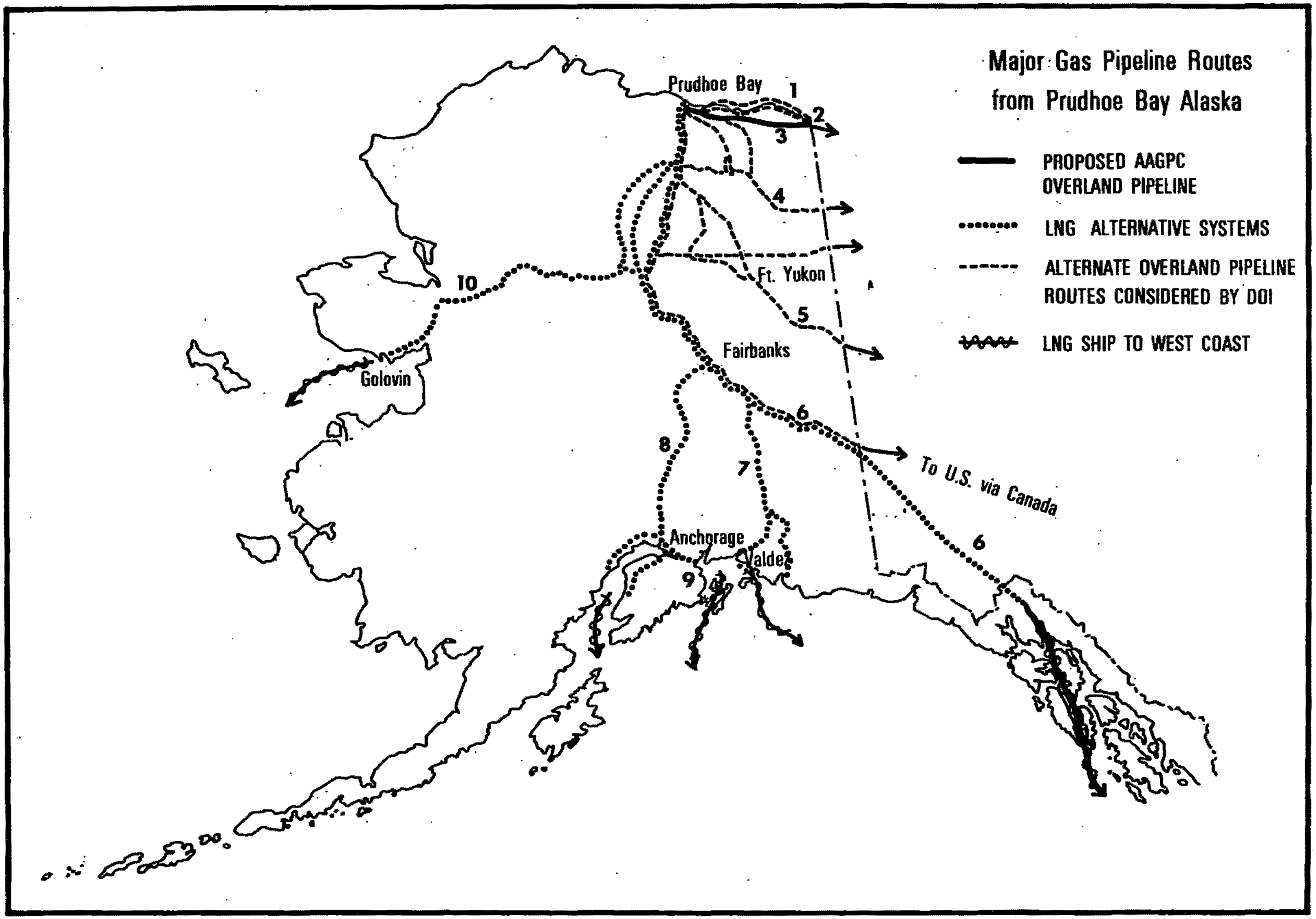

Figure 8.1.1-1 Alaskan alternative routes

Table 8.1.1-1 Major pipeline routes in Alaska from the Prudhoe Bay area

Map * number	Name	Prior studies
1.	Offshore	SITF, 1972; BLM 1973 and 1974; AAGPC, 1974
2.	Beaufort Sea Coast	BLM, 1973 and 1974
3.	AAGPC proposed Route	SITF, 1972; BLM, 1973 and 1974; AAGPC, 1974
4.	Interior Route	SITF, 1972; BLM, 1973 and 1974; AAGPC, 1974
5.	Fort Yukon Corridor	BLM, 1973 (partial), 1974; AAGPC, 1974
6.	Fairbanks Corridor†	SITF, 1972; BLM 1974; AAGPC, 1974; EPAC, 1974†
7.	LNG alternative system to Valdez-Cordova-Gravina area	SITF, 1972; BLM, 1974; EPAC, 1974
8.††	LNG alternative system to Cook Inlet area	SITF, 1972; BLM, 1974; EPAC, 1974
9.††	LNG alternative system to western Prince William Sound area	SITF, 1972; BLM, 1974; EPAC, 1974
10.	LNG alternative system to Golovin Bay area	SITF, 1972; BLM, 1974; EPAC, 1974

*figure 8.1.1-1
†Includes LNG Alternative System to Haines Alaska via Canada.
††For purposes of this analysis 8 and 9 are combined.

3) Seward on Resurrection Bay

4) Haines or Upper Lynn Canal

5) Golovnin Bay

Pipeline routings also considered were:

1) Offshore to the Mackenzie Delta in Canada

2) Coastal route which corresponds with the Applicant's proposed route

3) Interior route

4) Fairbanks to Delta, Alaska, to Edmonton, Alberta

The Bureau of Land Management (1973) evaluated eight utility corridors for pipeline routings from Prudhoe Bay through northeastern Alaska to the Canadian border. These routes include three corridors considered by the Applicant (including the proposed AAGPC pipeline route and the Interior route), but concluded "...a route adjacent to the beach of the Beaufort Sea would provide the safest, most useable utility corridor with the least amount of environmental damage."

In 1974 the Bureau of Land Management, in response to directives from the Congress (P.L. 92-203, P.L. 93-153), prepared an initial and conceptual analysis of a statewide multimodal transportation and utility corridor system. That analysis placed heavy emphasis upon the: (1) reduction of the proliferation of separate rights-of-ways across Federal lands, and; (2) transportation of energy resources from remote areas of Alaska to domestic markets in a manner creating minimum adverse social, economic, and environmental impacts. Pipeline routings from Prudhoe Bay were considered within the context of other expected surface transportation needs in Alaska.

On March 3, 1975, AAGPC submitted to the Department of the Interior and the Federal Power Commission a "supplemental" proposal to construct a 42-inch diameter, high-pressure, buried, and chilled gas pipeline as an alternative to the 48-inch pipeline system described in Section 1. This smaller pipe would be located on the same alignment in Alaska but would require construction of two compressor-chiller stations prior to startup. This size alternative is evaluated in this section.

Alternative LNG systems from Prudhoe Bay include several feasible pipeline routes and port areas in Alaska where LNG conversion plants would be located. These are pipeline routes to the Valdez-Cordova-Gravina areas; Cook Inlet; western Prince William Sound area; Haines; and Golovnin Bay area. A thorough analysis of these LNG systems can be found in Alternatives of this EIS.

In the evaluation of alternative pipeline systems within Alaska, all parameters are covered in the prior analysis of the proposed AAGPC pipeline system. No attempt has been made to repeat a condition previously described in another section of this draft statement unless the alternative being evaluated would cause significant differences. For example, the reader will be referred to discussions of the pipeline system construction, operation, and repair procedures described in Sections 1 through 3 whenever the alternative involves similar characteristics. Likewise, discussions of the climate along the Beaufort Sea Coast are contained only in Sections 2.1.1.1 and 3.1.1.1.

The analysis of alternative pipeline routings considers several major factors affecting selection of a route for construction of a gas pipeline like that proposed by the AAGPC in an arctic environment. These include:

1) Development and transportation of existing or prospective energy resources in Alaska without proliferation of separate rights-of-ways.

2) Length, topography, number of river or stream crossings, and amounts of gravel needed.

3) Permafrost conditions.

4) Avoidance of earthquake zones.

5) Avoidance of habitat for unique animals such as polar bear, musk ox, and peregrine falcon.

6) Avoidance of habitat for waterfowl.

7) Avoidance of traditional calving areas of caribou.

8) Time needed to have the system operational.

9) Consequences of repair activities.

10) Association with populated areas.

11) Numbers of construction and permanent workers.

12) Association with established transporation facilities.

13) Avoidance of prospective wilderness areas.

14) Connections at the United States-Canada border to extensions through Canada.

There are a variety of routes which could be used to construct pipelines from Prudhoe Bay. Each is assumed to be technologically feasible. When considered within the constraints listed above, it is concluded that 10 routes (including the proposed AAGPC pipeline system) warrant further evaluation. These involve five alternative pipeline routings to the proposed AAGPC pipeline system which will provide a direct pipeline link between Prudhoe Bay and domestic markets in the eastern, midwestern, and western United States via Canada. These six routes are considered to be within the stated intent and capabilities of the AAGPC. The remaining four routes involve the Alaskan pipeline and coastal terminal area of the LNG alternative. Pipeline-ship-pipeline systems are evaluated in Alternatives of this EIS. LNG alternatives are not considered to be within the intent of the AAGPC to construct and operate. (See Figure 8.1.1.-1.)

It is emphasized that <u>NO PIPELINE ROUTE FROM PRUDHOE BAY (INCLUDING THE LNG ALTERNATIVE SYSTEMS) IS FREE FROM ENVIRONMENTAL IMPACTS.</u> Each route varies in the extent and intensity of impacts on the existing environment and the expected social and economic structure of Alaska.

This evaluation of the alternative route includes only three parts: Description of the Project; Description of the Existing Environment; and Impacts. It does not include mitigation measures, a discussion of adverse effects which cannot be avoided, or irreversible and irretrievable commitments of resources. Many of the impacts could be mitigated as identified in Section 4.1.1.1 of the applied-for route.

8.1.1.1 Offshore Alternative Pipeline Route

An alternative to the route proposed by AAGPC would be to locate the pipeline offshore of the Beaufort Sea Coast. Such a route would avoid many conflicts with the Arctic National Wildlife Range and, therefore, have obvious benefits in reducing impacts on the Porcupine Caribou Herd. An offshore pipeline routing was given considerable attention as an alternative location for the hot oil pipeline from Prudhoe Bay (SITF, 1972) and was reevaluated in 1973 by the Bureau of Land Management as a pipeline corridor.

In 1972 it was concluded:

> Development of an offshore submarine pipeline is technically unfeasible at this time. It would be subject to possible ice scour damage from groundings of icebergs or ice islands, and probably subject to pipe bed foundation problems related to sea-bottom permafrost degradation that would result from altered thermal conditions introduced by dredging of the seabed for burial of the pipeline... (SITF, 1972, Vol. V, pgs. 191, 192.)

Description of the Alternative Offshore Pipeline System

Location

The Offshore route considered by AAGPC would be approximately 205 miles long in Alaska. The first 64 miles of pipeline are on land, with the route trending northeasterly from Prudhoe Bay to the coast in the vicinity of the west side of the delta of the Canning River.

The next 141 miles are located on the bed of the Beaufort Sea. The location of the Offshore pipeline system is shown on Figure 8.1.1.1-1. It returns to shore in Canada near the United States-Canada border.

The AAGPC routed the Offshore alternative to be located in water depths of 20 to 30 feet. Basic reasons for this selection were:

1. Conventional barge pipelaying equipment requires a minimum 15-foot draft. Therefore, basing plans on summer operation and available equipment, AAGPC concluded that a pipeline could be buried in the bed of the Beaufort Sea.

2. The route would lie outside the barrier islands; therefore, it would not be in the shallow lagoons used extensively by bird and aquatic life.

3. In water depths greater than 200 feet (outer zone), the summer construction season would be too short (about one-third that for shallow water routes) because of the presence of the polar ice pack.

4. In water 30 to 100 feet deep (medium water depths) pipe burial would have to be deeper because this area is subject to maximum ice scouring.

5. Construction in water 10 to 20 feet deep (shallow waters) would require development of shallow-draft marine equipment, and would be more likely to disturb aquatic and bird life.

AAGPC determined the most advantageous depth of water for the Offshore route basing conclusions on available marine construction equipment, economics, and the requirements of summer construction. Construction through the ice in shallow water (5 to 10 feet deep) during the wintertime was not considered. The following analysis highlights some of the advantages of constructing the pipeline in shallow water rather than burying it in the sea bottom under 20 to 30 feet of water.

1. Construction could take place in the winter, assuring a longer construction season than in summer.

2. Winter ice surface generally is smooth and easily traveled; during the last winter months, the ice rests on the shelf of the Beaufort Sea, thus providing sound runways and roads.

3. Ice gouging is not as deep.

4. No large ice blocks and pressure ridges are present.

5. The forces moving the ice are low.

6. Much of the route would be protected by barrier islands. Stretches of the shallow water route not protected by barrier islands would be affected the same as the Offshore route.

7. Open water season is longer in shallow water, making access for repair easier.

Disadvantages of the shallow water route compared with the Offshore route follow:

1. Frozen materials in seabed could pose greater trench excavation problems.

2. River flooding would affect the pipeline scour depth through strudeling.

3. Proximity to offshore islands and barrier bars makes it inevitable that important bird habitat will be severely disturbed.

Facilities

For the purposes of evaluating the Offshore alternative pipeline route, it is assumed that the same size and quantity of pipe would be used as for the route proposed by AAGPC in the applied-for pipeline system. This analysis is based upon assumed future construction of four compressor stations in Alaska, of which three are to be located on the coast of the Beaufort Sea within the Arctic National Wildlife Range (Figure 8.1.1.1-1). The total number of compressor stations between Prudhoe Bay and the Mackenzie Valley pipeline in Canada remains the same, as both systems require 10 compressor stations to maintain a throughput of 4.5 bcf/d (billion cubic feet per day). Throughput of 4.5 bcf/d could be achieved by constructing parallel 48-inch pipelines rather than by adding compressor facilities. This type of project would enhance system reliability because a failure probably would not occur simultaneously in both pipelines, and compressor stations would not be needed in the National Arctic Wildlife Range.

Compressor stations are assumed to be similar to those discussed in the applied-for route and are assumed to have similar ancillary facilities such as communication towers, airfields, storage, and quarters for workers.

The primary movement of equipment and construction supplies to the general area would be by ship and barge down the Mackenzie River to port areas along the Alaskan Coast. The Offshore alternate pipeline route would require port facilities at Prudhoe Bay, Compressor Station 2, near Kaktovik, and at Demarcation Bay.

Construction Procedures

The initial 64 miles and the first compressor station of the Offshore alternative pipeline route are located on areas very similar to those of the initial 63 miles of the applied-for AAGPC pipeline system between Prudhoe Bay and the Canning River. Accordingly, it is assumed that the onshore elements of this first 64-mile segment would be constructed and operated in a similar manner.

Construction procedures for the three future compressor stations located on the coast of the Beaufort Sea would be different from those used at inland locations on the applied-for route because of soil and permafrost differences. It is assumed, however, that overall construction procedures at coastal compressor station complexes would be similar to those required for the Camden and Demarcation Bay port areas proposed for construction as part of the applied for AAGPC pipeline system.

The marine segment of the Offshore alternative route would involve significant engineering problems not encountered with a land pipeline system. For example, the depth of burial in the sea floor will need to be below expected ice gouge depths. Thus, excavation of a seabed ditch probably would be in excess of 20 feet. Pipeline design will need to consider external pressures caused by large grounded ice masses and measures needed to maintain negative buoyancy of the pipe.

Conventional marine pipeline construction requires use of pipelaying ships. The ice conditions and relatively shallow depths of the nearshore and lagoonal waters along the marine portion of the offshore route restrict season of use (6 to 8 weeks) and depth at which the pipeline can be constructed. There is no existing technology for wintertime construction through sea ice or excavation of the seabed.

There is no detailed proposal to construct an offshore pipeline and, therefore, how the excavation would be made is unknown. Conventional techniques involve high-pressure water jetting and dredging.

The marine portion of the Offshore alternative pipeline system (141 miles) probably would be constructed with block valves only at the three onshore compressor station sites. Because sea ice will damage parts of the system protruding above the depth of scour and accessibility for repair is limited, it is assumed that block valves will not be installed offshore.

New gas temperature maintenance facilities, such as chillers or differential gas temperature maintenance equipment for marine and onshore segments of the systems at five contact zones with the Beaufort Sea are not considered in the analysis (only three will have chillers and these will not be constructed until after gas throughput exceeds 2.25 bcf/d).

Operation of the Offshore System

The principles of operating a chilled gas pipeline remain the same for this route as for the AAGPC proposed route. However, there are significant problems not found in the proposed route.

A major unknown in the operation of the offshore alternative system is the appropriate temperature range for the chilled gas. Onland segments are intended to operate at temperatures below freezing to maintain permafrost stability. Assuming temperature curves of the gas and adjacent permafrost to be similar for onland portions of this system to those of the AAGPC applied-for chilled pipeline system, major questions related to the marine segment include the following:

What are the temperatures and location of permafrost in the bed of the Beaufort Sea at the 20- to 30-foot depth?

Will the relatively uniform temperature of the Beaufort Sea waters affect the heat exchange between the chilled gas and its surrounding marine environment to the extent that permafrost degradation will occur before the next chilling facility is reached?

Will new gas temperature maintenance facilities need to be located at the five entrance and exit points along the Beaufort Sea (three compressor stations, Mile 64 initial entrance, and final exit in Canada)?

New gas temperature maintenance facilities, such as chillers or differential gas temperature for marine and on-shore segments of the system at five contact zones with the Beaufort Sea, are not considered in the analysis (only three will have chillers and these will not be constructed until after gas throughput exceeds 2.25 bcf/d).

Construction Schedule

It is assumed that onshore facilities, including the first 64 miles of the pipeline system, compressor stations, and ports, would be constructed during the wintertime. This plan is similar to that proposed by AAGPC in the applied-for system with the aid of snow/ice roads.

Early operation of a gas delivery system from Prudhoe Bay to domestic markets is in the national interest. It is assumed that only existing marine pipeline construction techniques would be used. New equipment, such as shallow-draft pipelaying vessels, air-cushion vehicles, and new techniques, such as those needed for winter excavation of a trench in the bed of the Beaufort Sea through sea ice, are not considered because of the additional time needed to develop them.

It is assumed that conventional marine pipelaying equipment can operate along the Beaufort Sea Coast from the end of July to mid-October with the aid of ice breakers. It is anticipated that two summer seasons would be required for construction of the 141 miles of marine pipeline. Plans for the AAGPC applied-for system contemplate initial construction of the pipeline system in a single construction season, with operation starting before the summer thaw cycle is well advanced.

Work Force

The exact number of people needed to construct the Offshore alternative pipeline route is unknown but it is expected that peak employment would be less than the 2,400 directly employed on the proposed AAGPC system. Workers would live on the North Slope of Alaska for longer periods than for the proposed route since there would be construction activity during a continuous period of approximately 2 years.

Maintenance and Repair

Maintenance and repair procedures of the onshore facilities needed to operate the Offshore alternative pipeline system are assumed to be similar to those described in sections 1.1.1.1 through .9 for the proposed AAGPC pipeline system.

Maintenance and repair of the marine segments of the Offshore alternative system have many unsolved problems. In 20 to 30 feet of water, conventional marine repair techniques are limited to the same July to mid-October period used for construction because of ice conditions. AAGPC, however, suggests that repair access can be extended to a 7- to 8-month period by using air-cushion vehicles as support vessels for diver- or submersible-capsule-assisted access to the pipeline. The critical periods of breakup (May to the end of July) and freezeup (mid-October to December) make repair access difficult, if not impossible, because of the likelihood of the presence of moving masses of ice.

Costs

AAGPC (1974a) estimates the Offshore alternative pipeline system will cost an additional $290.9 million to construct and $0.6 million annually to operate over similar costs for the applied-for route. Construction and operational costs have escalated sharply since the AAGPC estimate; hence the 1974 AAGPC estimates must be considered conservative.

Summary and Conclusions

Although AAGPC reasons that existing technology could be adequate to construct a high-pressure, buried, chilled-gas pipeline in the bed of the Beaufort Sea, major engineering design problems remain to be solved. Foremost are to learn the extent and condition of permafrost in the seabed of the Beaufort Sea, to develop proper stress design to withstand external pressures from large masses of grounded ice, and to select proper temperature maintenance of the gas in marine segments.

Movement of the polar ice pack along the coast of the Beaufort Sea during 4 to 5 months each year creates major access problems for repair and maintenance of the marine segments. It is during these periods (May to late July and mid-October to December) that interruption of gas delivery from Prudhoe Bay to domestic markets would have greatest impact on the consumer during the high risk period.

Substantial public comments were received at a series of public meetings in Alaska and other states in January 1975 on the potentials of an offshore routing as a means to avoid most of the Arctic National Wildlife Range boundary. An Offshore pipeline routing is a long-range potential which will have to be reconsidered should oil or gas be located in the Beaufort Sea Offshore Province (and there is a high probability that oil and gas will be found). Accordingly, anticipated impacts from such a marine pipeline system are discussed so that these aspects can be considered when a route for the Prudhoe Bay gas is selected.

Description of the Environment of the Offshore Alternate Pipeline Route

Climate

The climate of the area associated with the Offshore alternate pipeline route is similar to that described for the AAGPC applied-for route (Section 2.1.1.1). The apparent differences are slightly warmer coastal temperatures and the frequent occurrence of low-lying summer coastal fog. That section also discusses sea ice and the marine environment because of the need to move supplies and construction material along the Alaskan Coast of the Beaufort Sea from the Mackenzie River in Canada.

Construction of a pipeline buried in the bed of the Beaufort Sea must consider ice scour hazards. Accordingly, a discussion of ice gouging in the Offshore alternative pipeline route follows:

The normal freeze-thaw cycle starts with the formation of river and sea ice during the later part of September. By the end of December, when mean air temperatures are well below -20°C, ice is commonly more than a meter thick. Ice continues to thicken, reaching a maximum of about 2 meters in May, when melting is initiated by air temperatures rising above freezing. Twenty-four hour exposure to the sun's rays aids rapid thawing during the last part of May and early June, when river flow is initiated on top of the river and sea ice. The flood may exceed 1 m in depth on the sea ice and ultimately drains through cracks and holes in the sea ice called strudel (Reimnitz et al, 1974). Most snow cover and river ice has melted by mid-June. The sea ice along the coast continues to melt during June and much of July, usually resulting in a lead or an open-water area 10 to 50 miles wide off the coastal and insular beaches (Short, 1973).

Off rivers, this melt lead can reach a width of 10 to 15 km in response to the influx of warm river water. Sometime late in July, the remaining sea ice breaks up and moves offshore. The cycle is completed during the rest of the summer season--August and early September--when temperatures are above freezing and any remaining ice continues to melt. Most of the lagoonal ice and ice inside the 10-m contour melts with little or no lateral movement.

The winter ice on the Continental Shelf can be divided into three broad categories: (1) the seasonal fast ice along the coast; (2) a brecciated shear line and associated shear zone that mark the seaward boundary of the fast ice; and (3) the multiyear polar pack ice seaward of the shear zone.

The fast-ice zone is composed mostly of seasonal ice and is essentially immobile during the winter. By the end of winter, the ice inside the 2-meter deep contour rests on the bottom. As the seas oscillate vertically with astronomical and meteorological tides while downward adfreezing continues, the fast-ice is elevated inshore of the 2-meter contour and often contains layers of sediment (Barnes and Reimnitz, 1973).

The boundary between the stationary fast ice and the mobile pack ice is marked by the shear line oriented parallel to the coast along the 10- to 20-m depth contour. Seaward of this boundary, sheer ridges and pressure ridges develop in response to the impingement of moving ice against the fast-ice thereby forming a shear zone up to 20 km (Kovacs and Mellor, 1974).

The polar pack ice consists of multiyear ice floes 2 to 4 meters thick and pressure ridges with keels to 47 m (Weeks et al, 1971). As a result of wind stresses, the general drift of the ice is westward in the southern part of the clockwise Pacific Gyre (Campbell, 1965).

During the summer, ice conditions are controlled by local winds. Under the influence of westerly winds, the Eckman drift forces the ice and water onshore. When these conditions are severe, sea level is raised as much as 3 m, submerging the offshore islands and stranding ice on both the beaches and barrier islands (Reimnitz et al, 1972). Easterly winds, on the other hand, move water and ice offshore, resulting in a lowering of sea level by as much as 1 m. In the absence of an influencing wind, scattered drifting and grounded ice are a common sight inshore of the pack-ice boundary. The presence of the pack ice reduces the wind fetch and limits the development of waves during the summer so that seas higher than 1 m are rare (Wiseman et al, 1973).

Analysis of ERTS-1 imagery during the summers of 1972 and 1973 indicates that the dominant direction of movement for the river-supplied sediment plumes is westerly. During this season current-meter records show an overall westward current up to 25 cm/s (USGS, unpublished data) inside the 10-m contour.

Ice drifting westward along the coastal areas of the Beaufort Sea (Figure 2.1.1.5-2) often encounters the gently sloping shelf of the Beaufort Sea, causing ice gouges in the sediments of the sea bed (Pelletier and Shearer 1972; Reimnitz et al, 1972). Figure 8.1.1.1-2 shows how ice gouges are formed. Table 8.1.1.1-1 summarizes generalized data showing the relationship of the depth of water. It should be noted that the 6- to 45-m midshelf zone, which includes the area where the pipe would be located, occasionally has ice gouges 3 to 4 meters deep (13 feet). Ice gouges in this zone, especially in the 6- to 15-m upper limits of the midshelf zone, generally are from 0.5 to 1 m deep, but gouges 5.5 meters deep have been measured (Figure 8.1.1.1-3). The density of ice gouges along the Alaskan Coast of the Beaufort Sea has exceeded 300 or more per km. Gouges generally are oriented parallel to the coastline but sometimes are at right angles. As would be expected, ice gouges tend to be formed by ice moving from east to west. Sometimes, however, gouges are in the opposite direction. Figure 8.1.1.1-4 shows the dominant and subordinate trends of ice gouges examined in 1972 and 1973.

The seabed of the Beaufort Sea beneath the major ice pressure ridges of the winter shear zone, located in the 10- to 30-m depth range between the fast-ice and the offshore ice, is an area of high gouge density. Gouge densities are high on relatively steep, seaward-facing slopes and topographic highs. Lowest densities are found in regions landward of such highs and landward of islands, as well as in areas adjacent to river deltas. At depths shallower than 20 m, seasonal gouges may be abundant, but can be smoothed over by the waves and currents of a single summer. Gouges observed at depths greater than 50 to 70 m are older than those at shallower depths because rates of bottom smoothing are lower, and also because ice with more than about 50 m draft has not been observed. In shallower water where currents are strong, the flow around grounded ice is intensified and turbulent, producing current-scour depressions at the contact between the ice and the bottom of the Beaufort Sea.

The force required to produce a 2-foot (0.6 m) deep gouge in silt-clay size sediment, having a cross-sectional area of 100 feet was calculated by Kovacs and Mellor (1974) to be anywhere from 1.5 x 10^5 to 5 x 10^5 lb/ft. In addition, they conclude that almost any type of ice keel has sufficient structural strength to gouge wide or deep gouges in soft sediments; that first year ice can transmit the required thrust to either isolated ice messes or wide pressure ridges; and that the required forces can be generated by wind blowing over moderate expanses of ice (Kovacs and Mellor, 1974).

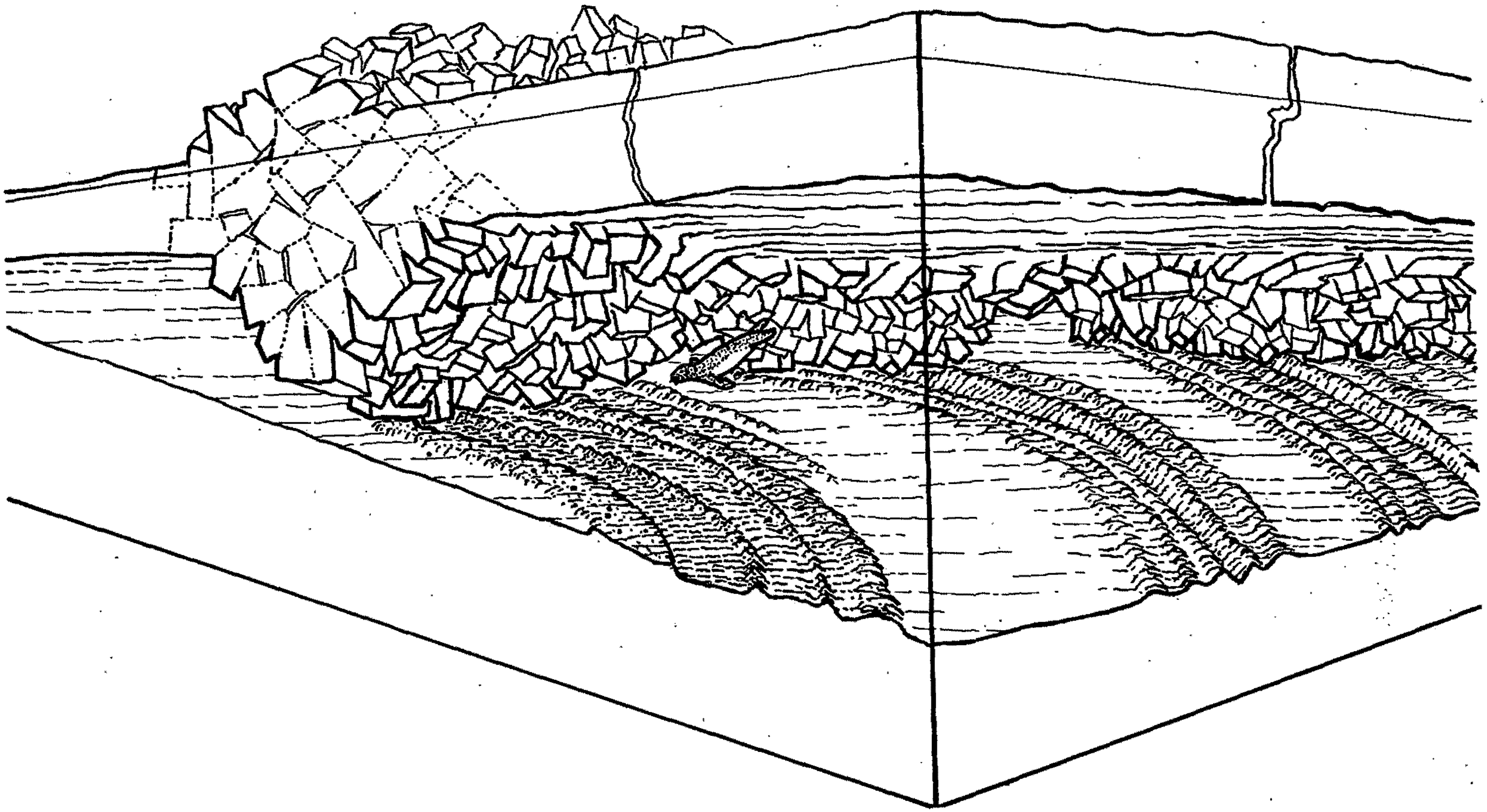

Figure 8.1.1.1-2 Ice scour dynamics

Table 8.1.1.1-1 Ice scouring on the Beaufort Sea shelf

Coastal Shelf Zone (less than 6 m deep):

Scouring in this zone by fragments of broken-up ice islands or other small pieces of ice may be very frequent. However, the resulting microrelief is shallow (less than 0.5 m). Any scouring is soon smoothed by wave action and local currents.

Mid Shelf Zone (between 6 to 45 m deep):

Considerable scouring by the grounding of ice islands and/or pressure ridge keels which mixes the surface sediments to a depth of perhaps 1.2 - 1.5 m, depending upon local sediments, destroying stratification, and oxygenating the sediments. The frequency of scours is about 10 to 15 km/mile, and the depth of a scour tends to be less than 1.5 m but on occasion reaches 3 to 4 m.

Outer Shelf Zone (between 30 and 80 m):

Scouring between 30 and 45 m depths is relict or caused by ice islands. Scour widths to 30 - 60 m, lengths up to 3 - 5 kms, and scour relief to 10 m have been reported. Scouring decreases very quickly beyond the 40 m depth, and little or no scouring is found beyond the 70 m depth.

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* From Namtvedt, et al. 1974.

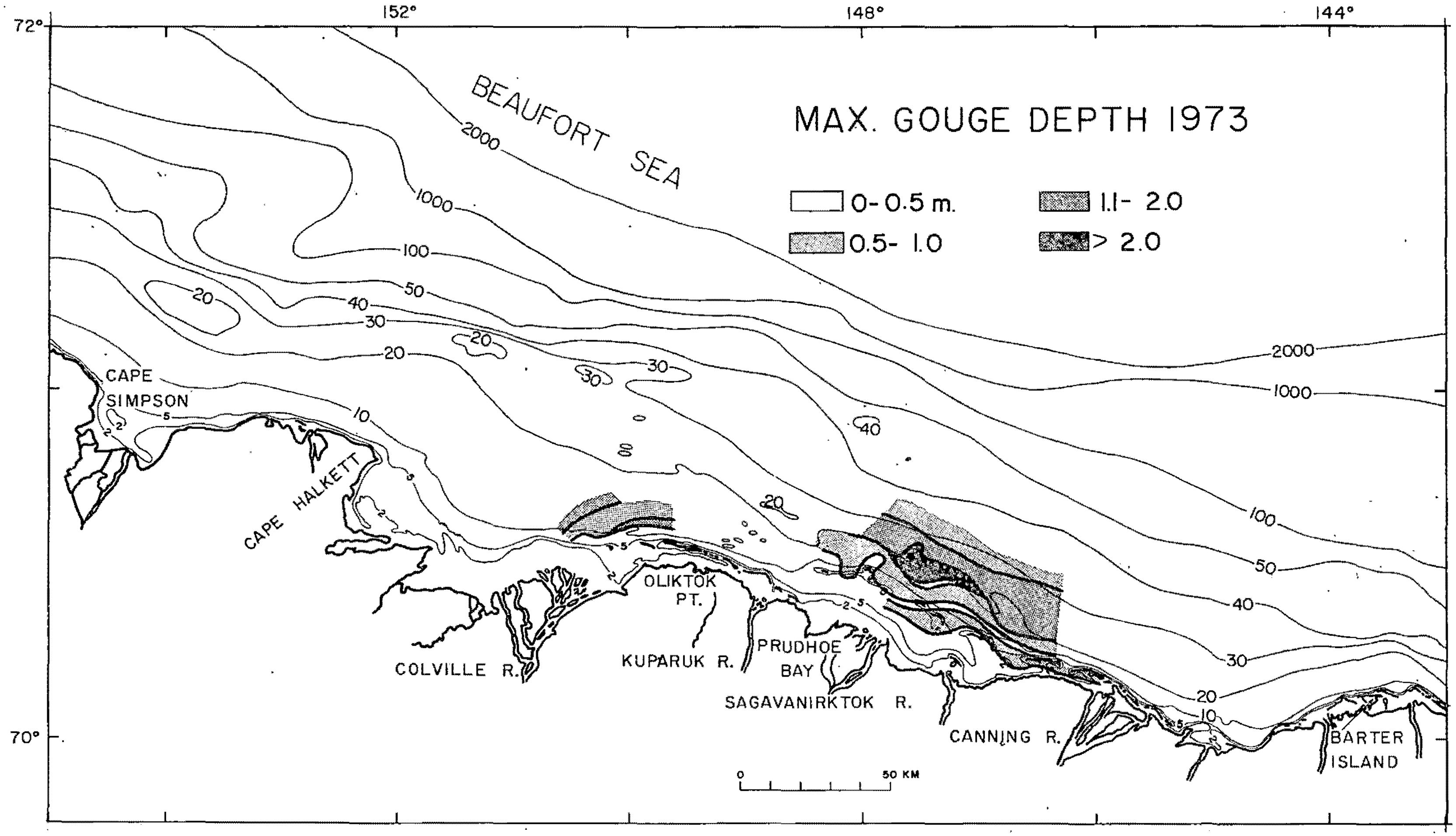


Figure 8.1.1.1-3 Maximum gouge depths (depths of incision), from 1973 surveys

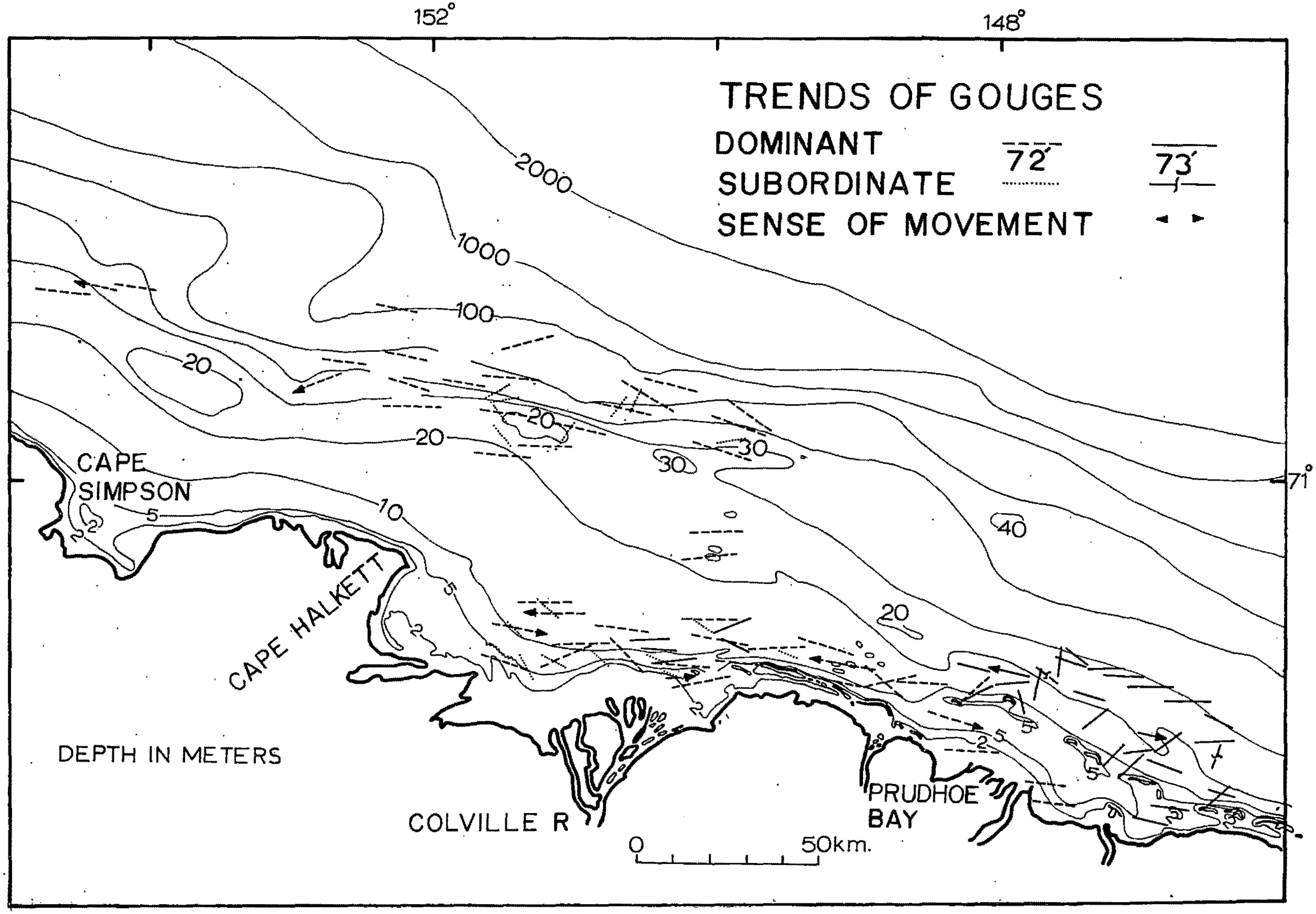


Figure 8.1.1.1-4 Dominant and subordinate trends of gouges for 2 survey years combined

Ice-gouging is active on the beaches and near shore during the winter, forming ice-push ridges on many beaches (Hume and Schalk, 1964, and Leffingwell, 1919). Time lapse photographs of the seaward beach of a barrier island indicate that ice is also active throughout the summer. Drift ice commonly arrives and grounds in the near shore zone, furrowing the bottom and restricting wave and current action. Ice gouge data from the inner shelf show trends parallel to the coast, with westward and eastward components that might relate to the dominant westerly flow and the occasional summer storm winds from the west.

Ice push ridges, a common feature of arctic beaches, are indications of ice thrusting. These have been noted at Barrow (MacCarthy, 1953; Rex, 1964; Hume and Schalk, 1964), as well as along the shore of the Beaufort Sea (Leffingwell, 1919). Evidence of extensive ice override is in the form of piles of gravel and driftwood left on the backshore. Rarely are these more than 100 feet (30 m) from the shore (Leffingwell, 1919).

Barrier islands buffer coastal beaches from pack ice in winter. Although some pressure ridges form within the fast ice zone and affect the nearshore bottom, the most frequent and strongest ridges form outside the barrier island screen (Reimnitz and Barnes, 1974).

The en echelon bars just seaward of the barrier islands act as a primary defense system, partly protecting the islands against ice attack. Ice ridges tend to form over and apparently fasten on the bars, blocking ice movement (Short et al, 1974).

Ice may mount beaches in unprotected areas, or during warmer weather when nearshore ice is free to move. Ice sheets ride up on shore until resistance halts movement. Piles of ice may form as one ice sheet follows another. Ice has been reported to override the beach to the extent of 15 to 20 feet during calm weather in the summer (Leffingwell, 1919).

Topography

Topography of the initial 64 miles of the Offshore alternative pipeline route (which is onshore) crosses the Arctic Coastal Plain. This is described in Section 2.1.1.2.

The remaining 141 miles of this route are on the Continental Shelf in the Beaufort Sea which extends about 50 miles off the North Alaskan coast before dropping rapidly into the Canadian Basin, a 12,000 feet deep basin noted for its featureless plain and table-top flatness. The Beaufort Sea shelf, while quite narrow compared to the Continental Shelf areas of other arctic seas, generally is characterized by very shallow depths.

Geology

The geology of land locations associated with the Offshore route is described in Section 2.1.1.3 and generally is similar to that discussed for the applied-for route from Prudhoe Bay to the Canning River. The major difference in the Offshore routing is that only the Arctic Coastal Plain is directly involved.

Seismicity is the same as that described for the applied-for AAGPC pipeline route.

The general geology of the Beaufort Sea bottom is not well known.

There is no information on the pre-Holocene geology of the shelf in the region of the Offshore alternate route. Quaternary deposits of the Gubik Formation, which underlies the coastal plain, are exposed in coastal bluffs. These materials consist of unconsolidated mud, sand, and gravel, with increasing numbers of boulders from Flaxman Island eastward. These boulders are referred to as the "Flaxman Boulders," and apparently have been rafted by ice from a source area east of the Mackenzie Delta during the Late Pleistocene (Rodeick, 1974). Thus, part of the Gubik Formation along the coast represents shallow water marine sediments, but these are apparently interbedded with terrestrial materials.

The shelf is essentially a seaward extension of the low relief coastal plain, and therefore, probably is underlain by materials similar to those exposed in the coastal bluffs. There apparently are no outcrops of bedrock in the shelf area under consideration.

Lithologic and/or Bedrock

The sediment distribution on the Continental Shelf has been described by Carsola (1954) and Barnes and Reimnitz (1974). Surface sediments generally range from fine mud through sand, but occasionally gravel and boulders are found (Figure 8.1.1.1-5). Most of the finer-than-gravel deposits were laid down since the last glaciation. They have been supplied by rivers and by coastal erosion, with ice rafting apparently playing an insignificant role in the modern environment. Concentrations of gravel are found mainly along the shelf break, with values ranging as high as 60 percent (Barnes and Reimnitz, 1974). This gravel apparently represents a thin deposit of relict ice-rafted material.

Deposits along the Beaufort Sea shelf are dominantly coarse silt (32 percent) and sand (36 percent). Fine silt and clay comprise 23 percent, while gravel makes up 9 percent. Decomposable organic material is low: 0.05 to 1.5 percent by weight (Carsola, 1954).

From various types of data collected on the shelf between Flaxman Island and Cape Halkett to the west, it is known that the Holocene marine sediments are only 5 to 10 m thick, and that in many areas, older sediments crop out (Reimnitz et al, 1972 and 1974; Reimnitz and Barnes, 1974).

The Holocene marine sediments are not significantly thicker near river mouths and in lagoons.

From extensive sampling operations using various types of gravity coring devices, it is known that the surficial deposits are extremely difficult to penetrate. Maximum core length generally has been 30 to 40 cm. Since regional slopes on the shelf are very low, these materials are not subject to large scale slumping. Microrelief features in the form of ice gouges on the open shelf (Reimnitz and Barnes, 1974) and strudel scours in the vicinity of deltas (Reimnitz et al, 1974), however, have steep slopes that are subject to small-scale slumping and sliding.

Coastal Slumping and Subsidence

The 2- to 10-m high coastal bluffs show much evidence of slumping and mass wasting. This activity is largely restricted to the ice-free summer season, when the combined effects of relatively warm sea water and wave activity undercut the frozen sediments exposed in the bluffs, and the erosional products are removed by waves and currents. Undercutting and mass

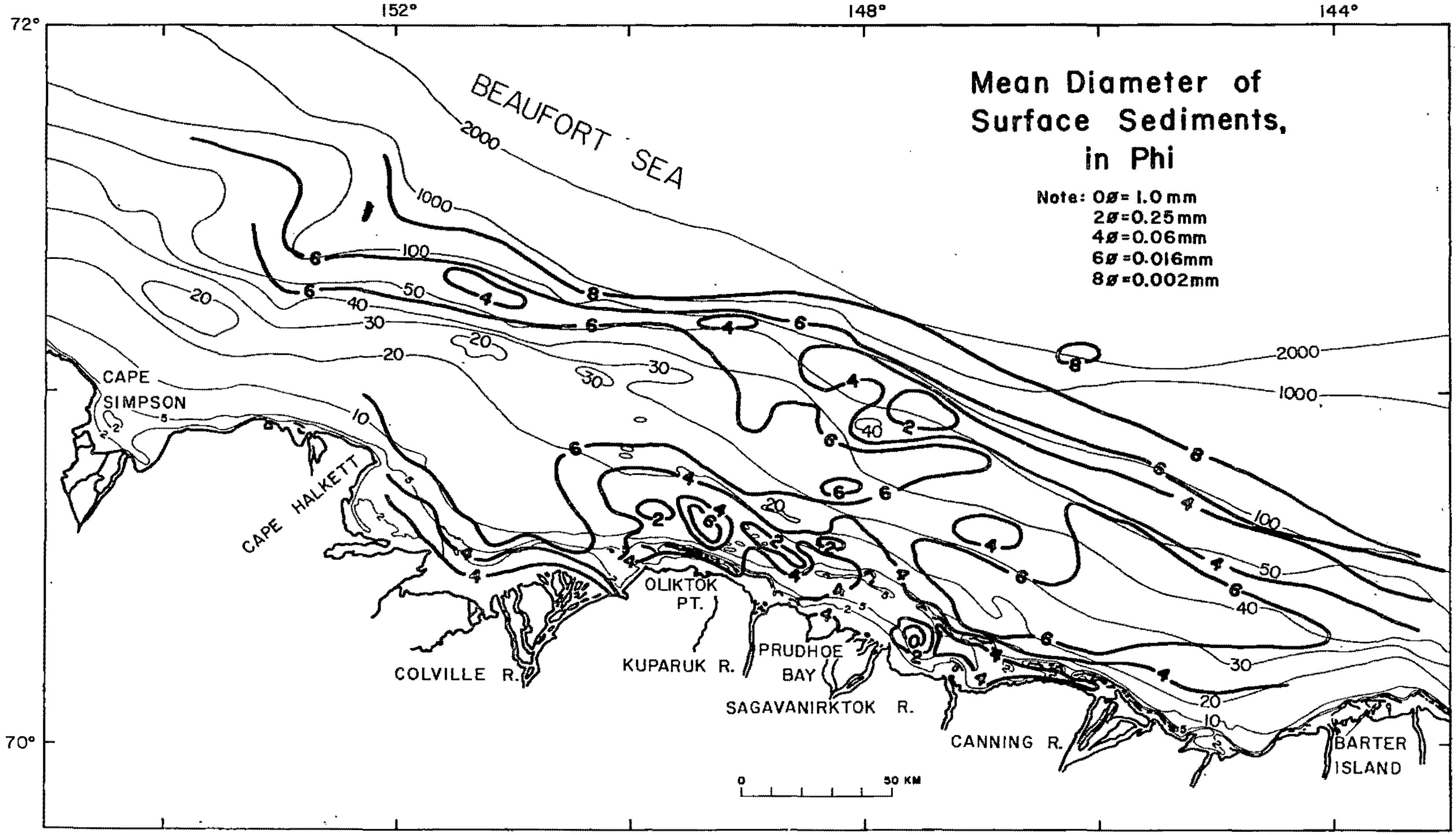


Figure 8.1.1.1-5 Texture of the surface sediments expressed in terms of mean diameted determined by the Folk and Ward method bathymetry in meters

wasting are most pronounced during times of strong westerly winds and associated sea level setup.

Coastal Erosion and Deposition

Coastline erosion, through the processes of wave and thermokarst activity, is common along the proposed offshore corridor. Leffingwell (1919) reported possible shoreline recession rates of 9 m per year between Flaxman Island and Brownlow Point. In a review of coastline erosion rates elsewhere on the Arctic Coast, Lewellen (1970) documented erosion rates up to more than 30 m per year. On the east end of Pingok Island, Wiseman et al. (1973) report that the low tundra bluffs retreated as much as 50 meters during a 3-week period in 1972.

Marine Erosion and Deposition

The nearshore bars and barrier islands to the west of the Offshore route is known to alter position in response to winds and currents (Wiseman et al, 1973). Bar migration was noted to average 70 meters per year, with migration apparently influenced by occasional storms. Barrier islands are apparently migrating to the west at 6 to 190 m/year. Similar rapid changes in nearshore morphology are known to occur around the inlets between the barrier islands (Wiseman et al, 1973).

Ice formation has protective aspects. Winter ice cover prevents wave action, and ice is less destructive than wave erosion. Ice may build up beaches by pushing or rafting sediment (Rex, 1964).

In nearshore areas off river deltas, overflow draining through the sea ice canopy creates strudel depressions in the seabed up to least 20 m in diameter and 4.5 deep (Figure 2.1.1.3-4) (Reimnitz et al, 1974). In the same area, however, little deltic deposition has been noted off any of the Alaskan arctic deltas.

Ice sediment interaction is the prime method of sediment reworking from about 4 m seaward. Ice plows and resuspends sedimentary material. (See prior discussion on ice gouging.)

Permafrost

The character of subsea permafrost and its ice contact associated with the Offshore alternate route or elsewhere along the Arctic Slope of Alaska is poorly understood. Certain observations and theoretical considerations are apparent, however.

The mean annual temperature on the land surface near the Arctic Coast is -7° to 10° C, and up until a century ago, it was lower by 2° or 3° C (Lachenbruch and Brewer, 1959; Lachenbruch et al., 1962; Lachenbruch and Marshall, 1969). The mean annual temperature of the shallow seabed, where ice does not rest on the bottom, is probably -1° to +0.8° C (Gold and Lachenbruch, 1973). Under steady conditions at a point a few kilometers offshore, a steady sea bottom temperature of -15° C would result in negative temperatures to a depth of 50 to 100 m, depending on the thermal conductivity.

Some permafrost in the Beaufort Sea bottom is merely land permafrost where the land has either eroded back or where sea levels have risen.

According to Mackay (1972), a site now covered by 50 feet of water on the Beaufort Shelf would have been dry land 60,000 years ago as a result of the large volumes of water locked up as ice in continental glaciers. Approximately 8,000 years ago these large continental glaciers started to melt and the level of the Beaufort Sea and worldwide sea levels rose. Therefore, such a site would have been exposed to arctic conditions as dry land for approximately 50,000 years. During that interval, permafrost could have grown to a depth of 500 to 1,000 feet, or more.

This amount of permafrost could take only a few thousand years to melt if the ice content of the permafrost were low (Lachenbruch 1957a), but several tens of thousands of years, if ice content were high.

In both cases the permafrost would thin from below. For the high-ice content case; the gradient in the permafrost would fall rapidly, and heat transfer at the sea floor would soon become unimportant. Heat entering from below could melt about 1/2 cm of solid ice per year. If the ice content were 40 percent by volume, as it probably is near Prudhoe Bay today (Gold and Lachenbruch 1973), permafrost would thin from below at a rate of about 1 cm/year. Thus, 20,000 years after transgression, the sea would, in this case, be underlain by 400 m of ice-rich permafrost. The transition of permafrost thickness from the offshore to onshore conditions and near islands and shoals is easily estimated by theoretical or numerical techniques, once the basic information on ice content and surface temperature is available (Lachenbruch 1957a, 1957b; Lachenbruch et al, 1966).

Thermoprobe measurements indicate that bottom sediment temperatures commonly are below 0° C on the inner shelf (Lewellen 1973; U.S Geol. Survey, unpublished data). As expected, the sediment temperatures landward of the 2-m depth contour, where seasonal ice rests on the bottom and can conduct heat away, are generally lower than temperatures measured in deeper water. Similarly, bottom temperatures might be expected to be lower on topographic highs or other areas where ice remains grounded for a considerable length of time. To date, however, no physically frozen sediment has been encountered off arctic Alaska. Ice has been recovered in the bed of the Beaufort Sea during Canadian studies in the Mackenzie embayment (Mackay, 1972). In the area of the Offshore route, extensive river icing commonly develops behind Icy Reef in response to icing on the delta of the Kangakut River, and remains all summer. This phenomenon must have a pronounced effect on the thermal regime.

Soils

Soils associated with onshore facilities (including the first 64 miles of pipeline) are similar to those described for the Arctic Coastal Plain in Section 2.1.1.4. Physical conditions and vegetational relationships are listed in Table 8.1.1.1-2 and distribution of these soils along the shoreline segment of the route are shown on Figure 8.1.1.1-6.

Sediments in the bed of the Beaufort Sea included under unit No. 3 of Figure 8.1.1.1-5 were described under geology in this section.

Water Resources

Water resources associated with the Offshore alternate pipeline route are similar to those described in 2.1.1.5 with three major exceptions: only 16 streams are involved; more estuarine areas are involved; and no spring areas are close.

Table 8.1.1.1-2 GENERALIZED SOILS INFORMATION ALONG THE

Soil Units	Miles	Land Position	Thickness Organic Mat	Depth to Permafrost	Dominant Texture USDA - Unified	Underlying Material
1A	10	Coastal Plain	<8"	12"	0"-60"sil ML	ML
1B	9	Coastal Plain Low Terraces	8"-16"	12"	0"-60"sil ML	ML
1C	7	Low Broad Kones Convex Slopes	8"-16"	10"-24"	0"-60"sil ML	ML
1D	3	Low Terraces & Ridges	<8"	Deep	0"-60"vgs GP, GM	GP
1E	3	Shallow Basins & Lake Borders	>16"	12"	0"-24" pt PT	PT
1F	2	Floodplains	<8"	10"	0"-60"vgr GP	GP
1G	1	Low Dunes	<4"	18"-30"	S SP	SP
2A	19	Floodplains Low Terraces	<4"	15"-30"	0"-60"vgl GP	GP
2B	4	Low Terraces	<4"	Deep	0"-60" vg GP	GP
2C	3	Floodplains Low Terraces	<4"	20"	0"-40" 1 ML 40"vgs GP	GP
2D	3	Floodplains & Swales	<4"	10"-30"	0"-60" s SP	SP

USDA Texture

cl - clay loam
l - loam
pt - peat
s - sand
sil - silt loam
vgl - very gravelly loam
vgr - very gravelly sand

Unified Group Symbols

CL - Lean clays - gravelly, sandy, or silty
GM - Mixed gravels, sands or silts
GP - Gravels - gravel and sand mixture
GW - Graded gravels - gravel and sand mixtures
ML - Silts and very fine sands - silty, clayey fine sands or clayey silts
PT - Peat
SM - Silty sands - sand-silt mixtures
SP - Poorly graded sandy, gravelly sands, little or no fines

OFFSHORE ALTERNATIVE PIPELINE ROUTE.

Drainage Class	Flooding	Frost Action	Reaction Class	Permeability	Slope
Poorly drained	None	High	non-acid to calcareous	Moderate	0-3
Poorly drained	None	High	non-acid to calcareous	Moderate	0-3
Poorly drained	None	High	calcareous	Moderate	0-7
Well drained	Moderate	Low	non-acid to calcareous	Rapid	0-7
Poorly drained	Moderate	High	strongly acid	Moderate	0-3
Poorly drained	High	Moderate	calcareous	Rapid	0-3
Well drained	Low	Moderate	non-acid to calcareous	Rapid	0-7
Poorly drained	High	Moderate	non-acid to calcareous	Rapid	0-3
Well drained	Moderate	Low	non-acid to calcareous	Rapid	0-3
Poorly drained	High	High	non-acid calcareous	Rapid	0-3
Poorly drained	Moderate	Moderate	non-acid to calcareous	Moderate	0-3

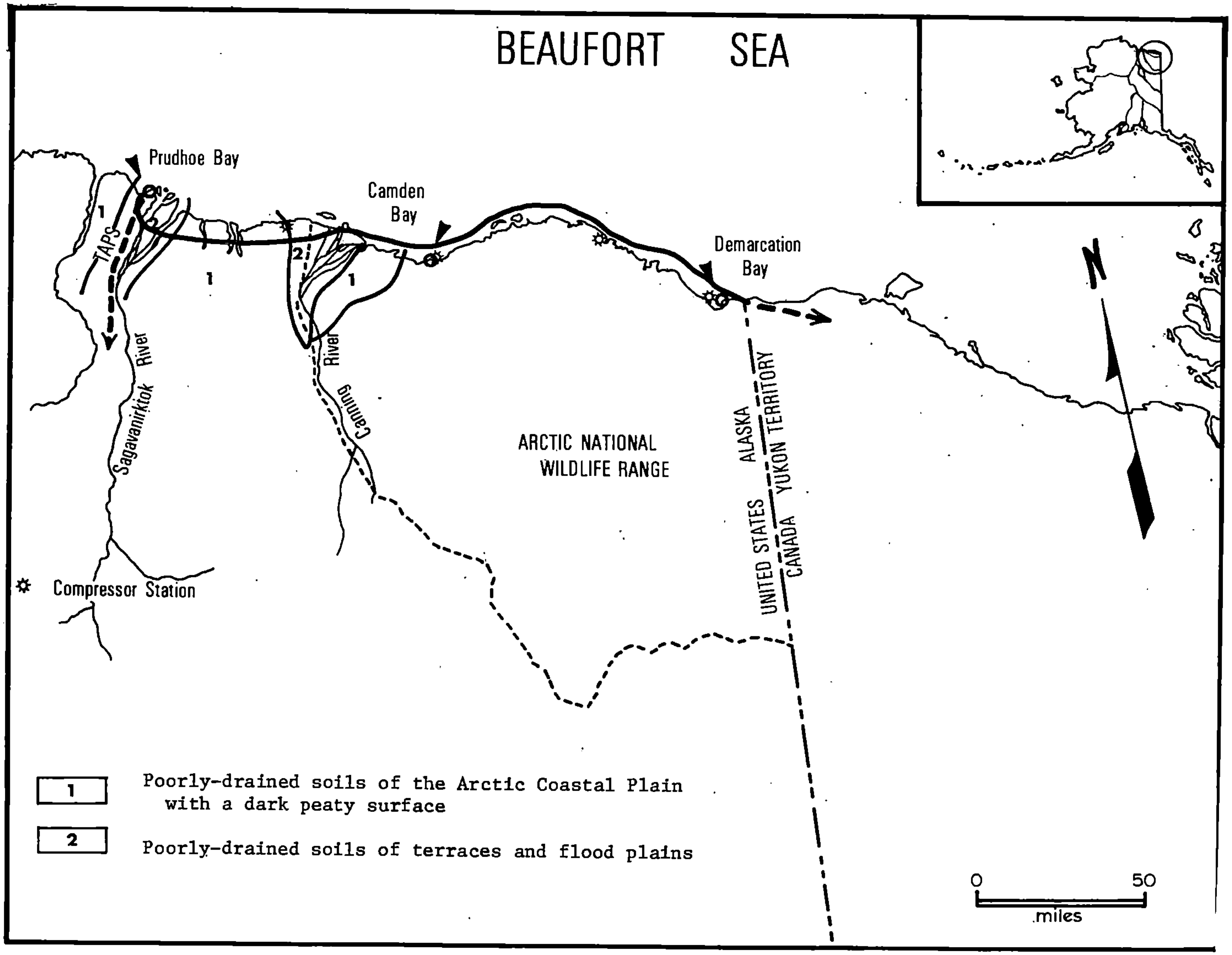


Figure 8.1.1.1-6 Soils of the offshore alternative pipeline route

The major streams crossed by this route are the Sagavanirktok, Kadleroshilik, and Shaviovik Rivers. The route proceeds offshore in the vicinity of the Starner River. Generally, stream and river crossings are closer to the coast than those along the AAGPC applied-for route. No rivers or streams in the Arctic National Wildlife Range are involved in the Offshore alternative route.

Marine segments of the Offshore alternative involve construction and/or operation of facilities in four estuarine areas in Alaska where the pipe first enters the Beaufort Sea and at the three compressor station sites along the coast in the Arctic National Wildlife Range. (A fifth estuarine pipeline area is involved in Canada where the pipeline last returns to shore.) In addition, port facilities will be used at Prudhoe Bay while three new port areas (Compressor Station 2, in the vicinity of Kaktovik, and at Demarcation Bay) will be built. Compressor Station sites 3 and 4 are located in places where barrier islands and shallow lagoons restrict access by ships or barges.

Vegetation

Vegetation associated with the land portion of the Offshore alternate pipeline route (Figure 8.1.1.1-7) is similar to that described for the Arctic Coastal Plain, Section 2.1.1.6.

Wildlife

Wildlife populations and distributions associated with the Offshore alternate route are the same as those described for the Arctic Coastal Plain and marine environment in Section 2.1.1.7 for the applied-for AAGPC Pipeline route.

Fish

According to the impact statement on oil and gas leasing in the Beaufort Sea (Alaska Div. of Policy Development and Planning, 1975), knowledge of marine fish in the Beaufort Sea is extremely limited. The following discussion reflects information assembled in that report and is limited to species found in the nearshore habitats, particularly the waters inside barrier islands.

Species known to be abundant in these areas are arctic cisco, least cisco, broad whitefish, humpback whitefish, arctic char, fourhorn sculpin, and arctic flounder.

The presence of some species, such as arctic cod, can only be inferred from the fact that ringed seals depend on this species during winter in other areas, and that ringed seals are present here. Because such species are the main food items of some seabirds and certain marine mammals the State of Alaska assumes that they are present, at least locally, in large numbers. However, almost nothing concerning growth rates, fecundity, size of stocks, or frequency of breeding by adults is known (Alaska Div. of Policy Development and Planning, 1975).

Arctic fish may occur in large numbers locally, particularly the pelagic species in association with plankton blooms. Sea birds near Cape Thompson may consume 13,000 metric tons of arctic cod and sand lance per day (Swartz, 1966). These fish are important foods, therefore, for birds, marine mammals, and other fish, and a staple part of the winter diet of ribbon seals (Alaska Div. of Policy Development and Planning, 1975).

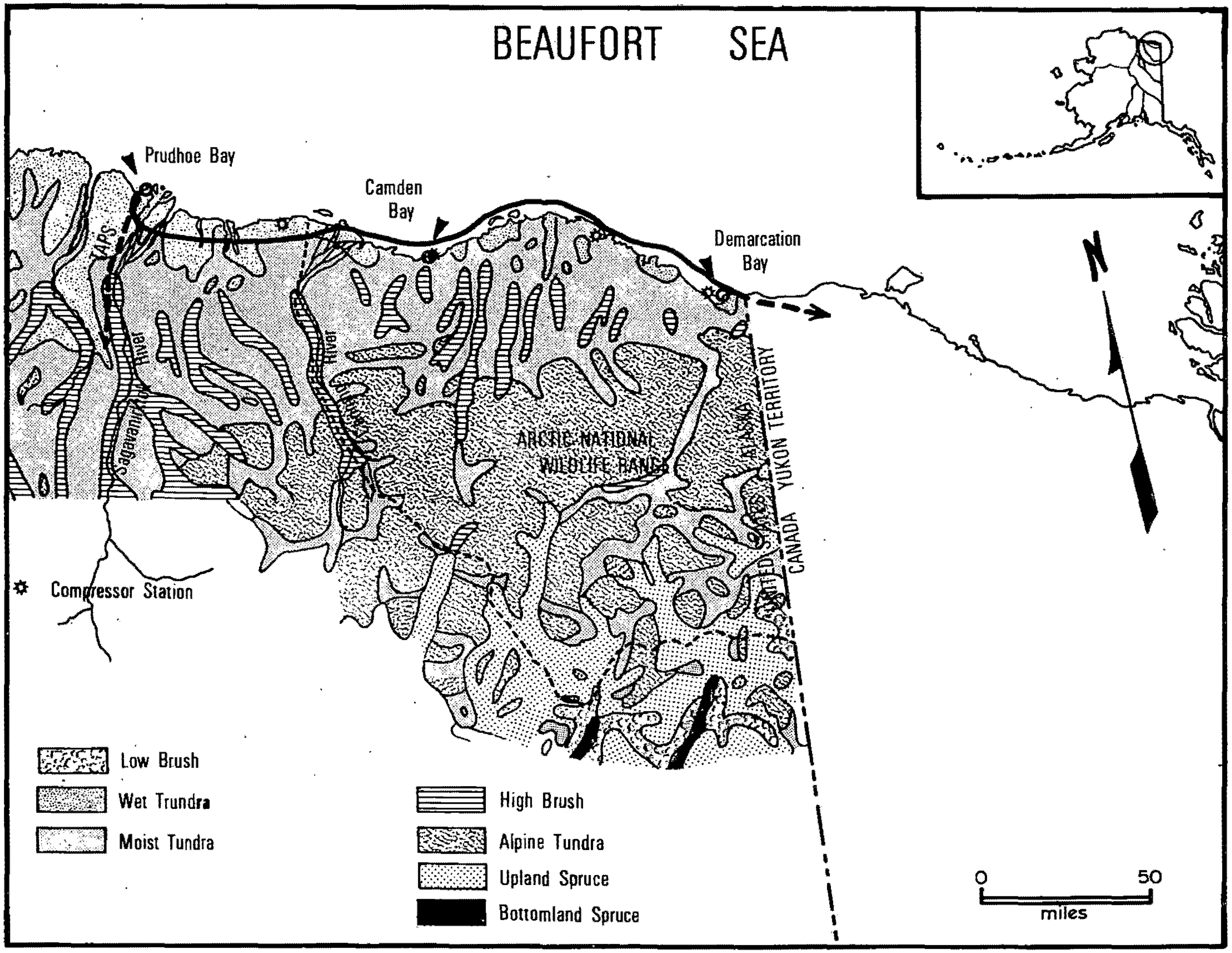


Figure 8.1.1.1-7 Vegetation of the offshore alternative pipeline route

Factors influencing the diversity and distribution of fish in the Arctic include freezing and other temperature problems and physiological stress associated with variable salinities. Many of the fish are essentially quiescent in winter and migrate from freshwater areas to feed in the brackish coastal lagoons in spring and summer. Migrating species able to withstand severe temperature, oxygen and salinity changes and stresses are therefore most conspicuous (Namtvedt, 1974).

The State Div. of Policy Development and Planning (1975) considered two distinct marine habitat areas for fish: unprotected coastal areas and nearshore areas (between the barrier islands and the coast line).

Nearshore marine fish habitat areas consist of a narrow band of water isolated from the sea environment by a network of barrier islands lying close to the mainland coast. The input of freshwater by large rivers emptying into the area inside the barrier islands has a major influence on the aquatic environment and faunal life (Alaska Div. of Policy Development and Planning, 1975).

The lagoon areas are shallow and of low salinity (1 to 25 parts per thousand) according to Roguski and Komarck (1972), Crane and Cooney (1974). Much of the area is less than 6 meters deep and ice is frozen to the bottom for most of the year. As ice forms it restricts water circulation, creating troughs and pockets of hypersaline water, less than zero degrees centigrade and probably deficient in oxygen. Ice scouring is prevalent in the shallow areas. Due to these factors, invertebrate, infaunal populations are prevented from establishing in shallow waters though mobile epifaunal species do move into these areas during the summer, providing forage for large numbers of fish.

Fish distribution, particularly of anadromous species, is strongly influenced by the presence of ice. In winter, freshwater species are confined to river deltas and spring areas when ice forms to a depth of 6 feet, essentially excluding them from the inshore habitat. Since inshore and offshore areas freeze to the bottom, except for small pockets of hypersaline water, fish present in these areas must possess exceptional tolerances to freezing and high salinities (Alaska Div. of Policy Development and Planning, 1975).

Critical fisheries habitat along the coast of the Beaufort Sea consist of areas important for: overwintering, spawning, rearing, feeding, and migration. Due to lack of fisheries research in the Beaufort Sea, only fragmentary knowledge about these areas is available. All five types of habitat are critically important to fish during stages of life histories. An ability to identify areas and periods critical to fish populations is necessary to provide adequate protection of stocks during petroleum development (Alaska Div. of Policy Development and Planning, 1975).

It is likely the large river deltas, which remain unfrozen during the winter, are principal overwintering areas for near shore species (Ward and Craig, 1974). Of course, marine fish spend the winter in deeper areas, under ice, beyond the barrier islands. Most fish probably move to their overwintering sites by mid-September and remain until spring breakup around the first of June (Alaska Div. of Policy Development and Planning, 1975).

Near shore beach areas are important spawning areas for some marine fish. Capelin have spawned on the beach at Point Barrow. Arctic cod spawn near shore, under the ice, probably from December to January. Fourhorned sculpin probably spawn near shore in late summer. Most species present, particularly anadromous species, migrate to specific limited spawning habitats which have suitable waterflow, temperature, and oxygen characteristics in winter. Freshwater and perhaps marine fish do not generally spawn until an advanced age and then may only spawn every other year or even less frequently. It is, therefore, possible to influence fish production in any given year by disrupting the spawning migration of only a few individuals (Alaska Div. of Policy Development and Planning, 1975).

During June-September the near shore areas of the Beaufort Sea are an important feeding area for broad and humpback whitefish, least and arctic cisco, arctic char, arctic cod, and fourhorned sculpin (Alaska Div. of Policy Development and Planning, 1975).

The entire Beaufort Sea coast from Barrow to Barter Island is a major migration path for arctic char (Alaska Div. of Policy Development and Planning, 1975). Char produced and tagged in the Sagavanirktok River migrate along the coast beginning in early June and ending in September (Yoshihara, 1973). Tag recoveries have been made at Point Barrow, Barter Island, and locations in between (Furniss, 1973 and unpublished).

The inshore area of Prudhoe Bay is an important migration path for whitefish and cisco (Furniss, 1974). Similar migrations have been observed by Mann (1974), and Craig and Mann (1974).

Ecological Considerations

Terrestrial and freshwater ecological factors are considered identical to those discussed for the proposed AAGPC Pipeline route in Section 2.1.1.8.

Marine Ecosystems

Arctic marine ecosystems have been variously described in terms of stability, diversity, and niche saturation (Dunbar, 1968). According to the State Div. of Policy Development and Planning (1975) the most widely accepted thesis is that polar ecosystems are representative of youthful development and are consequently lower in diversity than warmer marine environments. Northern systems are generally characterized by seasonal productivity and food availability, slow growth, numerical dominance by a few species, and relatively simple food webs. Such systems are regulated primarily by temporal oscillations in the physical environment, whereas biological interactions (e.g., competition, predation) are considered more significant in the maintenance of niche-saturated tropical ecosystems (Alaska Div. of Policy Development and Planning, 1975).

Arctic marine ecosystems also are generally considered to be inherently more fragile and susceptible to alteration by extreme environmental perturbation, either natural or man-imposed, in comparison to the relatively well established ecosystems in southern latitudes. Slow growth rates and resultant long recovery periods are typical of arctic marine ecosystems.

Given an everchanging combination of various parameters, most importantly, incident radiation, nutrient ions, grazing pressure, and depth of the photic zone, the phytoplankton seasonally undergo periods of net increase and decrease in production. This cycle in turn dictates oscillations in the directly dependent communities, specifically the zooplankton, in which the period of maximum standing stock lags 1 to 3 weeks. Arctic phytoplankton stocks are rarely regulated by predation (grazing) pressure from the primary consumers (zooplankton): rather, their population dynamics are usually controlled by available light and nutrients (Alaska Div. of Policy Development and Planning, 1975).

Redburn (1974) described the inshore zooplankton community at Barrow. He found that copepods were the major constituents of the community with hydromedusae, chaetognaths, and barnacle larvae as additional summer constituents (Alaska Div. of Policy Development and Planning, 1975). The benthic microalgae is restricted to the sublittoral zone of the sea bottom having sufficient solar energy for photosynthesis. Matheke (1973) measured the primary productivity of the benthic microalgae in the sublittoral zone near Barrow and estimated an average daylight rate during July-August of 26.7 mg C/m^2hr. This represents an annual production of about 50 g C/m^2. No such data are available from the lagoons near Prudhoe Bay. The State of Alaska Div. of Policy Development and Planning (1975) extrapolated the data from Barrow and estimated that benthic algae contribute over 60 percent of total annual primary production in near shore areas in the vicinity of Prudhoe Bay not severely ice stressed, with phytoplankton roughly 30 percent and ice algae 10 percent of the total carbon.

Little is known about the distribution of seaweeds in the Prudhoe Bay area.

The zooplankton are the major consumers in the pelagic ecosystem and are a large potential energy pool to fish, seals, and whales.

Dunbar (1940) pointed out the phenomenon of polyphasic, or alternating, breeding cycles for many species of zooplankton in the high Arctic. The simultaneous presence of three distinct size classes or broods in the plankton for these species is taken to indicate a 2-year cycle. This prolongation of the life cycle is due to the very short biological season in the high Arctic and results in low productivity. The life cycles of holoplanktonic species in seasonally ice-free coastal waters often appear to be intermediate between 1 and 2 years; this fact, coupled with the larger metroplanktonic component, allows for much higher productivity in coastal waters (Redburn, 1974).

Zooplankton (secondary) production in arctic neritic waters is comparable to that in temperate areas during select periods of the year, but is generally less productive on an annual basis (Alaska Div. of Policy Development and Planning, 1975).

Marine mammals such as the bowhead or other baleen whales feed almost exclusively on zooplankton during their spring-summer migration through arctic waters. Amphipods and shrimps constitute a significant portion of the diet of the ringed seal in shallow Beaufort Sea waters (Burns and Morrow, 1973). Pelagic fish, such as the larval and juvenile arctic cod, feed intensively on the zooplankton (Alaska Div. of Policy Development and Planning, 1975).

The feeding ecology of sea birds along the Beaufort Sea coast has been documented by Watson and Divoky (1974). They found juvenile arctic char, euphausiids, amphipods, and mysids to be major food items for surface-feeding birds, e.g., phalaropes, gulls, kittiwakes, and alcids. Benthic crustaceans and molluscs are preferred by the diving birds, including ducks. In this manner, sea birds link terrestrial and marine ecosystems, especially during breeding seasons when food requirements are high. At the ice edge there often occurs a diverse and productive assemblage of organisms, from the phytoplankton up through the marine mammals (Alaska Div. of Policy Development and Planning, 1975).

The majority of the isopod population probably breeds inshore, with some recruitment into the lagoons during the summer from deeper waters not subject to ice stress (Crane, 1974). Isopods in the shallow lagoons survive the winter by occupying hypersaline pools under the ice or by lowering the freezing point of the blood below that of the water/sediment they are frozen into (Alaska Div. of Policy Development and Planning, 1975).

The Alaska Div. of Policy Development and Planning (1975) in its draft environmental assessment of proposed petroleum leasing in the near shore Beaufort Sea concluded the benthic infauna standing stock across the entire continental shelf and upper slope of the western Beaufort Sea is as high as, if not higher than, that found in productive temperate regions.

The zoobenthos provide an important source of food for many varieties of bottom-feeding animals. Many species of diving birds extensively utilize benthic crustaceans and molluscs during the ice-free season (Watson and Divoky, 1974). Demersal fish or the cod family ingest polychaetes as well as small crabs and clams. Isopods, amphipods, and mysids are major food items for several bottom-feeding fish present in Prudhoe Bay during the summer season (Furniss, personal communication in Alaska Div. of Policy Development and Planning, 1975).

The ringed seal appears to have a diet that varies with the season (Burns, personal communication, 1975). Stomach analyses have shown high quantities of young demersal fish, such as cod, during the fall and winter. Invertebrates such as amphipods, shrimp (*Pandalus borealis*), small crabs, and other small bottom fauna have been reported to constitute from 62 to 84 percent of food items in the ringed seal stomach during May and June in the Chukchi Sea.

The microbial community of most marine waters has been either neglected or insufficiently treated in establishing an environmental baseline perspective. This is especially true in arctic regions (Alaska Div. of Policy Development and Planning, 1975).

The marine bacteria reside in both the water column and sediments, with largest concentrations generally found to be directly proportional to particulate organic matter concentrations. Terrestrially introduced bacteria may be important constituents in the nearshore environment. They are the primary group responsible for nutrient recycling, enzymatically breaking down organic compounds to the nutrient ions necessary for phytoplankton nutrition and growth. In poorly mixed waters, bacterial populations can create oxygen deficiencies that can severely stress and even kill benthic fauna and fish (Alaska Div. of Policy Development and Planning, 1975).

Economics

The economics of constructing the Offshore alternate pipeline system are assumed to be somewhat similar to those described for the applied-for route by AAGPC (Section 2.1.1.9). There may be significant differences, however, in that the construction of the marine segments will require two summer construction seasons and the onshore facilities will require a single winter season. Also, there would be more direct activity in Kaktovik associated with the Offshore route.

Sociological Factors

Because of the longer construction period with at least one complete year associated with the Offshore alternative, there will be different sociological factors than those described for the applied-for route of AAGPC (see 2.1.1.10). These factors are directly dependent upon the duration of the employment and number of workers involved.

Land Use

Land uses for the Offshore alternative route (Figure 8.1.1.1-8) would be similar to those described for the applied-for route in Section 2.1.1.11, except that changing uses would be concentrated along the Beaufort Sea Coast in Alaska between Prudhoe Bay and the United States-Canada border.

Historic and Archeological Areas

The following information is extracted from Iroquois Institute (1975).

Paleoenvironmental Settings

Paleoentological and geologic evidence indicate that throughout Pleistocene and recent time this area has had a continuously arctic climate with fluctuations to both slightly warmer and much colder than at present. An east-west, ice-free land corridor has always remained open for human migration and occupation in this area, and there are known archeological sites in the area.

Within the marine sector of the segment, such archeological sites as may exist in the shallow waters on the continental shelf have had significant chance of having been disturbed or obliterated by ice scour and gouging since having been covered by the sea. The same fate may have been suffered by some sites on present-day beaches that are subject to periodic scour from grounding sea ice.

Climatic factors probably have limited the density of human occupations and greatly diminished the probability of their evidence being discovered intact. Nevertheless, because of the strategic location of this unglaciated coastal plain corridor, a real possibility exists that few but significant archeological sites could be discovered.

The Beaufort Sea bed, on which the marine portion of the pipeline would be placed, is a gently sloping continuation of the Arctic Coastal Plain. Although the continental shelf is narrower here than elsewhere in Alaskan waters, portions were undoubtedly above sea level during Pleistocene glaciations. Underwater archeological sites (which date from 10 to 20 thousand years ago) may be expected to exist in the marine corridor.

Archeological Summary

A series of sites of late prehistoric and contact age from the coast of Beaufort Sea has been reported by the staff of the Arctic National Wildlife Range. The Elupak site on Barter Island (BRL 001) may have affinities with late-prehistoric villages on the island and adjacent sand spits excavated by Jenness and Mathiassen.

Archeological Evaluation

The Offshore route traverses a zone of some potential significance for archeological research. Eustatic lowering of sea levels during the Wisconsin glacial epoch expanded the Arctic Plain to a minimum width of 80 miles, thus exposing the offshore edge of the submerged continental shelf to potential occupation by man; underwater exploration of this zone may locate sites pertaining to Paleoindian adaptations.

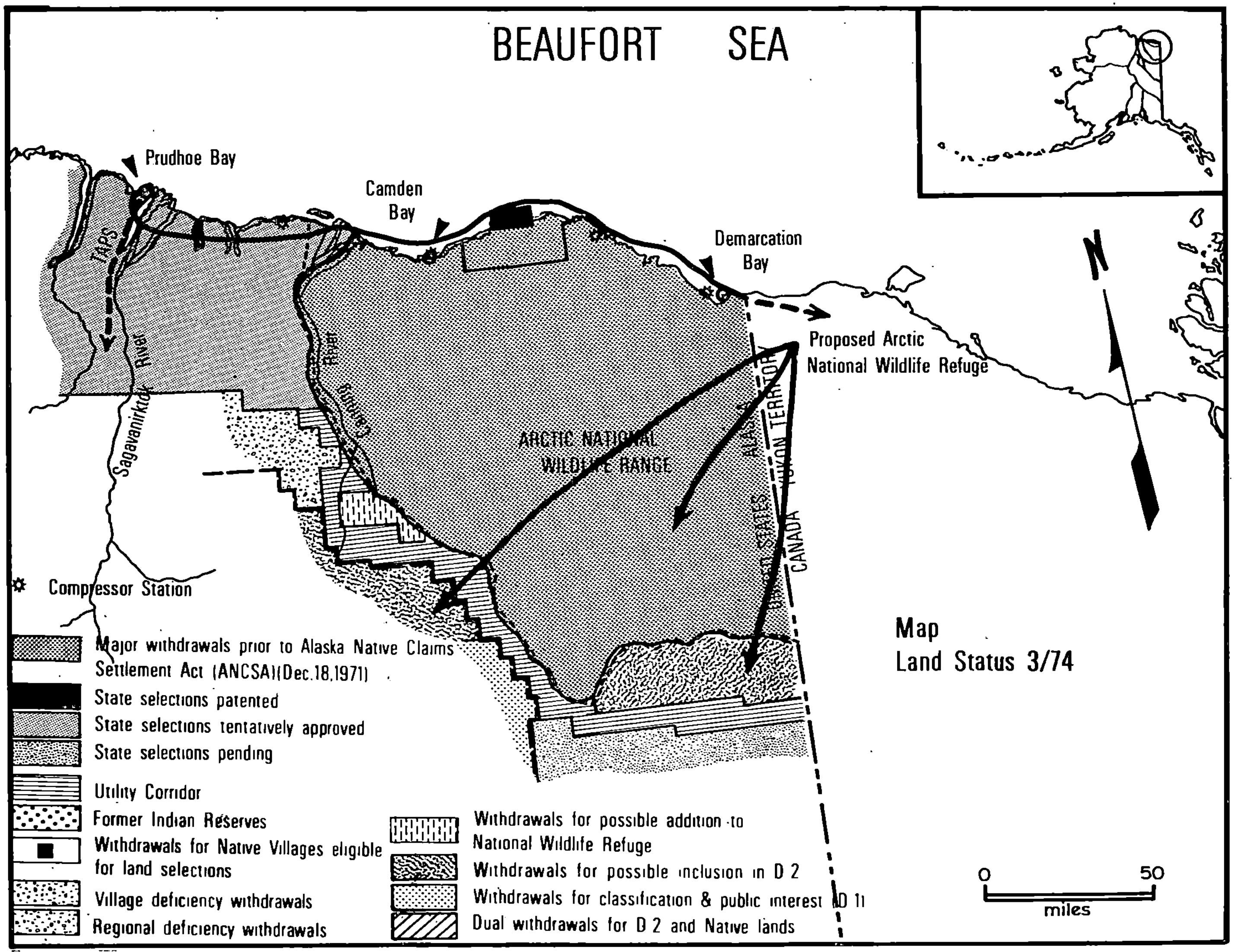


Figure 8.1.1.1-8 Land status of the offshore alternative pipeline route

A partial survey of the offshore region by Dr. John Bockstoce located a site on Herschel Island (Edwin Hall, personal communication), thus reinforcing the archeological potential of larger islands lying within this corridor.

Historic Summary

Ten sites of historic interest are recorded as existing within this segment. The sites XBP 001-004 and XDP 001 are historic Eskimo. Leffingwell Camp, XFI 002, is listed on the National Register of Historic Places. The Leffingwell site and Gordon, XBP 002, are the two former settlements of white inhabitants.

Historic Evaluation

The history of this corridor is primarily that of exploration, first to discover the Northwest Passage and later to discover and develop the fur and whaling resources in coastal waters and the immediate inland areas.

Esthetic and Recreational Values

Values described in Section 2.1.1.13 for the applied-for AAGPC pipeline route will be involved with the Offshore alternate route. As with archeological and related values, there are distinct recreation and esthetic values along the Beaufort Sea Coast.

Air Quality

Air quality factors associated with the Offshore alternative route are considered identical to those described for the AAGPC applied-for route (Section 2.1.1.14).

Environmental Noise

Environmental noises associated with the applied-for AAGPC route and its Offshore alternative routing are considered to be similar to those in Section 2.1.1.15. During ice-free periods, the coastal area will produce the sounds of the sea which will not be found inland such as sea birds, wave action, ice breakup, etc.

Environmental Impacts Caused by the Offshore Alternative Pipeline Route, Alaska

The Offshore alternative route to the proposed AAGPC Pipeline system will require construction of a pipeline with both land and marine segments. The Offshore alternative routing described and considered by AAGPC is the basis for this analysis.

It should be noted that AAGPC does not propose to construct an offshore pipeline system. No applications are pending before a Federal agency or the State of Alaska to construct an offshore pipeline system from Prudhoe Bay.

Several assumptions have been made in the following evaluations:

1) Early transportation of gas from Prudhoe Bay to domestic markets is in the national interest.

2) Construction, operation, and repair of land segments of the Offshore pipeline system will be similar to those proposed by AAGPC in the applied-for route.

3) Technology for marine pipeline construction is adequate to bury a high-pressure, chilled, 48-inch gas pipeline in the bed of the Beaufort Sea during ice-free periods.

4) Movement of the polar ice pack across the shelf of the Beaufort Sea makes necessary special engineering design and repair procedures to reasonably assure that pipeline integrity and reliable delivery of gas can be achieved.

5) Development of engineering and repair procedures for the marine segments will delay delivery of natural gas by at least 5 years.

As with the AAGPC applied-for routes, analysis of anticipated impacts is made on a "worst case" basis. This route is unique among all the Alaskan alternative routes in that it has a 141-mile segment of pipeline buried offshore under the Beaufort Sea. This single factor presents a unique set of environmental impacts and surfaces significant engineering problems.

The following is a summary of major impacts expected if the Offshore Alternative route is selected for construction of a gas transmission system:

Permafrost--Unsolved thermal problems concerning construction in underseas permafrost and transition to onland permafrost can threaten pipeline integrity.

Ice movement--Ice movement could preclude winter construction and repair. In addition, ice movement results in bottom gouging that can threaten pipeline integrity.

Water quality--Construction, operation, and repair of the Offshore pipeline system will affect sea bottom sediments, create turbidity, and threaten marine and estuarine life. Foreign substances as fuel, lubricants, and human waste that enter estuarine waters threaten freshwater aquatic life, anadromous fish, and waterfowl. Water pollution can interfere with the microscopic marine organisms that are the foundations of the marine food chain.

Wildlife--Waterfowl--Coastal areas, especially barrier islands, are key bird habitat. Construction and operation of pipeline facilities could displace nesting and molting birds. Major breeding populations will be lost and significant changes in total populations and distribution will result from activities along the Offshore route.

Marine mammals--Polar bears inhabiting the Bering Sea Coast may be deflected to other possibly less favorable areas or lose shore or land denning areas because of activities related to the Offshore pipeline with resultant reduction of Beaufort Sea polar bear population.

Fish--Alteration of spawning, feeding, rearing and overwintering areas of marine fish by pipeline-related activities will cause local loss of fish populations which may extend over large areas because of the multiage structure of aquatic populations.

Wilderness--The three compressor stations required in the Arctic National Wildlife Range and other pipeline facilities and activities would destroy the wilderness character of the remaining undeveloped arctic coastal areas of the Range.

Kaktovik--Because the Offshore route is close to Kaktovik, it will offer employment opportunities to village residents, but interfere with their subsistence harvests of fish and game. Both impacts will affect traditional lifestyles.

The State of Alaska has pointed out in its comments of October 24, 1975, that many of the impacts listed for the Offshore alternative could be avoided by relocation of the pipeline to nearshore areas where the water depth is less than 6 feet and utilizing the winter months for construction. This would permit pipe burial to be performed from the surface of bottom-fast anchor ice which would provide a level working platform and would require no gravel, water, or snow to construct long access roads and working pads. Biologically the nearshore area is extremely productive during the summer months but during the winter is essentially nonproductive. The State has also indicated that if a second line were buried, it would provide opportunity to increase the throughput volume without the necessity of locating compressor-chilling stations within the Arctic National Wildlife Ranges. Major concerns of this approach would be crossing the areas near the mouths of large streams and solving cf engineering and technological problems. Such a line might be somewhat longer than the Offshore alternative route but eliminating the need for access road and working pad surface along with a longer working time could offset additional costs.

Impacts of the Offshore Alternative Route on Climate

Construction, operation, and repair of the Offshore alternative pipeline system will have no significant impact on regional climate. However, climate, especially movement of ice across the shelf of the Beaufort Sea, will adversely affect the marine elements of the pipeline system. Land elements of the Offshore alternate are the same as those described on the applied-for AAGPC route in Section 3.1.1.1.

Impacts of the Offshore Alternative Route on Topography

Impacts from construction, operation, and repair of on-land segments of the Offshore alternate pipeline system would be similar to those of the applied-for AAGPC route, in that the ditch mound and compressor stations will accentuate the flatness of the existing terrain (Section 3.1.1.2). There will be a significant difference, however, in the impact of the ditch mound caused by the Offshore alternative route. Only 64 miles of the pipeline are located on land with the Offshore alternate route.

Location of compressor stations along the coast of the Beaufort Sea may create a more adverse impact on topography than along the applied-for AAGPC route because the artifically created new skyline of the buildings, exhaust plume, and communication towers on the Offshore route will be in the flat setting of the Arctic Coastal Plain and the Beaufort Sea.

In total, the impact of onland facilities of the Offshore alternative on topography approximates that of the applied-for AAGPC route because the lessened distance of the ditch mound is offset by the increased impact of the three compressor stations on the coast of the Arctic National Wildlife Range.

Impacts of marine segments of the Offshore alternative on topography of the bed of the Beaufort Sea are unknown. It is possible that excavation of bottom sediments will create a change in bottom topography large enough so that sea ice will be more likely to ground. Development of a frost bulb in bottom sediments adjacent to the buried, chilled pipeline may have a similar effect.

Impacts of the Offshore Alternative Route on Geology

Impacts from construction, operation, and repair of on-land portions of the Offshore alternate on geology are the same as those described for the AAGPC applied-for route in Section 3.1.1.3.

Impacts from construction, operation, and repair of marine segments on geology are unknown. However, permafrost in the bed of the Beaufort Sea creates special, unsolved problems which can adversely affect pipeline integrity. Pipeline foundation problems are expected, since excavation of a ditch up to 20 feet deep into bottom sediments will introduce water warmer than the adjacent bottom sediments, and the subsequent operation of a chilled pipeline will alter thermal conditions. It is possible that ice will form under the pipe, forcing the pipe upward. Should this occur, pipeline integrity would be adversely threatened by ice gouging.

Significant thermal problems will be associated with the transition of a gas pipeline from permafrost conditions under the Beaufort Sea to onland permafrost. Operating temperatures are assumed to be the same for onland segments of the Offshore alternative as those proposed for the applied-for AAGPC pipeline system. Therefore, gas will be received at a temperature of 25° F. Frost heave threatens pipeline integrity and increases the need for repair. The interaction of two potentially different types of permafrost with a chilled, buried pipeline is considered a significant unsolved problem that will cause adverse impacts on pipeline integrity.

In its assessment of leasing for development of oil and gas on near shore State-owned lands in the Beaufort Sea near Prudhoe Bay, the State of Alaska Div. of Policy Development and Planning (1975) concluded that presence of permafrost:

> ...presents a hazard both to a pipeline systems which may have to be buried due to ice gouging problems, and to offshore drilling structures due to brine migration and thaw, "freeze-back", and possible wellhead subsidence.

These same problems apply to an offshore gas pipeline and related facilities such as valve structures.

Erosion of coastal areas, including barrier islands, associated with the four crossings of marine segments of the Offshore alternative route will be affected by construction, operation, and repair of an Offshore pipeline system. The coastal tundra bluffs are presently actively retreating, slumping, and eroding due to thermal and wave erosion. With a predicted coastal retreat of 10 m/year and a pipeline life of 20 years, the pipe would have to be buried beneath the active layer starting 200 meters inland from the present coastline to avoid adverse impacts on the pipeline system created by the retreating coastline that would intiate pipeline failure. The presence of a refrigerated pipeline crossing the coastline might retard thermokarst erosion at that location, causing an interference with the natural process of erosion. The impact created by retarding the thermokarst action is unknown.

Impacts of the Offshore Alternative Route on Soils

Impacts on soils caused by construction, operation, and repair of the Offshore alternate pipeline route are identical to those described for the AAGPC applied-for route in Section 3.1.1.4. There is, however, a redistribution of the location of these impacts as 133 miles of soil disturbance across the Arctic National Wildlife Range will be replaced by 141 miles of disturbance of marine sediments in the immediate offshore areas of the Range.

Bottom sediments will be redistributed by excavation of a ditch in the floor of the Beaufort Sea. Bottom sediments are naturally redistributed through the action of ice gouging in the vicinity of the proposed offshore marine segments (Table 8.1.1.1-1 and Figures 8.1.1.1-2 and -4). Therefore, it is anticipated that excavation of the ditch in the bed of the Beaufort Sea would have little long-term impact on bottom sediments.

Impacts of the Offshore Alternative Route on Water Resources

For the onshore segment of this route, the primary use of water will be the construction of the snow/ice roads needed during the pipe laying construction periods as described in Section 3.1.1.5. There will be significant differences of impacts between the applied-for AAGPC route and the Offshore route. The latter transfers all activities closer to, or onto, the coast. Accordingly, impacts on water resources will be concentrated in the lower ends of the rivers and streams. Impacts on water resources are not expected to be appreciably different from those described in Section 3.1.1.5. As with other project impacts, the distribution of these other impacts is different. With the Offshore route, the number of river and stream crossings is reduced to 16 and all crossing within the Arctic National Wildlife Range eliminated. Instead, the entire estuarine and marine waters adjacent to the Range are affected.

Siltation of lagoon areas will be larger with the Offshore alternative because of the three coastal compressor stations, three port areas, and four pipeline transitions from land to marine environments. The extent of this increased lagoonal siltation is not known, but must be considered within the perspective that no streams in the Arctic National Wildlife Range will be crossed. Therefore, it is possible that the total impact of water quality would be less along the entire coastline while more severe locally at construction or regularly used shore areas.

Because facilities and activities are concentrated along the coast, it is probable that spills of fuels, lubricants, toxic substances, and human wastes will reach the estuarine waters. Control or cleanup of spills will be more difficult in estuarine waters. Therefore, the adverse impact of lowered water quality in estuarine areas will be more pronounced. The overall impact on lowered estuarine water quality is unknown but can be severe, causing deaths of large numbers of waterfowl and aquatic life (see Wildlife).

Trenching needed to bury marine segments of the Offshore alternative route will cause considerable turbidity and siltation. Offshore trenching will take place during the summer when marine and aquatic life is at maximum levels of activity. Siltation will reduce light penetration in lagoons and the shelf of the Beaufort Sea, causing a reduction of photosynthesis of plankton and thereby affect the entire marine food web. The magnitude of this impact is unknown.

Construction of marine segments of the Offshore alternative will be from ships. It is assumed that ships and barges will meet State and Federal water quality discharge standards. However, the expected number of ships involved with the Offshore alternative will be increased and it is possible that ships would be used as residences for two summers. Effluent discharges from ships will add nutrients to the Beaufort Sea locally. The impact of additional nutrients from ships is unknown but it is noted that the decomposable organic materials in bottom sediments are low (0.05 to 1.5 percent by weight). It is assumed, therefore, that growth of aquatic life such as plankton may be locally stimulated as a result of nutrient additions to the sea.

Impact of the Offshore Alternative Route on Vegetation

Impacts from construction, operation, and repair of on-land portions of the Offshore alternative pipeline system on vegetation will be identical to those described in Section 3.1.1.6. The total impact on terrestrial plants will be less with the Offshore route since only 64 miles are located on land.

Construction, operation, and repair of marine segments of the Offshore alternative route are expected to create an unknown impact on vegetation. It is noted, however, that there is natural regular disruption of the marine environment by ice scour. There may be major adverse effects on marine or estuarine plants such as algae as a result of siltation reducing the amount of light penetration in water.

Impacts of the Offshore Alternative Route on Wildlife

In its consideration of proposed Beaufort Sea near shore petroleum leasing, the Alaska Div. of Policy Development and Planning (1975) states:

> Hazards to Beaufort nearshore animals and ecosystems accompany oil development activities. The kind of losses sustained by the biota of the area, and the extent of such losses, are related to four main variables: 1) frequency of major oil spills; 2) extent of chronic and cumulative pollution, mainly from oil spills and sewage; 3) changes in currents, inshore ice action, salinity, and sedimentation processes resulting from physical alterations of near shore areas; 4) behavioral disturbances from acute or persistent human activity. None of these can be quantified at the present time.
>
> The most likely sources of risk to bird populations include disturbance or elimination of island-nesting terns, gulls, and eiders, and direct mortality to waterfowl and seabirds from oil spills. Mammals most likely to be affected are polar bears which den in the area, ringed seals, and carnivores (polar and grizzly bears, arctic fox, wolf). Fish populations risk mortality from seismic detonations and oil spills and may suffer habitat losses from gravel removal and siltation. Plankton and invertebrates, basic food sources in the marine ecosystem, could suffer temporary or long-term losses from large oil spills, cumulative

buildup of oil and other toxic compounds in muds or waters, and changes in currents, ice forces, and salinity affecting the near shore environment.

In the long run, chronic discharges of petroleum, drilling compounds, brines, and heavy metals may be more damaging to marine species of the area than large but infrequent spills or discharges.

These same conditions are expected to occur with the Offshore alternative pipeline system as a result of accidental spill of fuel, lubricants, and methanol.

Caribou

The Porcupine Caribou Herd will be less affected by the Offshore alternative route since the system would be located on the coast on the northern edge of the traditional calving area. Therefore, there would be no interference with annual movements of caribou between their wintering areas to the south and the calving area. Onshore facilities and the human activities will cause caribou to shift southward from the coast during the two summer construction seasons and from summer operation of maintenance and repair of system facilities. This will cause a small reduction in the amount of traditional habitat available for caribou use. Primary factors causing long-term southward movements will be compressor station noise and regular low-level aircraft approaches, landings, and departures to and from compressor stations for route maintenance.

The threat of major reduction of herd size is much less with the Offshore route, compared with threat from the proposed AAGPC pipeline system route. See Figure 8.1.1.1-9 for sensitive wildlife areas including caribou calving grounds.

Moose

The Offshore alternative route crosses no major known moose habitat areas because of its coastal orientation (away from better moose habitat areas in the Foothills and Brooks Range to the south). It is possible that summer extraction of gravel and increased human activity would cause moose to move away from coastal areas. This is not considered a major effect since only occasionally does a moose wander to the coast. It is concluded that there will be little, if any, impacts on moose caused by the construction, operation, and repair of the Offshore alternative route.

Musk Ox

Onshore portions of the Offshore alternative routing in the Arctic National Wildlife Range (compressor stations and port areas) are located at the edge of the known ranges of musk ox. Concentration of human activities associated with the construction, operation, and repair of facilities within the Wildlife Range will, therefore, affect musk ox. Disturbances of musk ox, especially by low flying aircraft, are identical to those described for the AAGPC applied-for route. Disturbances of musk ox will cause substantial interference with their movements, and result in death of animals or reduction in breeding. The importance of the coastal vegetation to year around survival of musk ox living in the Arctic National Wildlife Range is unknown, but must be considered.

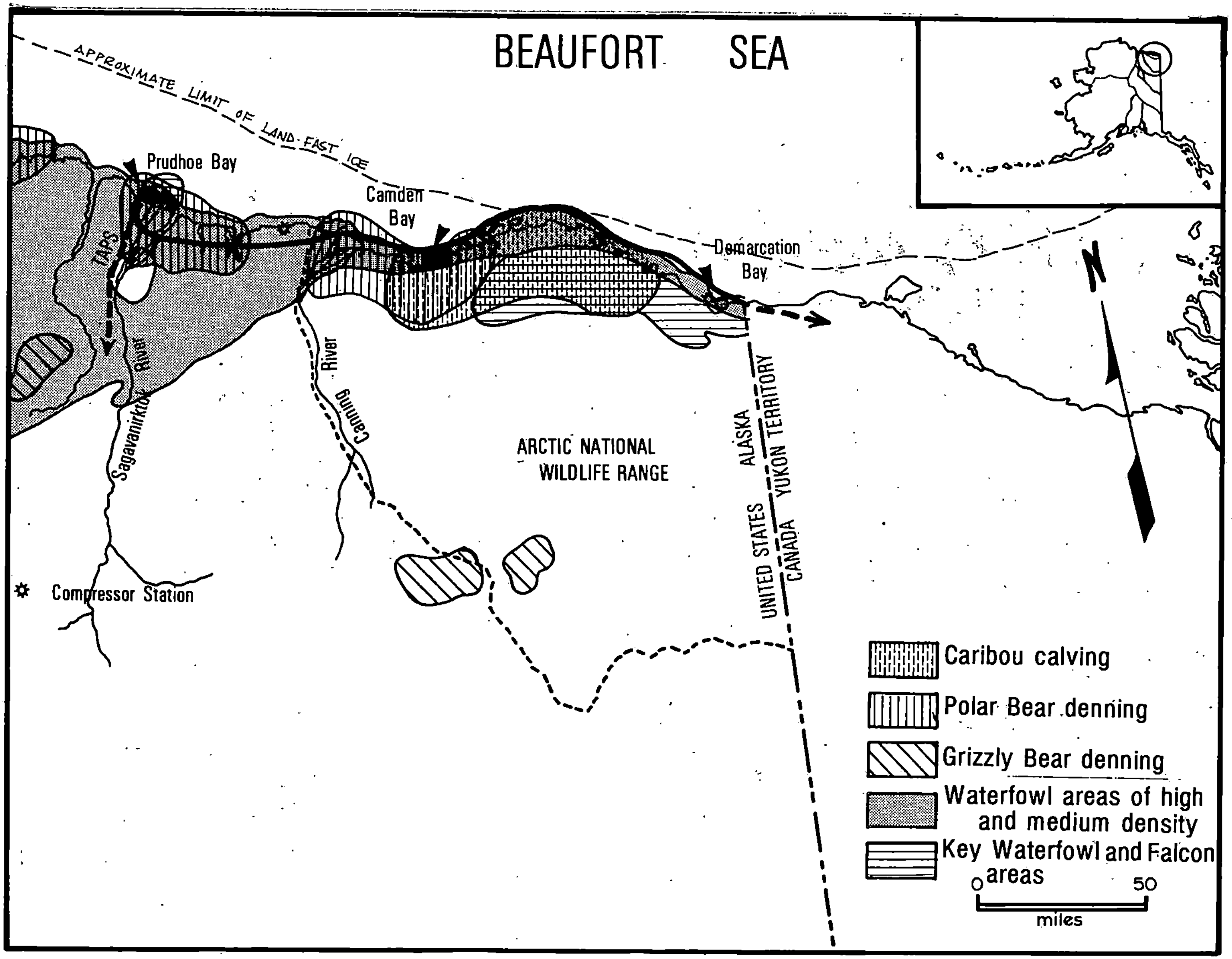


Figure 8.1.1.1-9 Sensitive wildlife areas of the offshore alternative pipeline route

Dall Sheep

The Offshore alternative route involves no Dall sheep habitat and therefore, will not affect these animals except to the extent described in Section 3.1.1.7 for the Canning River area. Impacts on Dall sheep in the Canning River will result from aircraft flights should the river valley become a heavily used aircraft transportation corridor and are the same for the Offshore alternative as those discussed in the applied-for route in Section 3.1.1.7.

Wolf

Impacts on wolves caused by the construction, operation, and repair of the Offshore alternative route will be in direct relation to any reduction of caribou numbers using the coastal plain. There are no known wolf denning areas associated with the Offshore alternative route.

Fox

Impacts on foxes caused by construction, operation, and repair of the Offshore alternative route are unknown. Because of the shorter distance on land, it is expected that destruction of fox denning habitat will be less than that described for the AAGPC applied-for route. Experience on the Alyeska Oil pipeline shows that fox often become attracted to construction camps and often become camp "pets."

Grizzly Bear

Grizzly bears range across the entire Coastal Plain but are more abundant in stream valleys close to and within the Brooks Range. Since the Offshore alternative route will shift human activities away from these areas to coastal areas, it is expected that there will be somewhat less impact on grizzly bears than that discussed for the applied-for AAGPC route in Section 3.1.1.7. As with Dall sheep, it is expected that grizzly bears living in the Canning River area will be adversely affected should the Canning become a heavily used corridor for aircraft movements to and from eastern segments of the pipeline system. Impacts on grizzly bears caused by increased aircraft use of the Canning River area would be the same as those described in Section 3.1.1.7.

Polar Bear

The polar bear occurs throughout the Beaufort Sea coastal areas during winter. Polar bears are described in 2.1.1.7. Distribution is directly related to the seasonal movement of ice.

For this alternative route, the work is to be done in the summertime when the ice pack has moved to the north. No impact on polar bear by construction activities is anticipated.

The Offshore alternative route concentrates all facilities and human activities on the coast of the Beaufort Sea. These new facilities, especially compressor stations and their requirements for regular inspection and maintenance, will adversely affect polar bear denning along the Alaskan coast of the Beaufort Sea. Human activities will influence all polar bears moving inland to den on the Coastal Plain of the Arctic National Wildlife Range. These adverse impacts will cause polar bears to seek new, possibly less favorable, denning areas with resultant reduction of polar bear population in the Beaufort Sea.

Construction activities will take place on marine segments during the summertime but the ice breakers will be used to prolong the construction season. Thus, it is possible that polar bears using offshore ice would be deflected to other areas, compounding population losses due to loss of shore or land denning areas.

It is concluded that the Offshore alternative route will have an immediate and long-term adverse impact on polar bear use of the Beaufort Sea Coast between Prudhoe Bay and the United States-Canada border with significant, but unknown, reduction in the number of polar bears.

Other Marine Mammals

Construction activities will start before ice is gone from the coast and will extend through the time when ice forms in the fall. Shipping and pipelaying activities during the summertime will have impacts on marine mammals similar to those described for the AAGPC applied-for route in Section 3.1.1.7. Construction activities on the shelf of the Beaufort Sea when ice is present will take place when seals are close to shore. The effect on seals by extended marine construction is not known.

Birds

Coastal areas, especially barrier islands, associated with the Offshore alternate route are key bird habitat areas. Barrier islands and the lagoons behind them are molting areas for many thousands of oldsquaws, eiders, greater scaups, and black brant. These same areas also are nesting habitat for gulls, eiders, terns, and other birds (see Section 3.1.1.7 for a more complete discussion).

The Offshore alternative route lies in the migration path of some 50 to 60 species of birds (SITF, 1972). These include approximately one million eiders (adult and young of the year), large numbers of brant, snow geese, and white-fronted geese.

The Offshore alternative route will concentrate facilities and human activities along the coast in key bird habitat areas. It crosses approximately 140 miles of key feeding, nesting, molting, and staging areas. Construction of facilities such as ports, compressor stations, and airfields will destroy some important habitat. However, most impacts on birds will result from construction and operation of facilities.

Facilities of the alternative route located on land include the initial 64 miles of pipeline, block valves, heliports, and the first compressor station. Coastal facilities (all within the Arctic National Wildlife Range) include three compressor stations, three port areas, communication towers, and between three and six airfields.

It is assumed that actual construction of land facilities would take place during the winter when most birds were not in the Beaufort Sea area. Activities for obtaining sand and gravel from borrow sites in active flood plains will occur during summer and fall. Noise and human activity associated with summer borrow operations will cause birds to relocate to other areas. Impacts on bird life associated with the first 64 miles of the pipeline would be similar to those described for the applied-for route as it crosses the Arctic Coastal Plain (Section 3.1.1.7).

AAGPC notes that low-flying aircraft and operation of compressor stations are especially disturbing to birds along the Arctic Coast and will cause birds to move to other areas.

Molting sea ducks will be disturbed by aircraft, compressor station activity, and shipping during the construction and operational phase of the Offshore alternative route (AAGPC, 1974a).

Studies for the AAGPC (Gollop, Goldsberry, and Davis, 1974) show that molting sea ducks traditionally concentrate and use areas directly associated with the Offshore alternative. Low-flying aircraft will change normal feeding behavior, causing the birds to abandon traditional use areas. Molting sea ducks go as far offshore as 2.5 miles to feed. Marine pipeline construction will take place at a time and location which infringes on these offshore feeding areas. Gollop and Davis (1974) in studies done for AAGPC found that noise similar to that made by a compressor station will frighten snow geese and would also adversely affect molting waterfowl.

During the summer, spilled fuel, lubricants, or toxic substances will come into direct contact with large numbers of bird life and could kill many birds. The Offshore alternative route increases the probability for spills occurring while birds are present since (1) the periods of peak activity will be during the two consecutive summer marine construction periods and (2) storage will be at sites immediately on the coast.

In summary, the Offshore alternative pipeline route concentrates facilities and human activities directly in key bird staging, nesting, feeding, and molting areas. Summer construction activities, noise from compressor stations, and repeated use of low-flying aircraft will have large, direct, and adverse impacts on bird life along the Beaufort Sea from Prudhoe Bay to the United States-Canada border. Major breeding populations will be completely lost and significant shifts in total population numbers and distribution of birds now using the area will result from the Offshore route.

Peregrine falcon habitat is not associated with the Offshore alternative pipeline system.

Fish

The Offshore alternative route involves no known freshwater overwintering areas or spawning areas for fish. A few streams are crossed near their mouths and the development of a frost bulb around a chilled pipeline buried in the streambed may restrict movement of fish to and from estuarine areas. Arctic char migrate to the sea several times in their life cycle. Therefore, water quality effects produced by construction activities adjacent to or in lagoons may have adverse impact on anadromous fish. The magnitude of the effect of lowered estuarine water quality on anadromous or other fish life is unknown, but can be significant.

Marine habitats for fish are expected to undergo substantial alterations. These will affect marine spawning, rearing, feeding, and overwintering areas. Fish populations will be lost locally and, in some instances, may be affected over large areas if rearing or overwintering areas are altered because of the multi-age structure of aquatic populations in the Arctic.

Impacts of the Offshore Alternative Route on Ecological Considerations

Ecological considerations associated with the Offshore alternative route are similar to those described for the applied-for route except there will be no impacts on the Arctic Foothills. See Section 3.1.1.8 for discussion of these relationships.

The Offshore alternative will cause disruption of benthic communities as a result of the construction, operation, and repair of a chilled pipeline buried in the bed of the Beaufort Sea. The Offshore route involves construction of 141 miles of marine pipeline and facilities (compressor station complex and ports) adjacent to four estuarine areas. Microscopic organisms living in their areas are the foundation of the food web reaching through fish, birds, sea mammals, polar bear, and man.

Impacts of the Offshore Alternative Route on Economics

The economic impacts from construction, operation, and repair of the Offshore alternative route are similar to those described for the applied-for route (Section 3.1.1.9) except the Offshore route will have:

1) Peak employment somewhat smaller;

2) Peak employment extended over a 2-year period;

3) Construction costs increased by at least $209.9 million;

4) Annual maintenance costs increased by at least $4.6 million;

5) Adversely impact waterfowl subsistence activities of residents at Kaktovik because of the concentration of facilities on the coast;

6) Increased employment opportunities for people at Kaktovik because of the closeness of the port and compressor station.

The University of Alaska has developed an econometric model that distributes the impacts of employment, expenditures, etc., generated by this proposed project throughout the Alaskan economy. The following data for this and the other alternative routes are derived from this model to facilitate a comparison of economic impacts between the alternative routes (Scott, 1975).

The economic impacts of the Offshore alternative route as developed by the University of Alaska econometric model include: a property tax of $11.8 million, construction employment of 682, a capital value (pipe and compressors) of $590.9 million, an increase in gross State products of $41.2 million, a total State employment effect of 4,400, an increase in real wages and salaries of $35.3 million, population growth of 5,900, an addition to personal income Statewide of $101.5 million with an increase in per capita income of $88 and a total addition to State revenues of $78 million. All figures are for 1980, the peak year of construction, and based on assumed production of 2.0 billion cubic feet of gas per day, wellhead price of 50 cents per Mcf, which means a total wellhead value of $3.65 million per year, royalties to the State of $45.6 million per year, and a State production tax of $14.6 million per year.

Impacts of the Offshore Alternative Route on Social Factors

The construction, operation, and repair of the Offshore alternative route are expected to have social impacts similar to those described for the applied-for route. See Section 3.1.1.10. The major difference for the Offshore alternative is at Kaktovik where the impacts will result from both increased wage employment opportunities and decreased chance to enjoy the cultural aspects of hunting, fishing, and trapping which are pivotal to the Eskimo way of life for the 150 Natives residing there. Both impacts will occur because route facilities will be adjacent to Kaktovik.

Impacts of the Offshore Alternative Route on Land Use

The Offshore alternative will have impacts on land use similar to those evaluated for the applied-for AAGPC route. Both involve long-term commitments of land use prior to development of a comprehensive land use plan for Alaska or a Policy for the Arctic as proposed by the Joint Federal-State Land Use Planning Commission.

The location of the Offshore alternative route favors development of oil and gas potentials for the Beaufort Sea Offshore Province and the Marsh Creek anticline (see Figure 8.1.1.1-10). The north end of the Marsh Creek anticline is located coincidentally with a compressor station. Thus, the Offshore alternative route transects the Marsh Creek and Beaufort Sea oil and gas areas, providing shortest distance for feeder line connectors. The offshore route would require the connector and feeder systems across the calving area of the Porcupine caribou herd, as does the proposed AAGPC route. The direction of the flow is different, however, as the compressor station locations are different.

The Offshore alternative route will be farther from the Kemik and Kavik gas fields and, thereby, require a longer network of feeder lines to reach the gas pipeline system if gas is not first sent to the Prudhoe Bay area.

The Offshore alternative route will destroy wilderness values of the remaining undisturbed parts of arctic coastal area of the Arctic National Wildlife Range for the same reasons as those outlined in Section 3.1.1.11 for the AAGPC proposed route. Principal features detracting from the existing wilderness character of the coast are: compressor stations, ports, exhaust plumes, noise, communication towers, and human activity (regular use of low-flying aircraft for access to pipeline system facilties). The total area affected within the Wildlife Range is smaller with this alternative because facilities and human activities will occur approximately 150 miles along the edge of the Range in contrast to those along the central location of the applied-for route.

Impacts of the Offshore Alternative Route on Archeological, Historic, and Unique Areas

The Offshore route will concentrate facilities and activities on the coast of the Beaufort Sea where significant archeological and historic areas may be found. Impacts on the Leffingwell Camp (on the National Register of Historic Places) and known areas of archeologic value on the coast will be similar to those described in Section 3.1.1.12 for the AAGPC applied-for route. The basic difference will be that the Offshore route will affect as many as five coastal areas in the Arctic National Wildlife Range. Whether this shift in location of facilities and activities will cause a net "benefit" or loss to archeological values is unknown. Inland aboriginal trade routes along the Canning, Hulahula, and Kongakut Rivers will be

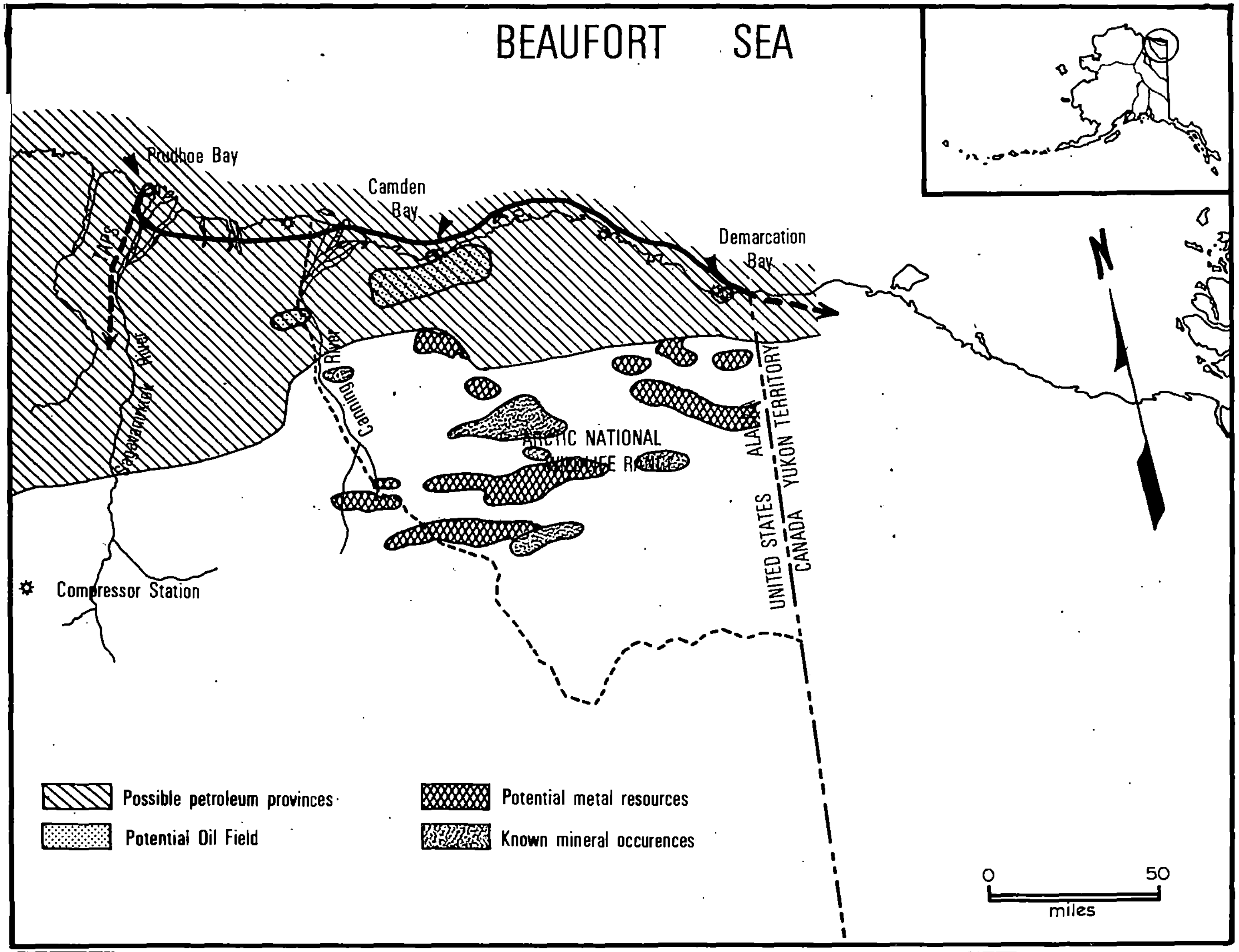


Figure 8.1.1.1-10 Potential minerals, oil and gas of the offshore alternative route

avoided with the Offshore alternate since the pipeline would be buried in the Beaufort Sea bed at these locations.

Unique areas associated with coastal locations would be affected by the Offshore route in a manner similar to that described for the applied-for AAGPC route (Figure 2.1.1.12-2). Larger areas within the Arctic National Wildlife Range such as the Jago River would be passed. The Sadlerochit Spring and Fire Creek are not involved with the Offshore routing. Coastal areas such as Icy Reef and Beaufort Lagoon will receive heavier impacts as a result of construction, operation, and repair of the marine segments and their associated offshore facilities (compressor stations, airfields, and ports).

Impacts of the Offshore Alternative Route on Recreation and Esthetics

The Offshore alternate pipeline system will produce impacts on recreation and esthetics similar to those described for the applied-for AAGPC pipeline route in Section 3.1.1.13. There are, however, major differences because the Offshore system concentrates all facilities on the coast.

Esthetics would also be affected differently in that a greater proportion of the Arctic National Wildlife Range will remain in its existing condition if facilities are concentrated on the coast. The elimination of the ditch mound with its discordant erosion, grading, and plant cover is a plus.

Overall, the cumulative impacts of the Offshore alternative pipeline system on recreation and esthetics are considered to be less than the cumulative impacts caused by the applied-for AAGPC pipeline system.

Impacts of the Offshore Alternative Route on Air Quality

The Offshore alternative route will create impacts identical to those described for the applied-for AAGPC route in Section 3.1.1.14.

Impacts of the Offshore Alternative Route on Environmental Noise

The Offshore alternative route will cause the same noise emission levels as those discussed for the applied-for AAGPC route in Section 3.1.1.15, Environmental Noise. Major noise sources include operation of construction equipment, blasting, compressor stations, blowdown, and aircraft. The differences are the numbers of wildlife and people exposed to the pipeline-related noise. These are discussed in Section 8.1.1.1 under Wildlife and Sociological Factors.

Impacts of the Offshore Alternative Route on Pipeline System Repair

Impacts from repair of onland facilities will be the same as those described for the applied-for route in 3.1.1.16.

Emergency repair on the marine portion of the Offshore alternative exceeds present technology during the 4- to 5-month period when the polar ice pack is near the coast.

Lack of direct access to a pipe buried in the bed of the Beaufort Sea presents serious threat to system reliability. Present offshore pipeline repair technology in arctic waters using surface equipment and divers is limited to the 8 to 10 weeks when sea ice is absent.

Worst case conditions for repair of the marine segments are during breakup or freezeup periods. Hazards from moving ice during these two periods prohibit safe operation of most types of known support vessels.

The only exception to presently conceived support vessels for repair is the air-cushion vehicle. However, operating experience during these periods is needed to learn which type of support vehicle is best for maintenance and repair.

8.1.1.2 Coastal Alternative Pipeline Route

In 1973 a study by the Technical Staff, Division of Pipeline, U.S. Bureau of Land Management, Alaska State Office, considered the merits of eight routes for pipelines in northeastern Alaska from Prudhoe Bay to the United States-Canada border.

Overall, the 1973 BLM study concluded the coastal (beach) route appears to be a preferable utility corridor. On the basis of the 1973 preliminary assessment by BLM, the alternative of locating a pipeline route between Prudhoe Bay and the United States-Canada border on the coast is evaluated herein.

The AAGPC did not originally consider the coastal route an alternative to the applied-for route inland across the Arctic National Wildlife Range. In a later submission, the Applicant has indicated a second choice would be the Coastal Alternative and the Interior Alternative would be the third choice.

No application is pending before Federal or State agencies to construct a coastal pipeline route.

Description of the Coastal Alternative Pipeline System

For the purpose of this analysis, the general alignment considered and described by the AAGPC for the Offshore alternative route has been selected as far as the west side of the Canning River Delta. From this point (64 miles from Prudhoe Bay) the Coastal Alternative Route follows the coastline to the Canadian border where it rejoins the Applicant's applied-for route. Refer to Figure 8.1.1.1-1 which shows the relationship of the Coastal Alternative route to the Offshore alternate and the applied-for AAGPC pipeline route. Compressor stations are at points selected by AAGPC for the Offshore route.

It is not known whether compressor stations feasibly could be located on the former DEW-line sites as suggested by the BLM (1973). This possibility needs study since throughput of the system requires careful placement of all compressor stations. Balancing the pipeline system after placement of compressor stations at abandoned DEW-line sites (Figure 3.1.1.11-1) appears to decrease maximum throughput of the delivery pipeline system from Prudhoe Bay without addition of a fifth compressor station on the Alaskan coast of the Beaufort Sea.

For the purpose of this discussion it is assumed that construction schedules, construction operation, and repair procedures, facilities, manpower requirements, and supplies will be substantially the same as those of the applied-for AAGPC pipeline described in sections 1.1.1.1 through .9.

Costs for construction will be slightly higher than those for the applied-for AAGPC pipeline system because: (1) approximately 9 miles of additional pipe are required for the Coastal alternative route, and (2) there is a higher incidence of ice-rich permafrost which will require more borrow materials. The overall construction costs are anticipated to be slightly higher than those of the applied-for AAGPC route, but substantially lower than costs of the Offshore alternative.

Maintenance costs for the Coastal Alternative route should be similar to those for the applied-for AAGPC route.

The Coastal route would be located inland on the first favorable location away from beach subject to erosion during the life of the pipeline system.

Description of the Environment of the Coastal Alternative Pipeline System

Environmental, social, and economic factors associated with the Coastal alternative route are similar to those described for the proposed AAGPC pipeline system (Sections 2.1.1.1 through .15) with the following exceptions:

Geology and Soils

Substantially more ice-rich permafrost will be encountered, with an estimated 50 percent of the route encountering conditions described for the Arctic Coastal Plain (Mile Post 00 to 62 of the applied-for route) and the Clarence Plain area (Mile Post 115 to 195 of the applied-for route). See Section 2.1.1.3, permafrost, for a detailed discussion of these two areas.

The Coastal alternative route (Figure 8.1.1.2-1 and Table 8.1.1.2-1) is located entirely within the Arctic Coastal Plains and thereby avoids the Arctic Foothills where rolling topography is more conducive to mass wasting.

Water Resources

There will be 35 fewer streams crossed on the Coastal route than on the applied-for AAGPC route. Although the Coastal alternative route has fewer stream crossings, more of it is located in active flood plains and would cross wider delta areas. For streams wider than 100 feet the coastal route would cross 17 as compared to 18 for the AAGPC applied-for route. However, approximately the same drainage areas are involved in both the applied-for and the Coastal routes.

Vegetation

Plant communities associated with the Arctic Foothills will not be crossed by the Coastal alternative route. No specific studies have been conducted of plant distribution along the Coastal alternative, but based upon data assembled by the Joint Federal-State Land Use Planning Commission for Alaska, it is estimated that the Coastal pipeline system, over its length in Alaska will cross:

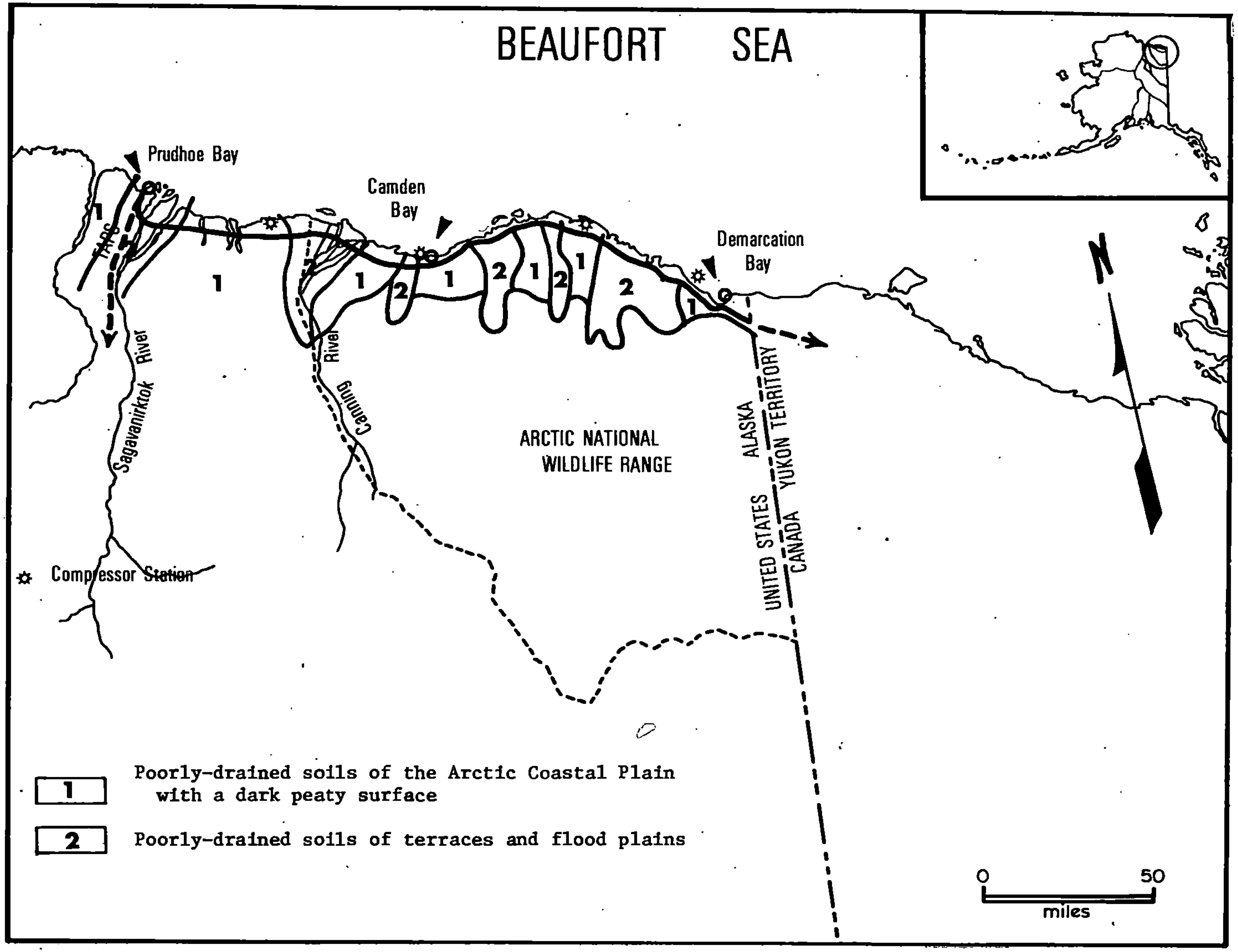


Figure 8.1.1.2-1 Soils of the coastal alternative pipeline route

Table 8.1.1.2-1 GENERALIZED SOILS INFORMATION ALONG THE

Soil	Units Miles	Land Position	Thickness Organic Mat	Depth to Permafrost	Dominant Texture USDA	Dominant Texture Unified	Underlying Material
1A	33	Coastal Plain	<8"	12"	0"-60"sil	ML	ML
1B	27	Coastal Plain Low Terraces	8"-16"	12"	0"-60"sil	ML	ML
1C	22	Low Broad Kones Convex Slopes	8"-16"	10"-24"	0"-60"sil	ML	ML
1D	11	Low Terraces & Ridges	<8"	Deep	0"-60"vgs	GP, GM	GP
1E	8	Shallow Basins & Lake Borders	>16"	12"	0"-24" pt	PT	PT
1F	5	Floodplains	<8"	10"	0"-60"vgr	GP	GP
1G	3	Low Dunes	<4"	18"-30"	S	SP	SP
2A	63	Floodplains Low Terraces	<4"	15"-30"	0"-60"vgl	GP	GP
2B	13	Low Terraces	<4"	Deep	0"-60" vg	GP	GP
2C	11	Floodplains Low Terraces	<4"	20"	0"-40" l 40"vgs	ML GP	GP
2D	10	Floodplains & Swales	<4"	10"-30"	0"-60" s	SP	SP

USDA Texture

cl - clay loam
l - loam
pt - peat
s - sand
sil - silt loam
vgl - very gravelly loam
vgr - very gravelly sand

Unified Group Symbols

CL - Lean clays - gravelly, sandy, or silty
GM - Mixed gravels, sands or silts
GP - Gravels - gravel and sand mixture
GW - Graded gravels - gravel and sand mixtures
ML - Silts and very fine sands - silty, clayey fine sands or clayey silts
PT - Peat
SM - Silty sands - sand-silt mixtures
SP - Poorly graded sandy, gravelly sands, little or no fines

COASTAL ALTERNATIVE PIPELINE ROUTE.

Drainage Class	Flooding	Frost Action	Reaction Class	Permeability	Slope
Poorly drained	None	High	non-acid to calcareous	Moderate	0-3
Poorly drained	None	High	non-acid to calcareous	Moderate	0-3
Poorly drained	None	High	calcareous	Moderate	0-7
Well drained	Moderate	Low	non-acid to calcareous	Rapid	0-7
Poorly drained	Moderate	High	strongly acid	Moderate	0-3
Poorly drained	High	Moderate	calcareous	Rapid	0-3
Well drained	Low	Moderate	non-acid to calcareous	Rapid	0-7
Poorly drained	High	Moderate	non-acid to calcareous	Rapid	0-3
Well drained	Moderate	Low	non-acid to calcareous	Rapid	0-3
Poorly drained	High	High	non-acid to calcareous	Rapid	0-3
Poorly drained	Moderate	Moderate	non-acid to calcareous	Moderate	0-3

"Moist Tundra" ---- 80 percent (163 miles)

"Wet Tundra" --- 14 percent (29 miles)

"High Brush" --- 6 percent (12 miles)

See Figure 8.1.1.2-2. Section 2.1.1.6 describes the plants associated with these vegetation types.

Wildlife

The alternative Coastal pipeline system would be located along the northern edge of the traditional calving area of the Porcupine Caribou Herd rather than crossing the calving area as does the applied-for route.

The shift of facilities to the coast of the Beaufort Sea would concentrate human activities in prime habitat for birds, polar bears, and musk ox. There are no known habitat areas for peregrine falcon associated with the Coastal alternative system.

Thirty-one species of waterfowl frequent tundra wetlands and adjacent coastal waters. Pintails, green-winged teal, and oldsquaws are the most common breeding ducks. An overall nesting population of 20 pairs of pintails per square mile has been recorded in the productive Arctic Coastal Plain. Pairs of ducks can be seen on most tundra lakes and ponds in early summer and broods of young appear in July and August.

Canada geese, white-fronted geese, and black brant nest on the tundra and produce an estimated 1,200 young annually. Whistling swans in this area raise an average of 40 cygnets per year. A density of 21 arctic loons per square mile was observed during the 1970 nesting season in the Coastal Plain. During August and September prior to their southern migration, many species of birds, including thousands of snow geese, frequent the tundra to feed on ripe crowberries, blueberries, and low-bush cranberries.

Arctic grayling are the most abundant and ubiquitous sport fish in the area and occur in all drainages. Grayling prefer clear waters of streams and lakes and commonly school in pools below rapids. Spawning occurs in the tributaries in early spring. Growth rates are slow, and it may require 6 years for a fish to reach 14 inches in length. Slow growth and ease of capture make them susceptible to local extirpation.

Both anadromous and landlocked populations of arctic char are present. Major runs of char are known to occur annually in the larger rivers of the Arctic Slope. Spawning takes place on river gravel beds in the fall. The fish overwinter in the deeper holes in fresh water before returning to the sea. Growth rates are very slow, and it may take 15 years for a fish to reach 5 pounds.

The extensive estuaries along the Arctic Coast constitute habitat for both marine and freshwater fish. In spring when rivers are high with meltwater and the estuarine water is consequently largely fresh, grayling descend into the estuaries where they find rich feeding grounds. In midsummer when freshwater flows subside and tidal movements begin dominating water chemistry, increasingly brackish water forces grayling back to the rivers. Marine fish, including the arctic flounder, arctic cisco, fourhorn sculpin, and others then dominate estuarine waters. Anadromous arctic char are present in estuaries throughout the year.

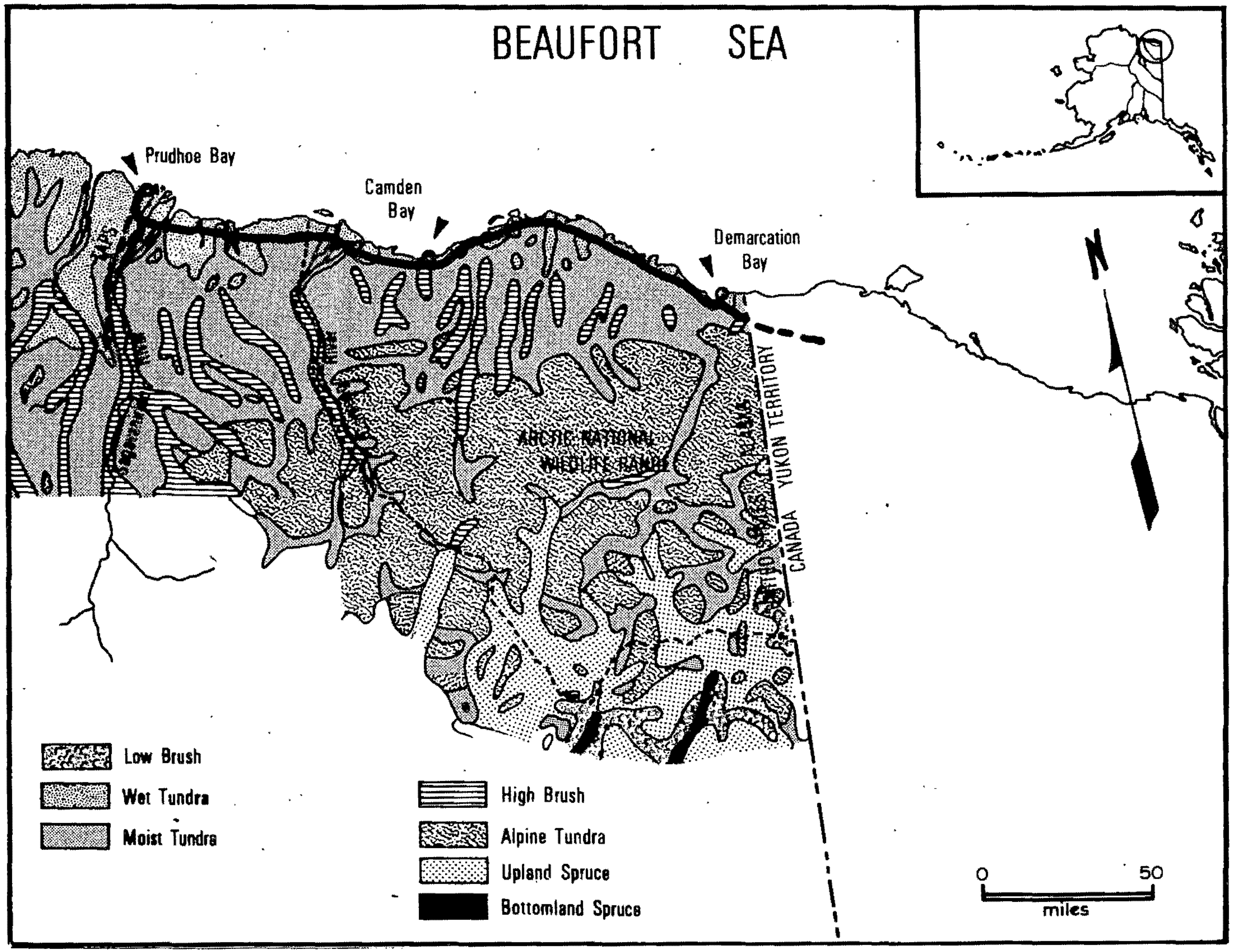


Figure 8.1.1.2-2 Vegetation map of the coastal alternative pipeline route

Economics

A Coastal pipeline system will be more directly associated with the village of Kaktovik than the AAGPC applied-for route, but is similar to the applied-for route. This will: (1) reduce opportunities for Eskimos to pursue hunting, fishing, and trapping--important elements of their culture; and (2) increase opportunities for employment in pipeline related jobs.

Environmental Impacts Caused by the Coastal Alternative Pipeline Route, Alaska

Impacts from the alternative Coastal pipeline system in the area of water withdrawal, frost bulb formation, and those on vegetation, wilderness, and subsistence are expected to be similar to those discussed for the applied-for route. A detailed discussion of the above and other impacts is summarized below:

Permafrost--Up to 50 percent of the route is located in areas of ice-rich permafrost that would aggravate construction and pipeline integrity problems. Impacts could be similar to those discussed for the applied-for route.

Wildlife--Polar bear and birds would be affected in a more pronounced manner with the Coastal route than the applied-for route because the former concentrates all facilities and human activities in prime habitat along the coast. Caribou, musk oxen, moose and grizzly bear would be affected less by the Coastal route than the applied-for route, because a coastal location involves less activity in important habitat areas.

Ecological Considerations--The proximity of the Coastal alternative route to estuaries makes it likely that sediments from construction will alter the chemistry and thus the productivity of phytoplankton and other light-requiring organisms. Resultant damage to the food chain could harm fish, birds, and mammals of the area.

The Arctic National Wildlife Range would be impacted due to three factors:

1. This project would reduce the animal populations involved.

2. The wilderness qualities now found on parts of the coast would be reduced.

3. The transportation system would significantly enhance additional oil and gas exploration and production probabilities for at least the Marsh Creek anticline within the Range and adjacent offshore areas.

Impact of the Coastal Alternative Route on Climate

The Coastal alternative will not affect climate, but climate will adversely affect the construction, operation, and repair of the pipeline system.

Snowfall along the coast is less than that expected in the vicinity of the inland applied-for AAGPC route; therefore. Water requirements are expected to increase since more roads may be constructed of manufactured snow to support wintertime construction schedules. Adverse climatic conditions of cold temperatures, darkness, and wind combine to produce hazardous working conditions. Ice in the Beaufort Sea will restrict barge and ship transportation if there is a late breakup, summer onshore storm, or early freezeup. Climatic conditions for extending the shipping season in the Beaufort Sea restrict the use of snow/ice roads for construction purposes, since they would be useful for a shorter time. These conditions are the same as discussed for the applied-for AAGPC route in Section 3.1.1.1.

Impact of the Coastal Alternative Route on Topography

The Coastal alternative pipeline system will have impacts on topography similar to those described in Section 3.1.1.2 for the applied-for AAGPC route. The major difference is that placement of the ditch mound, compressor stations, and related facilities in the flatter Arctic Coastal Plain adjacent to the Beaufort Sea will cause a more pronounced impact on landscape. This new impact is the same as that described for the Offshore alternative pipeline system in Section 8.1.1.1.

Impact of the Coastal Alternative Route on Geology

The effects of the Coastal alternative pipeline system on geology are the same as those described for the applied-for AAGPC route (Section 3.1.1.3) and the shore facilities of the Offshore alternative routing (Section 8.1.1.1).

The Coastal routing, however, will cross fewer areas where mass wasting is pronounced because of the general absence of topographic relief on the Arctic Coastal Plain. The avoidance of areas like the Arctic Foothills, where mass wasting could cause significant engineering problems, is a "benefit" of the Coastal location. This "benefit" is offset, however, by the fact that up to 50 percent of the Coastal alternative pipeline system is located in areas where ice-rich permafrost (up to 80 percent ice) occurs.

The Coastal tundra bluffs are actively being eroded near the coast. This is caused by slumping and erosion by thermal and wave action. The presence of a chilled, buried gas pipeline with its large frost bulb could retard thermokarst erosion along coastal bluffs.

Impact of the Coastal Alternative Route on Soils

Impacts on soils from the construction, operation, and repair of the Coastal alternative pipeline system are similar to those described for the AAGPC applied-for route. These include: mixing of soils through excavation and backfill of the pipeline trench; contamination from accidentally spilled fuels, lubricants, or toxic substances; and, reduced soil productivity as a result of lowered soil temperatures over the chilled, buried pipeline.

Impact of the Coastal Alternative Route on Water Resources

The construction, operation, and repair of the Coastal alternate pipeline system will cause impacts on water quality similar to those described for the Offshore alternative route (8.1.1.1). These include siltation of freshwater streams and rivers and lagoonal areas.

The Coastal alternative pipeline system will require building snow/ice roads for winter construction. It is questionable that snowfall along the coast will be adequate to construct needed snow roads. It is expected that water will be used to make an ice-coated bearing surface for vehicular traffic. Surface water is not available after late December from smaller streams and lakes that are frozen to the bottom. It is possible to withdraw water from some lakes before they become completely frozen, but withdrawal will further increase the concentration of dissolved solids in the water which would adversely affect water quality. The impact of water withdrawal from lakes that completely freeze is presumed to be small since aquatic life normally is not found in such lakes. Water withdrawal from larger, deeper lakes that do not freeze completely could have a severe adverse impact on overwintering aquatic life through increasing the content of dissolved solids to the extent that it is harmful.

Siltation in estuarine areas from construction and repair of the Coastal system is expected because of the proximity of pipeline facilities to the coast. The impact of increased siltation of estuarine areas is unknown, but can be serious in that it will restrict biological processes of aquatic life dependent upon light penetration and will smother bottom dwellers. Accidental spills of fuels, lubricants, human wastes, or toxic substances will quickly reach estuarine waters. The impact of lowered water quality in estuarine areas is major in that the life cycle of aquatic invertebrates would at minimum be affected. These aquatic plants and animals are the foundation of a food web which proceeds upward to forage fish, birds, seals, polar bears, and humans. Spills of fuels or toxic substances pose substantial hazard and potential death to the large numbers of bird life associated with the Coastal alternative system because spills will be more difficult to contain before reaching critical coastal habitat areas of large numbers of birds.

Freshwater springs are not known to be located near or associated with the Coastal route.

In summary, the construction, operation, and repair of the alternative Coastal pipeline system will cause adverse impacts on the existing good water quality of streams and rivers (and potentially, lakes). These lowered water quality impacts will be less than those described for the applied-for AAGPC route (Section 3.1.1.5) and the alternate Offshore route (Section 8.1.1.1). Increased and major lowering of water quality is expected in estuarine areas as a direct result of the concentration of facilities and human activities on the coast of the Beaufort Sea.

Impacts on ground water caused by the Coastal alternative are identical to those of the applied-for AAGPC route, and include the following:

Compression of the surface by heavy equipment could divert or enhance subsurface flow and upset the thermal balance.

Excavation of the pipeline ditch could intercept subsurface flow causing the water to flow down the ditch and threaten pipeline integrity by thaw consolidation, ultimately causing differential settlement.

Frost bulb formation around the chilled pipeline will divert subsurface waters which in turn could threaten pipe integrity by promoting slope instability.

The frost bulb will pond subsurface flows and enhance the formation of ground ice around and ultimately could promote frost heaving to the extent pipeline integrity may be affected.

Summertime repairs with heavy equipment will cause significant impact on subsurface water flow that may threaten pipeline integrity as well as promote surface and thermal erosion.

Streams and rivers will be affected in a manner similar to that evaluated in the applied-for route in Section 3.1.1.5 in that the frost bulb formed around the chilled pipeline will:

Cause an ice dam which will tend to change the river gradient by increasing ice scour and bank erosion; or

Threaten pipeline safety by increasing bottom or bed scour on the downstream side of the pipeline.

Impact of the Coastal Alternative Route on Vegetation

The effects on vegetation produced by construction, operation, and repair of the Coastal alternate pipeline system are identical to those described for plants on the Arctic Coastal Plain for the applied-for AAGPC route. For a more detailed analysis of these impacts see Section 3.1.1.6. Plants associated with the Arctic Foothills will not be involved in the Coastal routing.

Exhaust emissions (such as sulfur dioxide) can damage lichens. Although there will be major adverse impacts on vegetation caused by construction and operation of the future four compressor stations along the Coastal alternate pipeline system, these impacts on plants are not different in kind from those resulting from the applied-for AAGPC route. There are, however, significant differences in the extent of these impacts. Repair of the pipeline may also involve significantly less impact on vegetation since it may be possible to move repair equipment along the beach and on the active flood plains of the river deltas. It should be noted that if repairs were required during the summers, movement of repair vehicles along the beach or river deltas would have significant and major adverse impacts on waterfowl (see Wildlife).

Impact of the Coastal Alternative Route on Wildlife

The Coastal alternative pipeline system will cause impacts on wildlife similar to those described in the applied-for AAGPC route (Section 3.1.1.7) and the Offshore alternative (Section 8.1.1.1). The basic difference is that the winter construction season for the Coastal route would be identical to the AAGPC applied-for route while the Offshore system is scheduled for summer construction. Therefore, construction activities for the alternative Coastal system will take place when most wildlife species are elsewhere. The operation, repair, and associated human activities are concentrated in the coastal zone. Accordingly, long-term impacts on wildlife species using coastal areas will be similar to those described in the Offshore alternative discussed in Section 8.1.1.1.

In summary the impacts on wildlife resulting from the alternative Coastal pipeline system are as follows:

Traditional caribou calving grounds are impacted by competition for space. Interference with caribou migration between the calving area and their wintering area south of the Brooks Range in Alaska and Canada will be avoided with the Coastal route. (See Section 2.1.1.1). Thus, impacts on caribou will be significantly less with the Coastal alternative route than with the applied-for AAGPC pipeline route. Impacts on caribou on the

Coastal alternative route are considered similar to those caused by the Offshore alternative route (Section 8.1.1.1).

Moose and grizzly bears will be affected less by the Coastal alternative system than with the applied-for AAGPC route because its coastal location involves less human activity in habitat areas important to moose and grizzly bears. Therefore, the Coastal alternative pipeline system impacts are identical to the Offshore alternative impacts on moose and grizzly bears (See Section 8.1.1.1).

Polar bears will be affected in a more pronounced manner with the Coastal alternative system than with the applied-for AAGPC route because the former concentrates all facilities and human activities on the coast and adversely affects the polar bears. This is similar to impacts described for the Offshore alternative system, except that there would be no use of ice-breaking equipment in construction phases in the Coastal alternative. Accordingly, impacts on polar bears would be somewhat less with the Coastal route than the Offshore route. See 8.1.1.1 for a detailed discussion of the expected impacts on polar bears caused by the Offshore alternative pipeline system.

Birds would be adversely affected by the Coastal alternative pipeline system by operation and repair activities in the same manner as described for the Offshore alternative system (See Section 8.1.1.1) which includes destruction of nesting habitat and repeated disturbance during feeding, nesting, rearing, and migration. The construction phase of the Coastal alternative system will cause fewer impacts than those described for the Offshore alternative because the latter requires two summers of construction; whereas, the Coastal alternative would be built during a single winter season when there are few birds on the Arctic Coast. The long-term impacts of the operation and repairs of the Coastal alternative pipeline system are identical to those of the Offshore facilities since both concentrate human activities in a zone containing very important habitat for birds.

The Coastal alternative pipeline system will cause impacts on fish similar to but not as extensive as those described for the Offshore alternative in Section 8.1.1.1.

Impact of the Coastal Alternative Route on Ecological Considerations

The Coastal alternative system concentrates facilities and human activities in the coastal area. Thus, impacts on ecological considerations will be similar to those described for coastal facilities and human activities in the applied-for AAGPC route in Section 3.1.1.8.

Impact of the Coastal Alternative Route on Economic Factors

The Coastal alternative pipeline system will be constructed in the same time span with approximately the same number of construction jobs and permanent jobs in Alaska as the applied-for route. Therefore, impacts on economic factors in Alaska are considered the same as those described for the applied-for AAGPC pipeline system in Section 3.1.1.9.10 through .15.

Impact of the Coastal Alternative Route on Social Factors; Land Use; Historic, Archeologic, and Unique Values; Recreation and Esthetics; Air Quality; and Environmental Noise

Impacts caused by the construction, operation, and repair of the alternative Coastal pipeline system will be similar to those described for the Offshore alternative because facilities and human activities are concentrated along the coast under both routes. See Section 8.1.1.1 for discussions of these impacts.

Impact Caused by Repair of the Coastal Alternative System

Repair activities will be concentrated along the coast with the Coastal alternative system. Wintertime repair will cause similar impacts to those described for the applied-for AAGPC pipeline system in Section 3.1.1.16. Because of the coastal location, summer repair will cause impacts similar to those described for land facilities in the Offshore alternate in Section 8.1.1.1.

Impact on the Arctic National Wildlife Range and Wilderness

The impacts on the Range are similar in character to those discussed in Sections 3.1.1.7 and 11. The routes differ in the severity of impacts on different species of both terrestrial and marine animals and on the wilderness concept. In general terms, the Coastal route presents less impact on the wilderness concept than the applied-for route, less impacts on caribou, grizzly bear, moose, and wolf, but a greater impact on musk ox, polar bear, birds, fish and the marine ecosystem.

8.1.1.3 Interior Alternative Pipeline Route

The Interior Alternative routing has received considerable study over the past few years. This routing was considered as a potential "inland" routing for oil from the Prudhoe Bay Field via Canada (SITF, 1972). In 1972, this route was withdrawn as a 6- to 18-mile wide utility and transportation corridor by the Secretary of the Interior. This route was reevaluated in 1973 by the Bureau of Land Management. In 1973 the Joint Federal-State Land Use Planning Commission for Alaska considered portions of the route in connection with potential expansion of the Arctic National Wildlife Range to the west and south (August 2, 1973). The AAGPC gave detailed consideration to the Interior route and in its applications to the Department of the Interior and the Federal Power Commission noted that the Interior route would be considered by the Applicant in the event that the proposed route [applied-for] was not available. In a later submission, the Applicant has indicated a second choice would be the Coastal alternative and the Interior route would be the third choice.

Detailed information on the Alternative Interior pipeline system has been provided by AAGPC and those data are reflected in the following analysis.

<u>Description of the Interior Alternative Pipeline System</u>

It is assumed that major features such as size and quality of pipe, compressor station, general design, operational characteristics, and construction procedures of the Interior Alternative route are the same as those described for the applied-for AAGPC route in sections 1.1.1.1 through

9. There are, however, several major differences in the work force, scope of facilities, and the construction schedule required to build and operate the Interior Alternative pipeline system.

The Interior Alternative route proceeds from Prudhoe Bay southeastward to the Canning River, up (south) the Canning River Valley through the Brooks Range to the Continental Divide and then southeasterly down small drainages from the Continental Divide to the southern flanks of the Brooks Range where the route swings easterly to the United States-Canada border. There are two routes for crossing the Continental Divide from the north: The Canning River and the Marsh Fork of the Canning River. The Canning River is less rugged and requires 5 miles less pipe. (It would cross a portion of the Arctic National Wildlife Range.)

The Marsh Fork Option is included in the utility and transportation corridor withdrawal of 1972; the Canning Option is not. Total distance in Alaska is 292.6 miles via the Canning River crossing and 297.5 miles via the Marsh Fork of the Canning route.

Initial capacity of the Interior Alternative pipeline system would be 2.25 bcf/d with one compressor station at Mile Post 118. With addition of five compressor stations in Alaska, and additional compressors in Canada, the initial capacity could be doubled in the future to 4.5 bcf/d.

Figures 8.1.1.3-1, -2, and -3 show the location of the Marsh Fork Option. Figure 8.1.1.3-4 shows the Canning River Option. Although the Marsh Fork Option is part of the 1972 withdrawal by the Secretary of the Interior for potential pipeline routings to Canada, the Joint Federal-State Land Use Planning Commission for Alaska recommended that the Marsh Fork of the Canning be "...closed to all developmental uses, including mining and oil and gas production, and other uses which would alter the existing ecology..." because of its "...high wildlife values and potential as a scientific study area..." (August 2, 1973).

Ancillary facilities required for initial operation of the Interior Alternative pipeline system are shown in Table 8.1.1.3-1 and on the previously mentioned maps.

Supplies will be distributed to the Interior alternative routing along the existing highway and rail network in Alaska. Supplies will be shipped to ports at Prudhoe Bay, Anchorage, and Skagway, Alaska. A total of 12.5 miles of permanent road will be built.

The construction schedule for the Interior alternative pipeline system suggested by AAGPC (1974a) is shown in Table 8.1.1.3-2. Within Alaska, construction will be underway on a year-around basis for 2 years.

The AAGPC (1974a) estimates construction cost to reach full capacity for the Interior alternative pipeline system is approximately $1.1 billion ($525.5 million more than the applied-for AAGPC route). This increased cost reflects total costs for the 532.6- to 537.5-mile long Interior route in Alaska and Canada compared with the 492.1-mile long Alaskan and Canadian applied-for route to the Mackenzie River Valley.

A breakdown of construction costs in Alaska alone is not available. Annual operating costs for the Interior alternate pipeline system are estimated by AAGPC (1974a) to be $11.2 million. Operating costs were computed by AAGPC on the same basis as construction costs (both Alaska and Canada without a separate breakout).

Table 8.1.1.3-1 Facilities required in Alaska on the interior alternative pipeline system

No.	Facility
1	Metering Station
1	Compressor Station [(w)2.25 bcf/d]
6	Compressor Stations [(w) 4.5 bcf/d, includes initial compressor Stations]
9	Material stockpile sites (includes 1 at Prudhoe Bay and 1 at Circle)
2	Gravel air strips (2,400' for STOL aircraft)
3	Gravel air strips (6,000' for large cargo aircraft)
22	Helipads
14	Communication Towers
12.5	Miles of permanent road
189.6	Miles of temporary access road (includes 175 miles from Circle across Yukon and Porcupine Rivers and up Coleen River to a material stock pile site)
31.5	Miles winter trails
293 or 298	Miles each of working pad and access road along pipeline route

*AAGPC, (1974a)

Table 8.1.1.3-2 Construction schedule for interior alternative pipeline system, Alaska

Summer 1976

1. Stockpile site under construction at Prudhoe Bay area.

Winter 1976-1977

1. Stockpile site completed at Prudhoe Bay area.
2. Compressor station site 1A-02 under construction.
3. Stockpile sites at approximately M.P. 75 and M.P. 95 under construction.

Summer 1977

1. Compressor station site 1A-02 continues under construction.
2. Stockpile sites at approximately M.P. 75 and M.P. 95 completed.
3. Stockpile site at approximately M.P. 168 under construction.
4. Compressor station sites 1A-03 and 1A-04 under construction.
5. Stockpile site at Circle under construction.

Winter 1977-1978

1. Compressor station site 1A-02 completed.
2. Stockpile site at approximately M.P. 168 completed.
3. Compressor station sites 1A-03 and 1A-04 completed.
4. Stockpile site at Circle completed.
5. Compressor station sites 1A-01, and 1A-05, and 1A-06 under construction.
6. Stockpile sites at approximately M.P. 44, M.P. 190, and M.P. 252, under construction.

Summer 1978

1. Compressor station sites 1A-01, 1A-05, and 1A-06 completed.
2. Stockpile sites at approximately M.P. 44, M.P. 190, and M.P. 252, completed.
3. Clearing and rock excavation along the route between M.P. 95 and M.P. 190 under construction and completed.

Winter 1978-1979

1. Stockpile site at approximately M.P. 268 under construction.
2. Pipeline between approximately M.P. 44, and M.P. 95 under construction.
3. Pipeline between approximately M.P. 190 and M.P. 268 under construction.
4. Clear pipeline R.O.W. between M.P. 268 and Canadian Border.

Summer 1979

1. Stockpile site at approximately M.P. 268 completed.
2. Pipeline between approximately M.P. 44 and M.P. 95 completed.
3. Pipeline between approximately M.P. 190 and M.P. 268 completed.
4. Compressor station at site 1A-03 under construction.
5. Meter station at Prudhoe Bay under construction.
6. Pipeline between approximately M.P. 95 and M.P. 190 under construction.

Winter 1979-1980

1. Compressor station at site 1A-03 continues under construction.
2. Meter station at Prudhoe Bay continues under construction.
3. Pipeline between approximately M.P. 95 and M.P. 190 completed.
4. Pipeline between M.P. 0 and approximately M.P. 44 under construction.
5. Pipeline between approximately M.P. 268 and Canadian Border under construction.

Summer 1980

1. Compressor station at site 1A-03 completed.
2. Meter station at Prudhoe Bay completed.
3. Pipeline between M.P. 0 and approximately M.P. 44 completed.
4. Pipeline between approximately M.P. 268 and Canadian Border completed.

*AAGPC, 1974a

The work force needed to construct the Interior alternative pipeline system will provide peak employment for approximately 5,000 workers over a 2-year period. The permanent work force in Alaska would require increasing the work force at the Prudhoe Bay Field Office by 11 people to a total of 50 workers. The additional 11 maintenance technicians would be needed for the compressor station built in Alaska as part of the initial system.

The Interior alternative pipeline system will provide direct transportation of gas from the Prudhoe Bay area to domestic markets the same as the applied-for AAGPC route. The Interior route is not as well suited as the applied-for route for early development of the Marsh Creek anticline or the eastern Beaufort Sea Offshore Province because of increased distances from these two areas to this alternative pipeline system. The Interior Alternative route will provide closer access to the 19,500 square mile Yukon-Kandik Province which is estimated by the State of Alaska (1974) to contain a speculative recoverable 1.7 billion barrels of oil and 2.7 trillion cubic feet of gas.

The Interior alternative route primarily is located in a utility and transportation corridor withdrawn by the Secretary of the Interior as a potential pipeline route on March 9, 1972. Accordingly, existing regional parks or wildlife refuges are not involved directly. Portions of this route separate the existing Arctic National Wildlife Range from areas to the west and south proposed for inclusion in the National Wildlife Refuge System by the Secretary of the Interior in 1973. Although located to the west and south of the existing Arctic National Wildlife Refuge, the Interior alternative pipeline system (specifically the proposed temporary access road) from Circle, Alaska affects portions of the proposed: Yukon Flats National Wildlife Refuge, Porcupine National Forest, Yukon-Charley National Rivers, Porcupine National Scenic River, and Sheenjek National Scenic River. The alternative pipeline system in its entirety affects all these areas.

Description of the Existing Environment of the Interior Alternative Route

Climate

The Interior alternative route is primarily within the Arctic climate zone, one of four zones within Alaska. See Figure 8.1.1.3-5.

The Arctic Zone lies north of the Brooks Range. Mean annual temperature is about 17°F. Average annual precipitation ranges from less than 4 to about 17 inches. Characteristics of the climatic zone are long cold winters, short cool summers, moderate to light rainfall during summers, and relatively light snowfall during winter.

North of the Brooks Range, temperatures along the proposed Interior alternative route range from 40° to 75° F during summer months and between -20° to -60° F in winter. (See discussion in Section 2.1.1.1.)

South of the Brooks Range the summer temperatures probably range from the upper 60's to the upper 70's, but during winter drop to -5° to -25° F. Annual temperature extremes range from about 100°F to -60° to -75° F in both areas. On the basis of partial-year records from Arctic Village, a monthly average of -36° F is recorded during January and a monthly average of 54.9° F is recorded for June. Refer to Figures 8.1.1.3-6 and -7 for mean July maximum and January minimum temperatures.

Precipitation in the area ranges from 4 to 10 inches per year along the sea coast to highs of about 40 inches per year in the Brooks Range. It

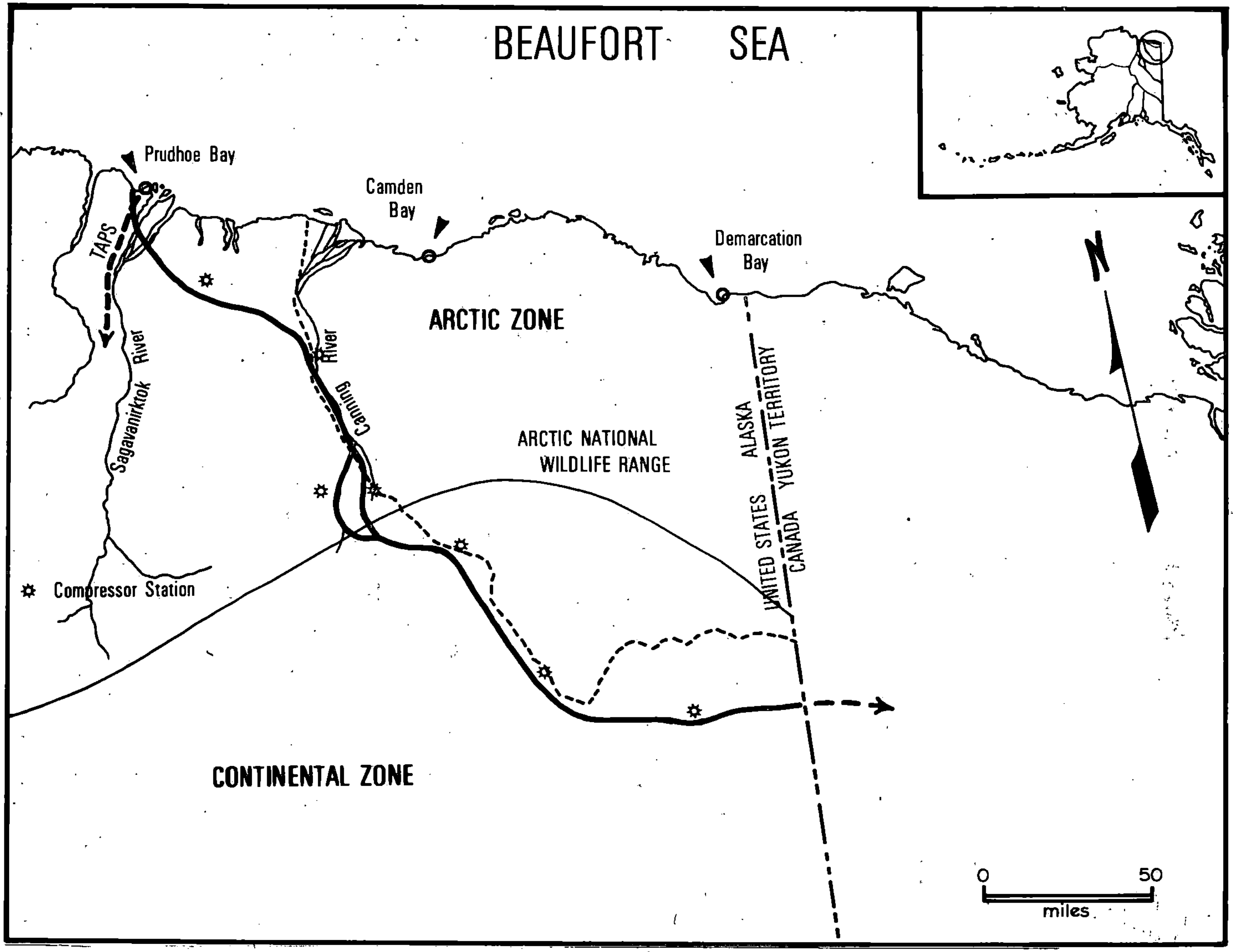


Figure 8.1.1.3-5 Climatic zones of the interior alternative pipeline route

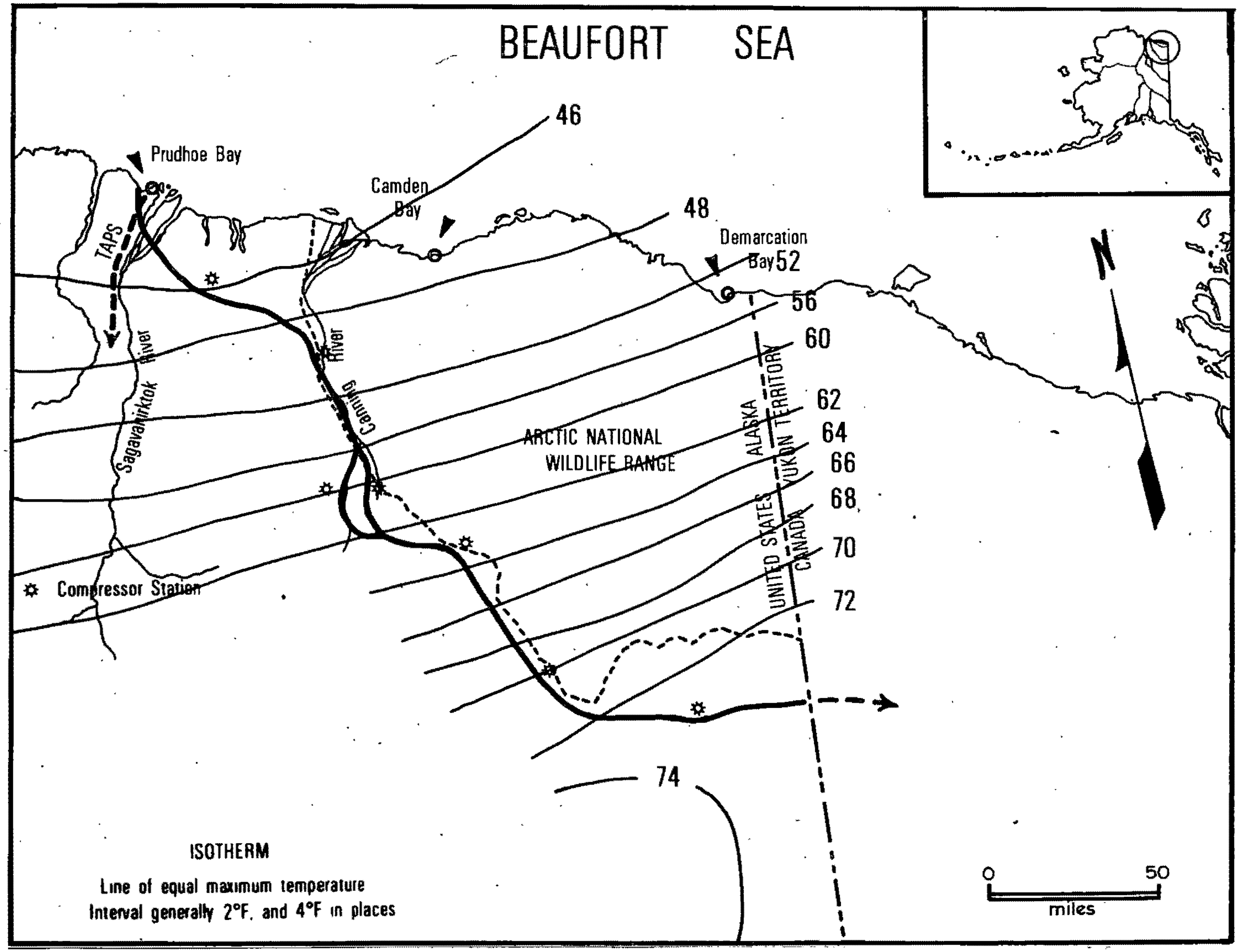


Figure 8.1.1.3-6 Climate, mean summer temperatures of the interior alternative pipeline route

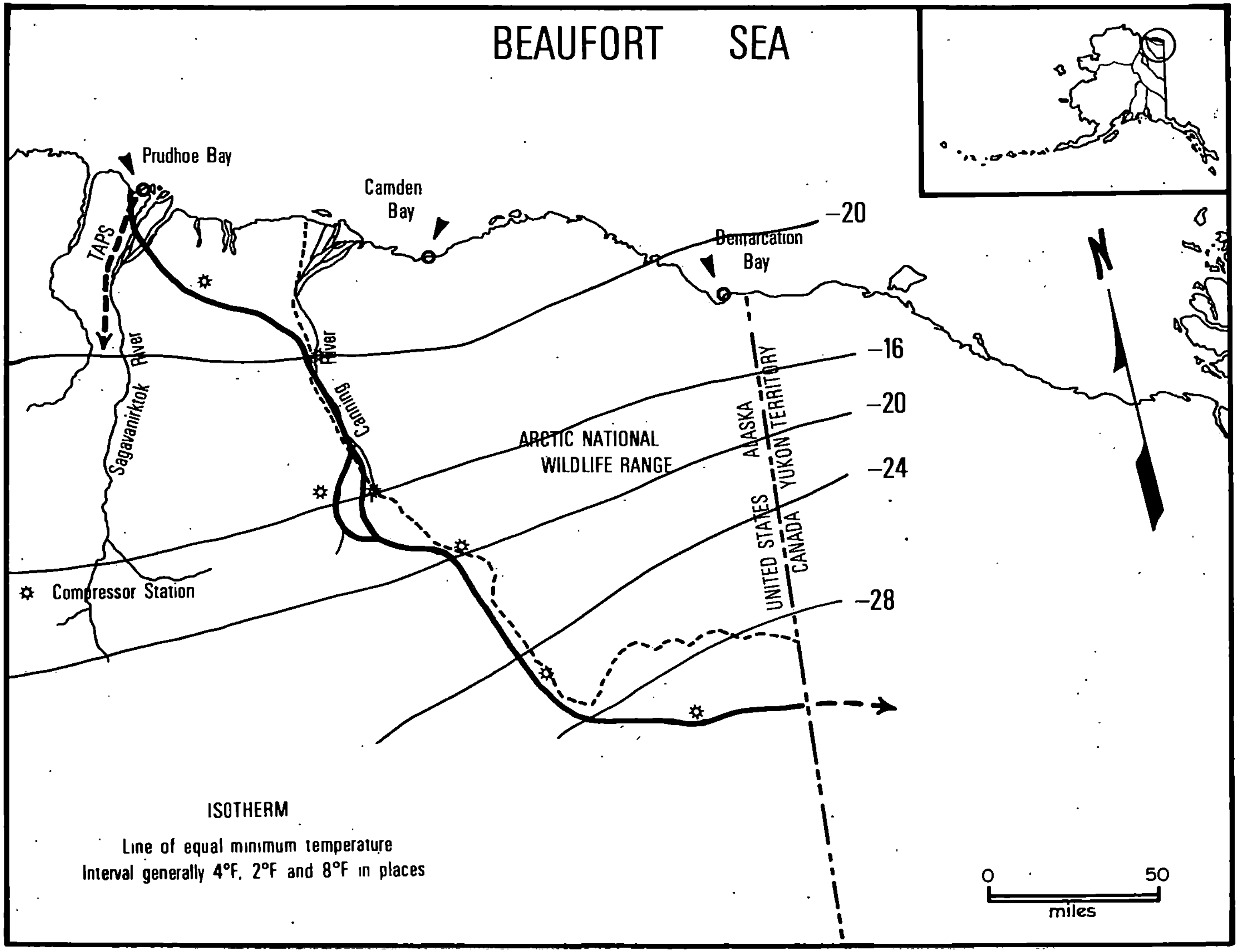


Figure 8.1.1.3-7 Climate, mean winter temperatures of the interior alternative pipeline route

drops again to less than 10 inches per year in the lowlands south of the Brooks Range. Refer to Figure 8.1.1.3-8.

Partial year records at Arctic Village show that the months of heaviest precipitation are in the summer, although the records indicate fairly uniform distribution throughout the year.

Wind conditions north of the Brooks are discussed in Section 3.1.1.1. South of the range, direction is variable with little seasonal pattern. Wind speeds generally range from about 3 to 7 miles per hour, although winds of 50 miles per hour have been noted. In passes across the Brooks Range, even higher wind speeds could occur.

No data are available from the Arctic Village area for wind velocities and direction. Data at other Interior stations, further removed from the route, indicate that wind speeds are generally lowest during winter and highest during summer.

Ice fog (ice crystals are suspended in the air), normal fogs, or blowing snows can cause locally dangerous conditions throughout the entire area. A more complete discussion of ice fog is contained in section 2.1.1.1. Although the Interior alternative route also involves operation of facilities, such as compressor stations, in mountain valleys and the interior Yukon basin of Alaska, the conditions for formation of ice fog are similar to those described for the applied-for AAGPC route. Dispersion of ice fog, however, will be different than on the Alaskan Arctic Coastal Plain in that mountain valleys will tend to confine ice fog to the linear geographic confines of the valley. On the south side of the Brooks Range, winter wind velocities are low and therefore, ice fog will not be quickly dispersed.

Topography

For the purpose of description, the Interior alternative route is subdivided into four physiographic divisions--Arctic Coastal Plain, Arctic Foothills, Brooks Range, and Porcupine Plateau. See Figure 8.1.1.3-9.

Arctic Coastal Plain

The Arctic Coastal Plain is a smooth plain rising imperceptibly from the Arctic Ocean to a maximum altitude of 600 feet at its southern margin. See Section 2.1.1.2 for a detailed description of the Arctic Coastal Plain.

After crossing the Sagavanirktok River, the Interior alternative route intersects the northeastern extension of the Franklin Bluffs. The maximum elevation in this area is about 300 feet above sea level and the ground slopes gently to the northeast at 1 to 5 percent.

Southeastward from Franklin Bluffs, the Interior route crosses relatively flat ground through the transition zone between the Arctic Coastal Plain and the Arctic Foothills. The major topographic features in this transition area are pingos, Kadleroshilik and Shaviovik Rivers, and numerous other streams which cross the Interior pipeline alignment essentially at right angles.

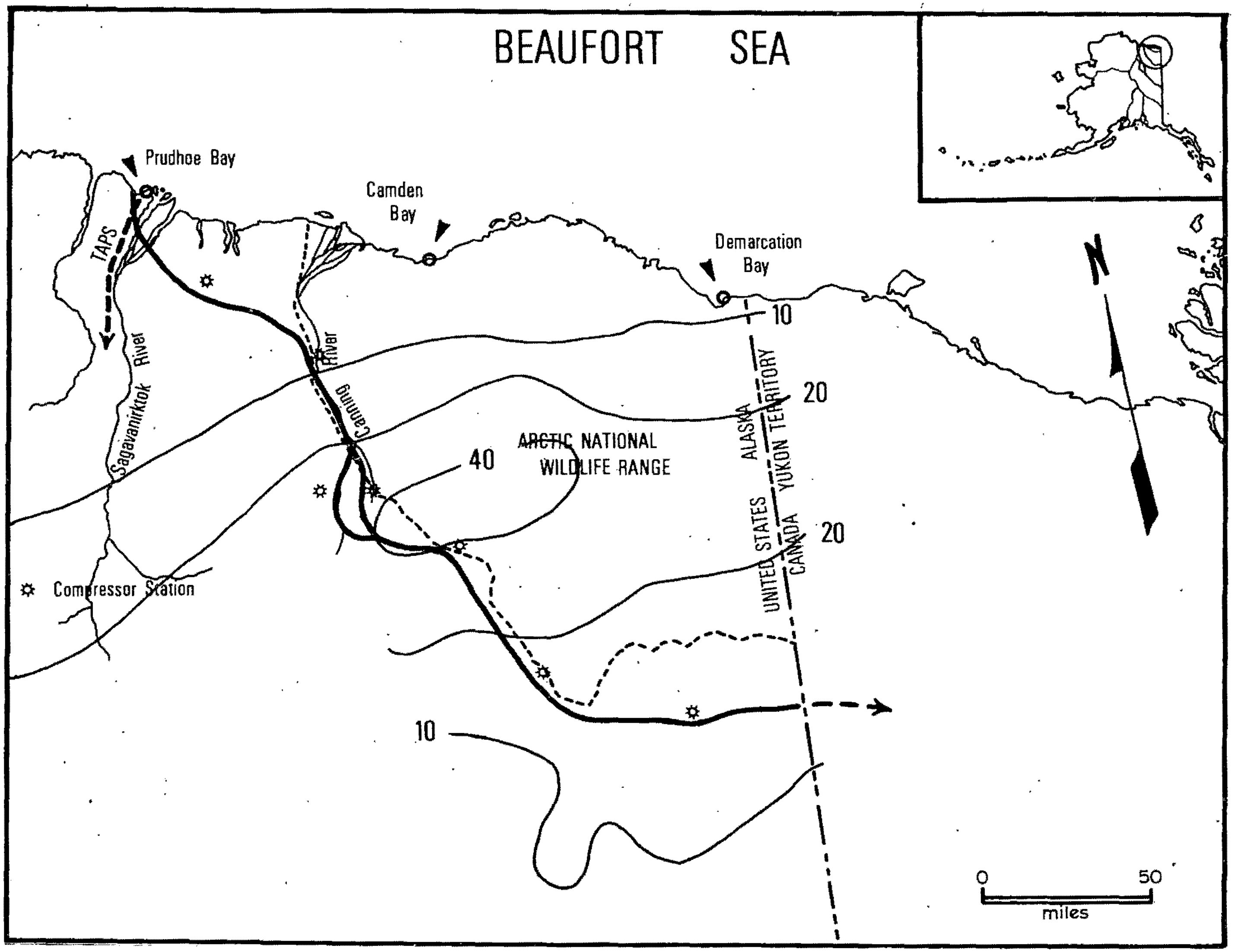


Figure 8.1.1.3-8 Climate, mean annual precipitation of the interior alternative pipeline route.

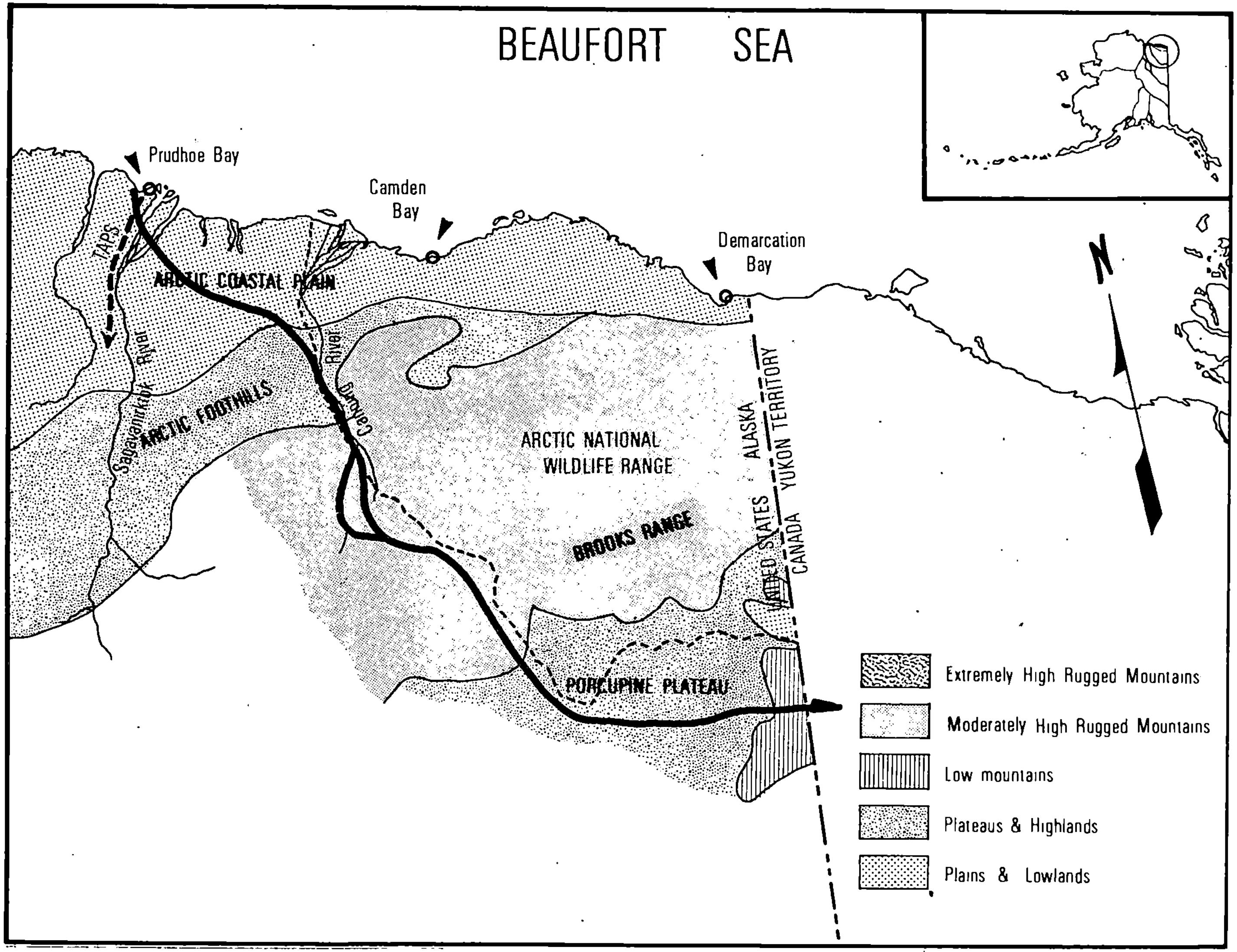


Figure 8.1.1.3-9 Physiography of the interior alternative pipeline route

Arctic Foothills

Between Mile Posts 40 and 96 the Interior alternative route crosses the Arctic Foothills. The Arctic Foothills in the vicinity of the alternative route are characterized by low, gently rolling hills, broad, U-shaped valleys, and flat-topped terraces. The Kavik River lies in a wide, flat-floored valley with bordering terraces at several levels. Subdued hummocky (glacial) topography is present on the long, high slope between the Kavik and Canning Rivers. The Canning River valley is 5 to 10 miles wide, very broadly U-shaped and liberally mantled with fresh glacial till producing a pronounced hummocky topography. The Interior route at Mile Post 50 follows the Kavik River upstream to where it crosses the divide between the Kavik and Canning River drainages at Mile Post 84. The route continues southward up the Canning River Valley to where the Canning River emerges from the Brooks Range at Mile Post 96. The last 8 miles are along the west side of the Canning River. In the Arctic Foothills the Interior route transects slopes in all directions: parallel, normal, and at angles to the contours.

The Kavik and Canning Rivers are swift, braided courses. Locally, they are covered in winter with extensive sheets of aufeis. A few thaw and morainal lakes are present.

Brooks Range

The route traverses the Brooks Range for approximately 110 miles between the entrance to the Canning River canyon and the area just north of Index Mountain (Mile Post 96 to 205). Two optional alignments for this passage have been selected and studied.

The Brooks Range contains a series of rugged glaciated east trending ridges that rise to generally accordant summits 7,000 to 8,000 feet in altitude. The mountains have cliff-and-bench slopes characteristic of glacially eroded bedded rocks. Abrupt mountain fronts face foothills and lowlands on the north.

The Continental Divide between the Bering Sea and Arctic Ocean drainages is approximately 5,000 feet in altitude along the proposed pipeline route and is surrounded by steep, rugged, talus-covered slopes. Major rivers (Canning) flow north to the Arctic Ocean and south (Chandalar, Sheenjek, Coleen) to the Yukon River in flat-floored glaciated valleys 1/2 to 2 miles wide. Small tributaries flow east and west parallel to the structure, superposing a trellised pattern on the broadly dendritic drainage. Large rock-basin lakes lie at the mouths of several glaciated valleys on the north and south sides of the range. For a glaciated area, however, the Brooks Range in general has few lakes.

The Interior Route, Marsh Fork Option, follows the canyon floor of the Canning River upstream from M.P. 107 to 133. Both the Marsh Fork of the Canning and Canning Rivers are in flat-floored valleys from 1 to 2 miles wide and mostly occupied by braided channels. Valley walls are steep, sloping 90 percent or more. Peaks on both sides of the flood plain rise to elevations in excess of 5,000 feet.

The Marsh Fork of the Canning River normally flows in only a few of its many braided channels except during the melt period in early summer when all channels are filled (Leffingwell, 1919). Average gradient is approximately 40 feet per mile; and water is seldom more than 4 feet deep. Most of the tributaries to the Marsh Fork flow in narrow, deep, steep-sided valleys that are 2 to 6 miles long, are spaced 1 to 4 miles apart, and trend at right angles to Marsh Fork. Tributary streams are up to 10 feet wide and generally less than a foot deep. Flows are intermittent.

The Interior Route leaves the Marsh Fork of the Canning River and crosses the Continental Divide near Mile Post 133. The maximum elevation in the Marsh Fork Option is approximately 4,600 feet.

The Canning River Option follows the Main Fork of the Canning River from approximately M.P. 107 to approximately 142, after which the Canning River and Marsh Fork Option Routes are again the same. Such an alignment would bypass the divide between the Canning River and the Marsh Fork.

The pass, about 5,000 feet in altitude, is in an area of extremely rugged terrain. Valley walls slope over 100 percent and the valley gradients are 10 to 30 percent. The valley floors are generally less than 100 feet across in the Divide area.

The Interior Alternative route then follows an unnamed tributary creek downstream for 5 miles and then downstream along Cane Creek, 15 miles to its confluence with the East Fork of the Chandalar River at M.P. 169, approximately 38 miles north-northeast of Arctic Village. The unnamed tributary of Cane Creek is contained in narrow steep-sided canyons. In the upper part of this drainage, canyon walls slope into the creek at gradients approaching 90 percent. The remainder of the tributary is somewhat wider (100 to 200 feet) and the canyon walls are less steep, but the active flood plain occupies most of the valley bottom. Cane Creek flows in a relatively broad, U-shaped valley, with the pipeline generally parallel to the active flood plain on the west side. Ground slope is relatively slight in the area of pipeline alignment, being on the order of 1 to 10 percent in a direction normal to the proposed pipeline route through the entire length of the Cane Creek segment.

It is the Cane Creek segment that the route begins to shift from a southerly direction to a more easterly orientation, generally paralleling the south slope of the Brooks Range on its course to the United States-Canada Border. Numerous alluvial fans and small streams are crossed.

The Chandalar Valley is 4 to 5 miles wide, flat-floored, with the river flowing in a braided channel more than 2 miles wide. At M.P. 169 the valley floor is 2,800 feet wide and spurs and ridges rise to about 6,500 feet. The valley walls are highly dissected and slope 20 to 80 percent. Along the Chandalar River, discontinuous morainal benches lie along the flanks of the valley and rise from 10 to 100 feet above the valley floor. The channels in the braided parts of the river are up to 200 feet wide, and in midsummer the water is up to 4 feet deep.

After leaving the Chandalar River, the route ascends to the headwaters of Old Woman Creek between M.P. 180 and 200 and passes to the north of Index Mountain near M.P. 205. Throughout this segment, topography is basically low ridges and shallow valleys on reasonably flat slopes. Hills are rounded, and maximum gradients seldom exceed 15 to 20 percent. Numerous pothole lakes are present in the flatter segments. This area is the transition zone between the Brooks Range and Porcupine Plateau provinces, and the routing follows this transition zone easterly for most of the remaining distance to the United States-Canada border.

Porcupine Plateau

Low ridges having gentle slopes rounding to flat summits 1,500 to 2,500 feet in altitude dominate the topography of the Porcupine Plateau; a few domes and mountains rise to 3,500 feet. Valley floors are broad. Valley patterns are irregular, having many imperceptible divides. The terrain is gentle sloping, generally ranging from 5 to a maximum of 10 percent.

Two major rivers, the Sheenjek and Coleen, are in the Porcupine Plateau. They rise in the Brooks Range and flow south across the plateau in broad valleys floored with outwash terraces. These rivers eventually empty into the Porcupine River south of the route.

A few moraine-dammed lakes lie in the broad glaciated valley east of Index Mountain. Grayling Lake, 5 miles east of the Sheenjek River, is the largest lake in this portion of the route. It is 2 miles long and 1 mile wide and lies in a broad silt-mantled valley bounded on the north and south by gently rising, smooth, bedrock-cored hills.

Broad flats are adjacent to Grayling Lake, and numerous lakes and swampy, muskeg areas are adjacent to the Coleen River. A north-south trending ridge is crossed between Grayling Lake and the Coleen River. Maximum elevation is approximately 2,000 feet above sea level.

East of the Coleen River the route follows the broad valley of Strangle Woman Creek and crosses some low north-south trending bedrock ridges just prior to entering Canada.

Geology and Soils

Mineral Resources

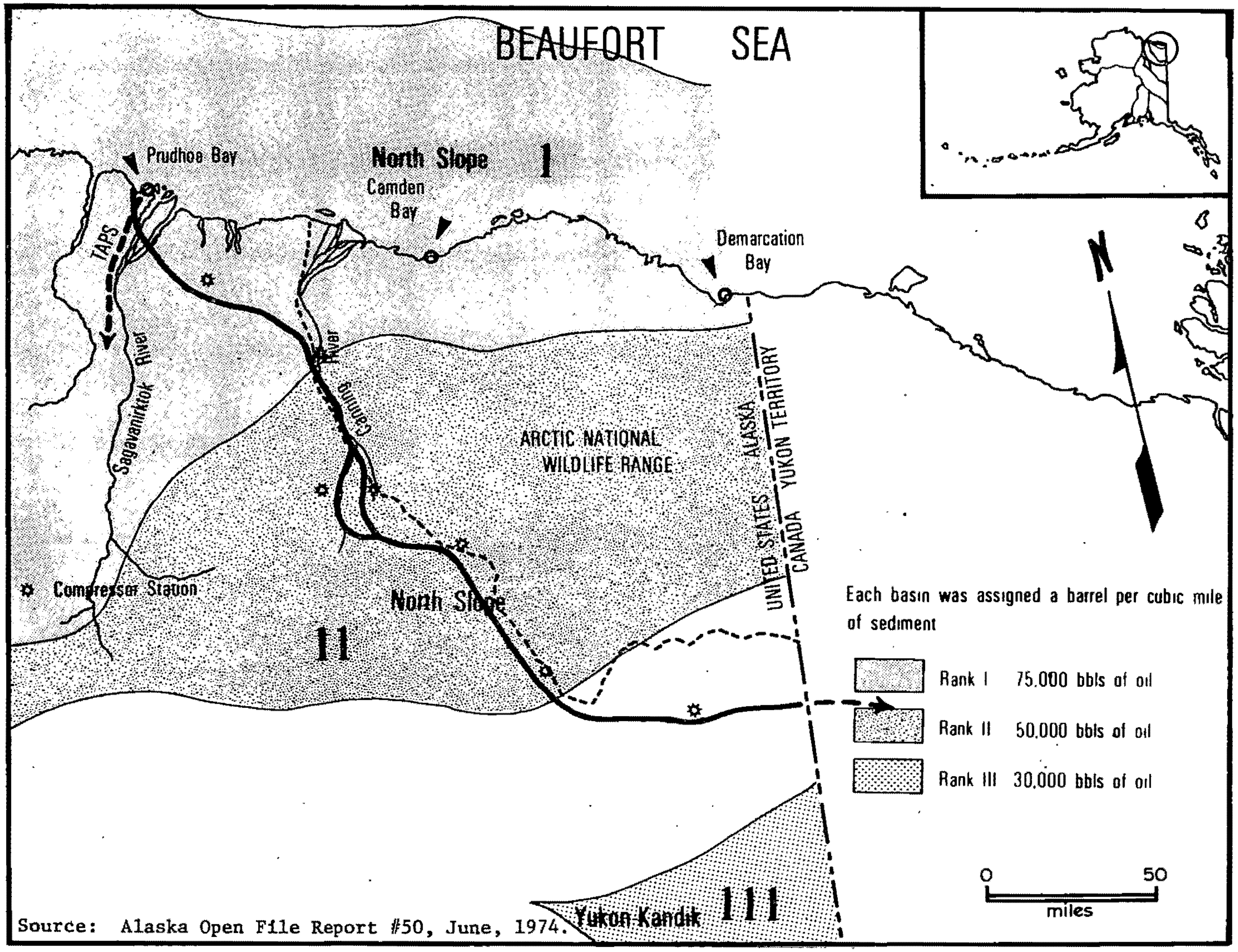
Petroleum potentials for the eastern part of the Alaskan Arctic Coast and specifically the Prudhoe Bay area are discussed in Sections 2.1.1.3 and 4.

On the south side of the Brooks Range the Interior route passes to the north of the eastern portion of the 19,504 square mile Yukon-Kandik Basin, estimated to contain 1.67 billion barrels of recoverable oil and 11.37 trillion cubic feet of recoverable gas (Alaska, 1974, Open File Report #50). The Kandik area -- a triangle of approximately 15,000 square miles bounded on the north by the Porcupine River, the south by the Yukon River and on the east by the United States-Canada border -- is, according to AAGPC "...ranked second as a producing prospect in northern and central Alaska..." (AAGPC, 1974a). See Figure 8.1.1.3-10. Initial exploratory drilling is scheduled to commence in early 1976 in the Kandik Basin. The basin is approximately 120 miles from its center to the Interior alternative pipeline system at the Coleen River (Mile Post 267). In discussing the Fort Yukon alternative routing (Section 8.1.1.4), AAGPC notes "...a route in Alaska from the Kandik Basin...will be desirable if developments in these basins prove out." (AAGPC, 1974a.)

The Interior alternative route is considered to involve areas where there is potential for development of large coal deposits. Refer to Figure 8.1.1.3-11.

Within the Canning River area the route is associated with warm water spring areas and therefore, is considered to have some potential for development of geothermal energy. There are no known plans to develop geothermal energy in that part of Alaska.

South of the Brooks Range the Interior alternative involves an area where there is good potential for gold, lead, copper, zinc, tin, tungsten and florite. However, within a 50-mile radius of the Interior Route on the



Source: Alaska Open File Report #50, June, 1974.

Figure 8.1.1.3-10 Petroleum provinces and basins of the interior alternative pipeline route

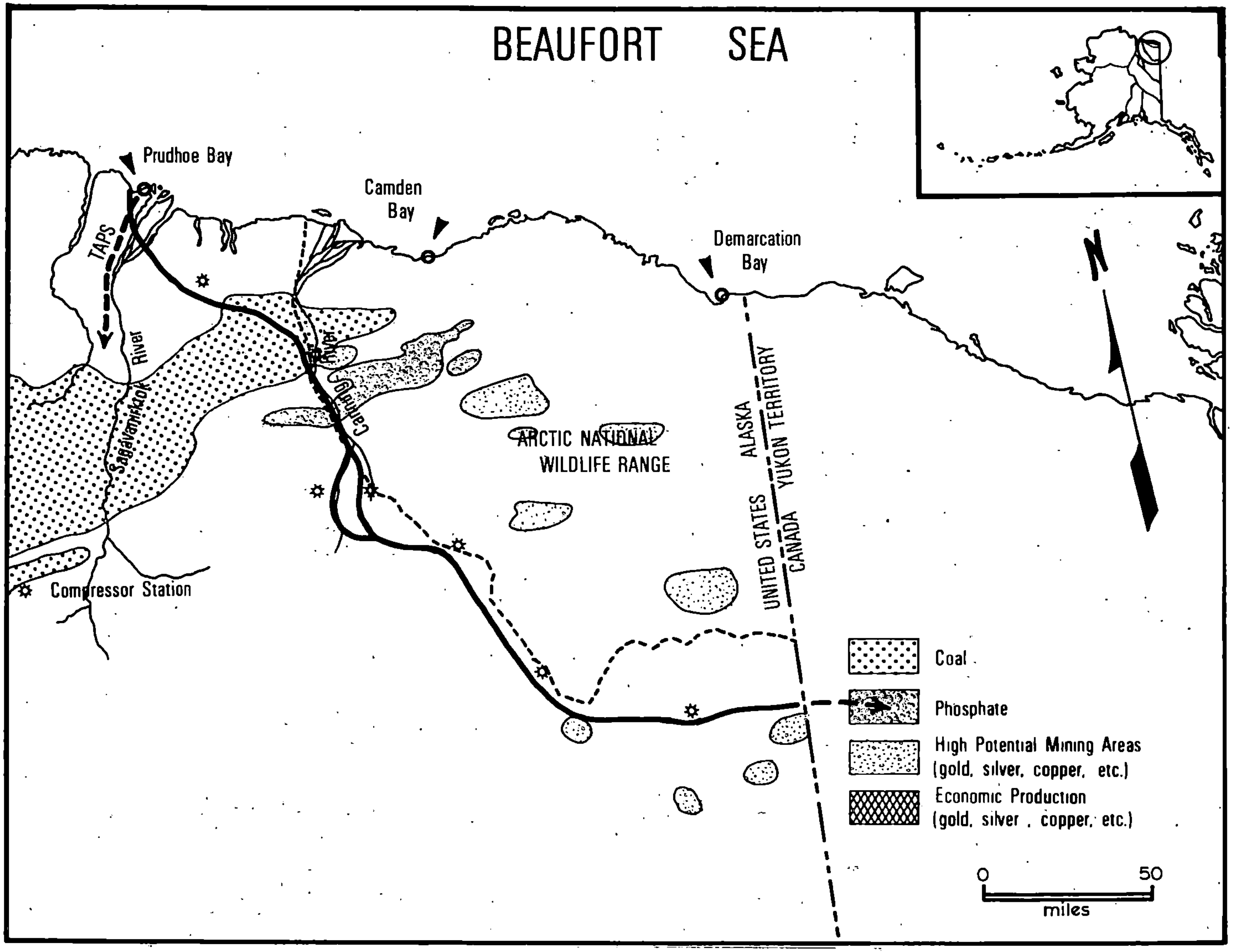


Figure 8.1.1.3-11 Minerals of the interior alternative pipeline route

south side of the Brooks Range fewer than 10 mining claims are recorded. At Bear Mountain, approximately 40 miles north of the Interior route, stream sediments around rhyolite dikes and plugs contain highly anomalous amounts of lead as well as anomalous amounts of zinc, molybdenum, and tungsten. Together with copper, and locally with silver, these metals also occur in the soil, and quartzs, galena, and chalcopyrite veins in and near the rhyolite (APG, 1974a).

Along the southside of the Brooks Range, two distinctly different regimes of magnetic character have been identified. The constant zone between the two magnetic areas roughly parallels, but is south of the bedrock surface contact between the locally mineralized older Paleozoic rocks (which trend into the southern Brooks Range mineralized belt) and the relatively unmineralized Paleozonic rocks to the north. According to the Geological Survey (APG, 1974) this zone suggests favorable mineral potential south of the contact zone. The contact zone between different magnetic areas trends southward across the Interior alternative route between the Sheenjek and Coleen Rivers.

The mineral character of the north side of the Brooks Range is described in Section 2.1.1.3.

The AAGPC has conducted preliminary reconnaissance grade evaluations, and selected sites where gravel can be obtained. Supplies of gravel are available to construct the Interior pipeline system.

Stratigraphy and/or Lithology

The Arctic Coastal Plain is underlain by from 10 to more than 150 feet of unconsolidated Quaternary marine sediments, made up largely of carbonaceous pebbly silt and silty sand overlying sandy gravel. These rocks rest on nearly flat-lying Cretaceous and, in several areas, lower Tertiary sedimentary rocks. Refer to Figure 8.1.1.3-12.

The northern part of the Arctic Foothills is underlain by semiconsolidated Tertiary sand and gravel and Cretaceous sandstone, siltstone, and shale. These rocks are predominantly gently dipping: however, locally they have been deformed into long linear folds. They are exposed west of the Kavik River in the low, smooth, broad hills where they are beyond the glacial drift cover. Bedrock is exposed only in small isolated localities in the southern foothills because of the extensive mantle of young glacial deposits. The bedrock in this area is gently folded and occasionally faulted. It is made up of quartzitic sandstone and siltstone, shale, and conglomerate ranging in age from Cretaceous to Permian.

Bedrock along the Interior alternative route within the Brooks Range north of the East Fork of the Chandalar River is chiefly Paleozoic limestone, quartzitic sandstone, conglomerate, shale, chert, and phyllite. The rocks are folded and faulted, with the folds commonly overturned.

In the Continental Divide area giant plates or nappes have been thrust upright to the north. Between the Chandalar River and Index Mountain the bedrock is progressively mantled with surficial debris, isolated hills, and mountains protruding. The rocks are conglomerate, chert, argillite, slate, quartzite, and limestone. Typically, all have been complexly folded and faulted.

West of the Coleen River the rocks are dominantly Paleozoic conglomerate, sandstone, shale, and limestone. Thick sills of gabbro,

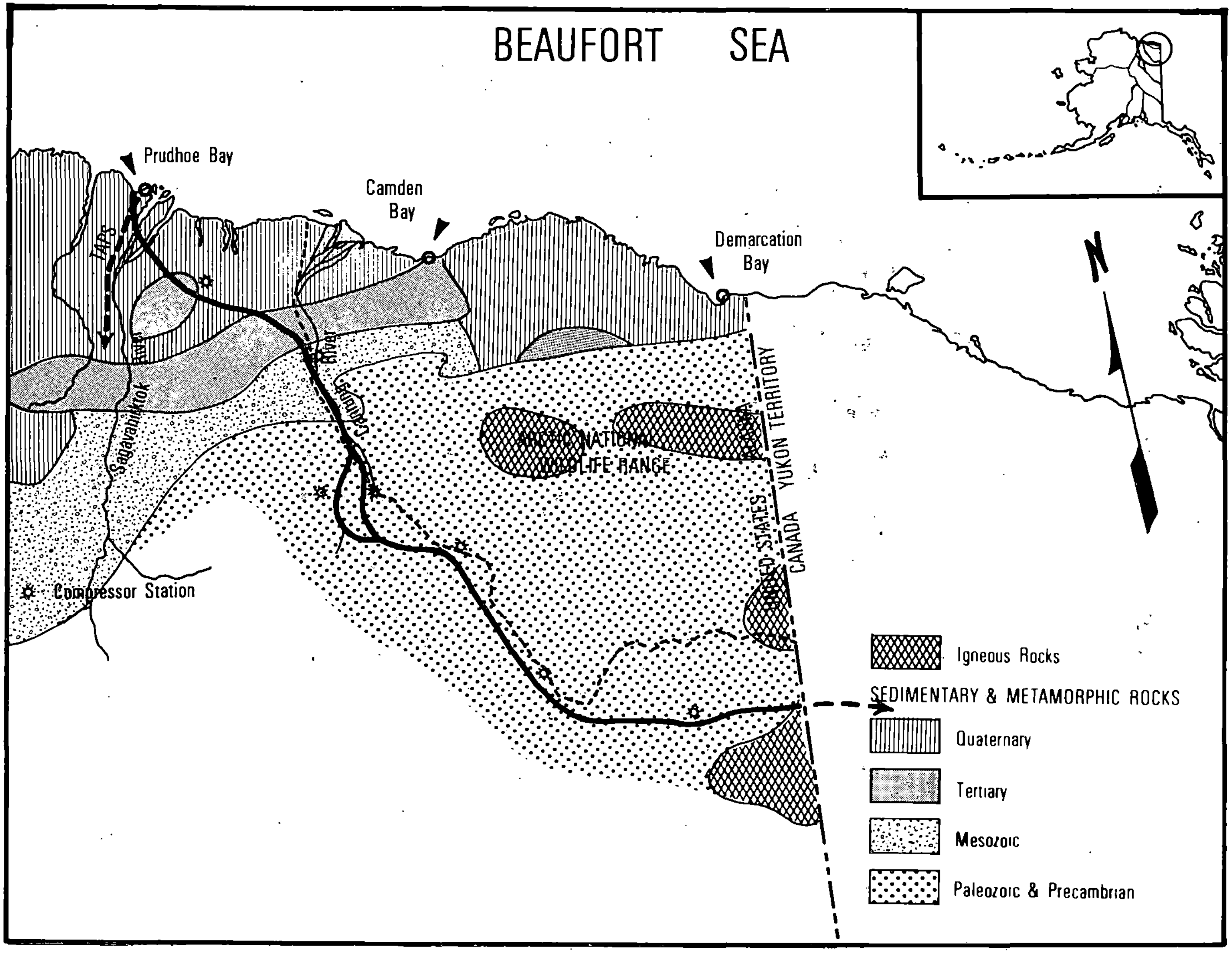


Figure 8.1.1.3-12 Geology of the interior alternative pipeline route

diabase, and quartzdiorite are intruded into the sedimentary rocks. The rocks are folded with gentle dips west of the Sheenjek River and steep dips between the Sheejek and Coleen Rivers (Mertie, 1930; Brosge and Reiser, 1969).

East of the Coleen River metamorphic rocks, chiefly quartzite, schist, phyllite and greenstone, occur as far east as the Alaska-Yukon boundary.

The route actually crosses bedrock outcrops at only two places in this subdivision. These are: (1) a small exposure of schistose sandstone on the low divide between the Sheenjek and Coleen Rivers, and (2) several narrow ridgetop exposures of semischist and phyllite at the headwaters of Potato Creek just west of the United States-Canada border.

Thick deposits of silt occur in the Foothill region. From M.P. 67 to the point where the Canning River emerges from the Brooks Range at M.P. 96, the predominant material along the route is glacial till, commonly mantled with 1 to 5 feet of organic-rich silt.

Thick sequences of sands and gravels are found on the active and inactive flood plains from the mouth of the Canning River to M.P. 107 (the point of separation for either the Marsh Fork Option or the Canning River Option). Deposits of till and ice contact deposits, intermingled with and generally overlain by colluvial debris and solifluction deposits are found on the lower valley slopes. These deposits are frequently interrupted by alluvial fans. The surficial materials are chiefly poorly sorted sand, silt, and clay, with some coarser materials.

In the Continental Divide area, surface material is primarily talus and rubble. Within the middle and lower portions of Cane Creek and the upper portions of Old Woman Creek, a veneer of generally frozen glacial silt, sand, and gravel is encountered. Locally these surficial deposits are ice-rich. Silt-rich solifluction debris becomes increasingly prevalent eastward from the Chandalar River.

Sand and gravel form the beds and bordering low terraces of the large braided rivers. A thin silt and muck mantle is present on the gravel terraces. East of Index Mountain and south along Monument Creek is till of several ages comprised of unsorted boulders and gravel mixed with sandy clay. The older till has been extensively covered with a silt-rich solifluction mantle on the slopes bordering Monument Creek. East of the Sheenjek River a moderately thick veneer of active solifluction debris, primarily fine sand and silt, covers the flats and adjacent hill slopes. Several feet of organic-rich silt and muck cover the solifluction debris and display streamline "horsetail" drainage on the slopes. On the uplands, frost rubble is extensive and covers many of the summits.

Additional information on surficial materials, particularly their stability, follows.

Permafrost

The Interior alternative system primarily is located in a region of continuous permafrost. Permafrost north of the Brooks Range is described in Section 2.1.1.3 for the applied-for AAGPC route.

South of the Brooks Range, the Interior alternative pipeline system is located in an area where continuous permafrost may occur. The route, however, is located in a transition zone between continuous and discontinuous permafrost and therefore, the chilled pipeline may or may not actually come in contact with permafrost. The absence of permafrost, or permafrost underneath a deep active layer, will occur where the route crosses major river valleys such as the Sheenjek and Coleen Rivers. Temporary access roads proposed to be used northward from Circle are located entirely in a zone of discontinuous permafrost.

Distribution and thickness of permafrost depend on the local glacial and climatic history, the thermal properties of the local sediment and rock, and the insulating properties and thermal balance of material at the ground surface. Figure 8.1.1.3-13 shows the general statewide distribution of permafrost.

Soils encountered along the Interior alternative route in the Coastal Plain are extremely ice-rich silt and fine sand overlying frozen sand and gravel. Massive and interstitial ice forms occur throughout the 5- to 15-foot thick mantle of silt and fine sand, but in the underlying several hundred feet of sand and gravel the ice generally occurs as coatings on clasts and as void fillings.

Massive ice forms and extensive interstitial ice are common in the silty soils in the Arctic Foothills. This condition is common along the route between the Shaviovik and Kavik Rivers. Massive ice forms are rare in flood plain sand and gravel, but occur in the silty soils on low terraces of sand and gravel. This condition is prevalent where the route parallels the Kavik River. Ice in the sand and gravel generally occurs as thin coating on clasts or as void fillings. The entire province is underlain by continuous permafrost. Ice wedges, stone stripes, and polygonal ground -- features of a frost climate--are common. Information gathered by the AAGPC indicates that high ice content soils will be encountered between Mile Posts 23 and 96 of the Interior alternative system.

Within the Brooks Range some unconsolidated deposits are ice-rich, especially the silt and clay-rich tills. Ground ice in the form of beds and lenses up to a foot or two thick are probably present in the moraines. Isolated masses of ground ice also probably occur along the braided channel of the Marsh Fork. Bedrock is free from ground ice, although its temperature is almost always below freezing. Data supplied by AAGPC show that high ice content soils will be found in some alluvial fans and some deposits.

Within the middle and lower portions of Cane Creek and the upper portions of Old Woman Creek, the route is underlain by a veneer of generally frozen glacial silt, sand, and gravel over bedrock. Locally these surficial deposits are ice-rich. Polygonal ground is common in the upper reaches of the valley of Old Woman Creek. From Mile Post 196 to the United States-Canada border soils are not expected to be ice rich. Morainal deposits resulting from glaciers flowing southward from the Brooks Range may create local conditions where ice rich soils will be found.

The section of the route between Index Mountain and the United States-Canada border lies near the southern edge of continuous permafrost. Ground ice is extensive along the major river flats and large blocks and wedges of ground ice are present in the till-rich areas. Polygonal ground is particularly evident in the Grayling Lake area and large amounts of ground ice are probably present. Ice mounds are common in the broad, flat valleys of the Sheenjek and Coleen Rivers. The active zone over permafrost is probably up to 4 feet thick. General soils information along the Interior alternative route is summarized in Table 8.1.1.3-3 and Figure 8.1.1.3-14.

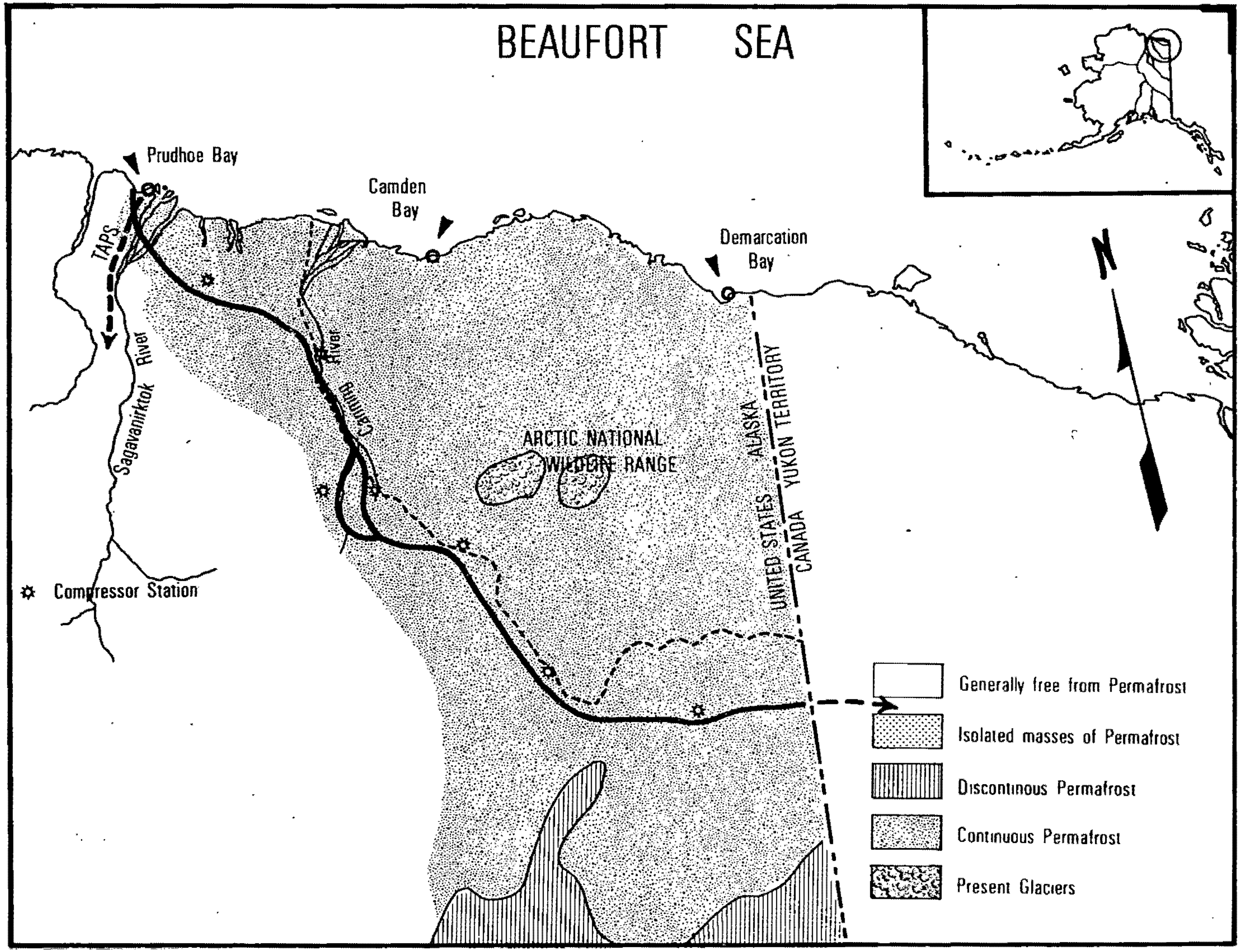


Figure 8.1.1.3-13 Permafrost and glaciers of the interior alternative pipeline route

Table 8.1.1.3-3 Soils of the interior alternative pipeline route

Soil	Description	Miles	Percent of Route	Location
1.	Poorly drained loamy soil with peaty surface layer	40	14	Rolling uplands and drainage adjoining
2.	Poorly drained loamy soils with overlying peat layer in association with well drained gravelly gray soils	33	11	South slopes of Brooks Range
3.	Poorly drained loamy soil with overlying peat layer in association with peat	36	12	Drainages in uplands adjoining south slopes of Brooks Range
4.	Poorly drained gravelly to sandy soils	12	4	Sagavanirktok River flood plain and terrace
5.	Poorly drained gravelly to sandy soils in association with well drained gravelly gray soils	17	6	Porcupine Plateau
6.	Poorly drained loamy soils with a dark upper layer in association with poorly drained loamy soils having an overlying peaty layer	62	21	Arctic Coastal Plain
7.	Well drained gravelly soils with a dark upper layer in association with poorly drained gravelly soils with a dark upper layer	23	7	Steep north slopes of Brooks Range
8.	Rockland	75	25	Brooks Range
	Total miles	295	100	

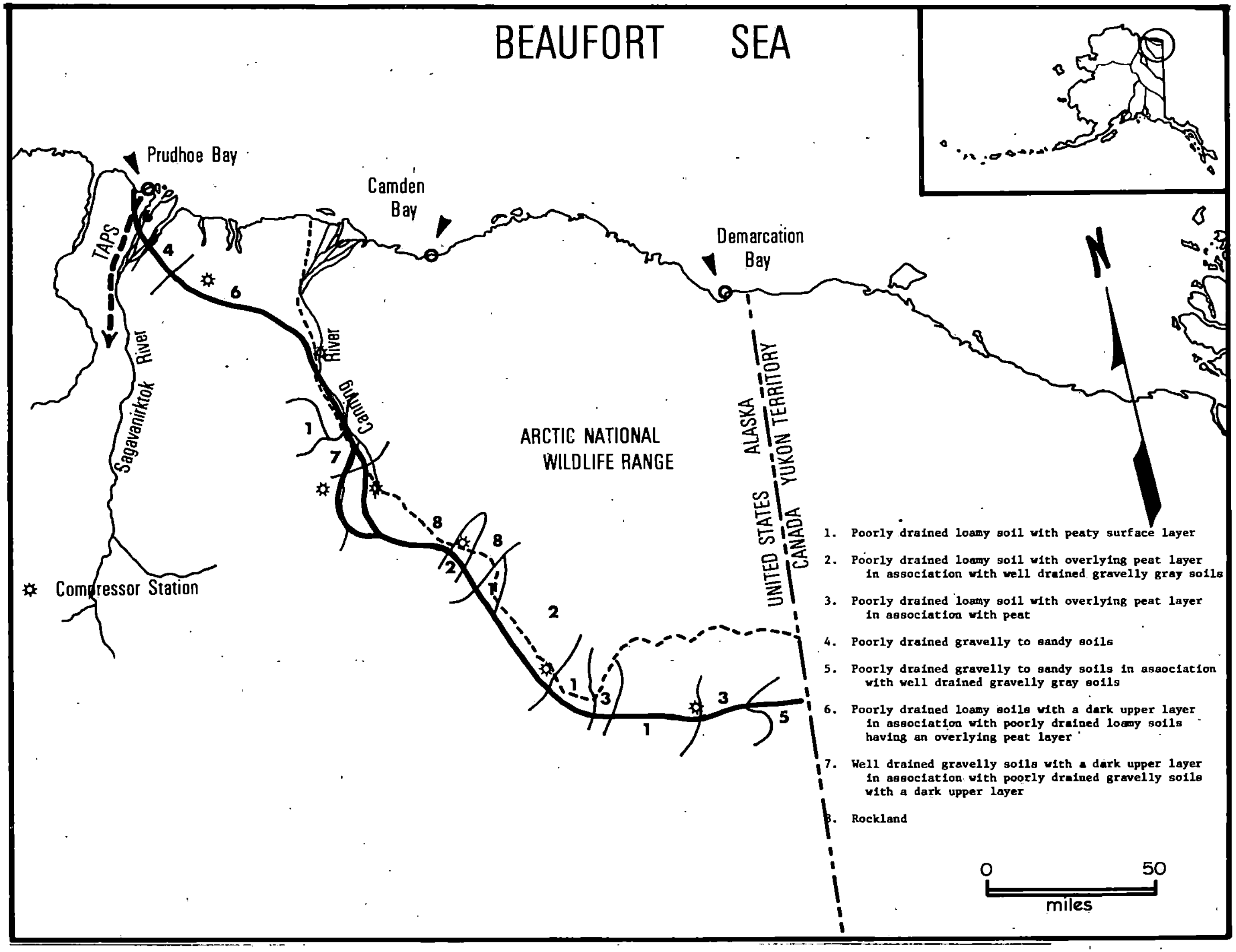


Figure 8.1.1.3-14. Soils of the interior alternative pipeline route

See applied-for route for a general discussion of Permafrost (Section 2.1.1.3).

Erosion, Landslides, Slumping, and Subsidence

The primary environment of erosion along the pipeline is at the major river crossings. Erosion is concentrated during the peak runoff periods of late spring and early summer as the water in the channels shifts from bank to bank, widening and forming new channels and scouring the channel floors. The buildup of ice at certain locations along the river during the winter (aufeis) can produce local flooding and significant channel shifts. In the Coastal Plain and Foothills, flooding erosion and aufeis occur along the Sagavanirktok, Kadleroshilik, Shaviovik, Kavik, and Canning Rivers.

Earthquakes

The level of earthquake activity along the alternative Interior route is similar to that described for the AAGPC applied-for route in section 2.1.1.3. The route lies entirely within zone 1 of the seismic risk map for Alaska published in the 1973 edition of the Uniform Building Code (International Conference of Building Officials, 1973, p. 123).

Since the mid-1960's, epicenters of at least four shocks larger than magnitude 4.0 have been located within 60 miles of the alternate route between longitudes 143° and 146° W. The uncertainties in the epicentral determinations are estimated to be on the order of 25 miles.

Soils

Physical characteristics and revegetation conditions of soils of the Interior Route are noted in Table 8.1.1.3-3.

The three principal soils occupying the coastal plain are described in the applied-for route (Section 2.1.1.4).

Soils along this route south of the Brooks Range are principally poorly drained, loamy soils with an overlaying peat layer and continuous shallow permafrost in the valleys with poorly drained gravelly to stony soils in the high valleys near the east end of the route. The potential for erosion on these wet soils following disturbances is moderate.

Gullying on hill slopes occurs when the organic mat is removed by natural erosional processes such as mass wasting, fire, or human activities such as mining or road construction. When permafrost melts at these localities, a small scar becomes the site of increased erosion and gullying as rain and meltwater are channeled into the newly formed gully.

Within the Brooks Range aufeis is extensive on the upper half of Marsh Fork, reaching thicknesses of 12 to 15 feet; single fields may be up to 3 or 4 miles long. Aufeis remains in the valley until as late as July. The river begins to freeze in mid-September but flow beneath the ice and overflow on the ice continues until late November. During this period, considerable hydrostatic head exists in the water confined beneath the ice; domes and ridges up to 15 feet high are formed where the water escapes (Leffingwell, 1919).

Scour and shifting channels are common along the Chandalar. From early June until early July, the river flows with a full channel and very swift current, carrying large quantities of driftwood. Aufeis is present on the Chandalar in the vicinity of the pipeline route. It is up to 10 feet thick and generally persists until late summer; in some years it does not melt completely.

Within the Arctic Coastal Plain, slopes are flat to gently sloping and mass wasting features are few. Summer melting of ice-rich silt results in periodic cave-off and slumping of the steep river and lake banks. Soil and organic mat-creep and solifluction are common (see Section 2.1.1.3).

In the Arctic Foothills, the ice-rich, silt-covered slopes are sufficiently steep to produce mudflows, small landslides, and widespread solifluction mantle. Where the organic mat insulative cover has been stripped, either naturally by mass wasting or artificially by man, vivid scars are evident on the landscape. Deep melting of the underlying exposed ice-rich sediments results in the development of small lakes in gently sloping areas and deeply eroded valleys (up to 20 feet deep) on steeper slopes. Such a scar is evident on the south slope of the Kavik River valley where the vegetative mat was removed by man along a straight line leading up out of the valley. Except on the steeper valley slopes, mudflows and landslides are rare in the Foothills area.

In the Brooks Range, valley walls are steep and talus and rock falls are prevalent. A few earth flows, mudflows, soil slips, and landslides are present on the steep slopes underlain by glacial silt. A small earth-mud flow of recent origin is present on the west side of the Canning River valley at approximately M.P. 104. It is developed in glacial till on the steep valley side slope. Talus and block rubble deposits are common on the sides and at the bases of the steep valleys near the Continental Divide.

Between the East Fork of the Chandalar River and the Alaska-Canada border, the proposed route is through terrain liberally mantled with solifluction deposits. These solifluction features look fresh, with many of the slopes displaying streamlined features and horsetail drainage. There are insufficient data to determine decisively the activity of the solifluction mantle in this area.

Water Resources

Surface Water

The Interior alternative pipeline route crosses 106 rivers and streams between Prudhoe Bay and the United States-Canada border (exclusive of rivers and streams crossed by the temporary access road northward from Circle, Alaska). On the north side of the Brooks Range, major river basins crossed are the Sagavanirktok, Kadleroshilik, Shaviovik, Kavik, and Canning Rivers. On the south side of the Brooks Range the route crosses the upper tributaries of the east fork of the Chandalar River and the upper segments of the Sheenjek and Coleen Rivers. In total, 12 large rivers and streams are crossed on the south side of the Continental Divide.

The number of streams directly involved with the Interior route is 106, and about 50 percent of the system (150 miles) is located parallel to and not more than 1 mile from these streams.

No glaciers are associated with the Interior route. There are, however, small residual glaciers along the Continental Divide.

Stream gage data are available, and have been published by the U.S. Geological Survey for the State of Alaska, on the Sagavanirktok River on the Arctic Slope. None of the rivers on the south slope have been gaged.

On both the north and the south sides of the Brooks Range, flooding is caused by the spring breakup in late May or early June. Other periods of high waters are caused during the summer months by local heavy rainstorms.

Seasonal runoff is characterized by high flow in the spring, a gradual decrease during the summer (except for local heavy rainstorms) and virtual cessation of flow during the winter season.

The quality of water on both the north flank and the south flank of the Brooks Range is good. Dissolved solids content of waters generally averages less than 200 milligrams per liter (mg/l) and no appreciable amount of iron is present in the waters sampled. All of the waters are of the calcium bicarbonate type and would be acceptable for most uses. Ward and Craig (1974) indicate there are different water chemistry characteristics between streams on the north side of the Continental Divide and those on the south. Dissolved solids tend to be lower on the south. This is probably due to smaller size of the drainage area upstream from the Interior route location and difference in basic geologic outcrops (see Section 8.1.1.3.).

Ground Water

At ground surface, ground water movement is controlled generally by thawed alluvial deposits in major stream valleys and the direction of movement is down the stream valleys. A number of springs exist on both sides of the Brooks Range and are shown on Figure 2.1.1.5-1. The Interior route is close to a number of springs in the Canning River area. These are similar to those described in the AAGPC applied-for route in Section 2.1.1.5.

Quality of ground water from the springs and beneath rivers is generally good. The water beneath rivers reflects the quality of the surface water and probably contains fewer dissolved minerals than do the spring waters. Ground water trapped beneath permafrost is likely to have a high mineral content.

No data are available on recharge rates of the ground waters in the area along the Interior pipeline route.

Vegetation

Except for the Arctic Coastal Plain, there has been relatively little study of the plant life along the general location of the Interior route.

As noted in Section 2.1.1.6, permafrost plays a very important role in determining the variety of plant life capable of living in the Arctic.

Vegetation Types

The Joint Federal-State Land Use Planning Commission for Alaska identifies seven broad vegetation types traversed by the Interior alternative route as shown on Figure 8.1.1.3-15. These are from north to south and east: "Wet Tundra," "Moist Tundra," "High Brush," "Alpine Tundra," to the top of the Brooks Range and then descending to the south and east "Alpine Tundra," "High Brush," and "Upland Spruce-Hardwood Forest"

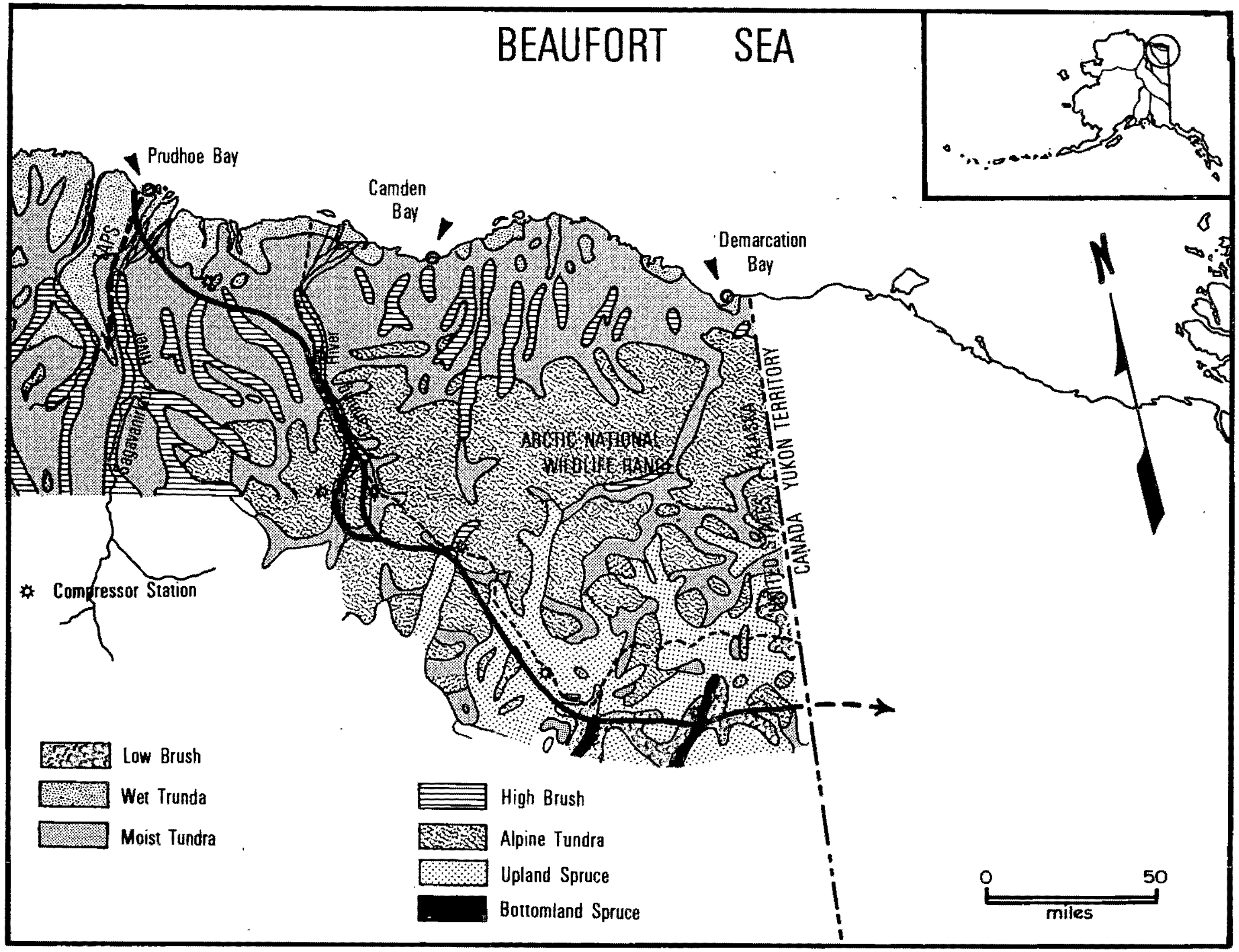


Figure 8.1.1.3-15 Vegetation of the interior alternative pipeline route

interspersed with "Low Brush, " "Muskeg-Bog," and "Bottomland Spruce-Poplar Forest" along the Sheenjek and Coleen Rivers (RPT, 1973).

These seven broad vegetation types are found along the 297.5-mile long Interior route as follows in Table 8.1.1.3-4.

Wet and Moist Tundra and High Brush plant associations are described in detail on the applied-for AAGPC pipeline route in Section 2.1.1.6. These associations are considered typical of similar groupings of plants along the Interior route.

The following four vegetative types are not found in the Arctic Coastal Plain or Arctic Foothills areas associated with the applied-for route: Alpine Tundra; Upland Spruce-Hardwood Forest; Low Brush; Muskeg-Bog; and Bottomland Spruce-Poplar Forest.

Alpine Tundra systems occur on rocky ledges and mountain tops above 2,500 feet in the Brooks Range. Soils are well-drained, shallow, stony, gravelly, loams, and silt loams over coarse rubble and bedrock on ridges, steep slopes, and mountain tops.

This system often consists of barren rocks and rubble interspersed with low mats of herbaceous and shrubby plants. White mountain-avens are dominant and may cover entire ridges and slopes. Associated species are resin birch, dwarf arctic birch, cassiope, crowberry, alpine-azalea, Labrador tea, mountain heath, rhododendron, arctic willow, dwarf blueberry, bog blueberry, and cranberry.

Upland Spruce-Hardwood Forest is found to an elevation of 2,000 feet--the approximate treeline on the south side of the Brooks Range--on slopes of mountains, ridges, and low mountains. Sites with permafrost often support black spruce-hardwood while soils on north slopes are shallow and gravelly with continuous permafrost. On the south-facing slope of the Brooks Range this vegetation type occupies well-drained, shallow, gravelly terrace soils and shallow silt loams on adjacent slopes.

Dense forests of white spruce, birch, aspen, and poplar grow on better sites. Root depths are shallow and fire scars common. White spruce between 40 and 80 feet high and up to 16 inches in diameter may be found on south slopes with well-drained soils. Along streams white spruce occur in pure stands and mixed with aspen and birch. Poplar, 80 feet in height and 24 inches in diameter, are found locally along streams.

Undergrowth is comprised of mosses with grasses on dryer sites and brush on moist slopes. Associated plants are willow, alder, ferns, rose, high- and low-bush cranberry, raspberry, currant, and horsetail.

Low Brush, Muskeg-Bog systems occur on the southern drainages of the Brooks Range on peat of varying thicknesses over poorly drained, deep, sandy or silty loams. Extensive bogs are found where conditions are too wet for tree growth.

Plant composition is varied but generally consists of sedges, sphagnum, and other mosses, bog rosemary, resin birch, dwarf arctic birch, Labrador tea, willow, cranberry, and blueberry in differing combinations.

Bottomland Spruce-Poplar Forest occupies water deposited soils in river valleys and adjacent slopes along the Coleen and Sheenjek Rivers up to an elevation of about 1,000 feet.

Table 8.1.1.3-4 Vegetation types

Vegetation Type	Approximate % of Total Length
Wet Tundra	6
Moist Tundra	26
High Brush	15
Alpine Tundra	18
Upland Spruce-Hardwood Forest	24
Low Brush, Muskeg-Bog	9
Bottomland Spruce-Poplar Forest	2
Total	100

These sites support white spruce, locally mixed with cottonwood or balsam poplar. The cottonwood poplar are considered successional stages preceding the climax white spruce community. Undergrowth is usually dense and comprised of both high and low shrubs such as American green alder, thinleaf alder, willow, rose, dogwood, Labrador tea, and berry bushes. The forest floor is usually carpeted with ferns, bluejoint, fireweed, horsetails, lichens, moss, and herbs.

The seven broad vegetation types described by the Joint Federal-State Land Use Commission for Alaska are variously lumped or split by plant scientists investigating Alaska and Canada. Consultants for AAGPC have split the seven types and have mapped 22 vegetation types along the Interior route on 1,250,000 scale aerial mosiacs (AAGPC and CAGPL, 1974, Alignment Sheets, Interior Alternative Pipeline Route). These types are listed in Table 8.1.1.3-5.

Unique or Threatened Plant Communities

The National Herbarium of the Smithsonian Institution has compiled a list of endangered plant species which includes 35 species found in Alaska. One of these, <u>Thlaspi arcticum</u>, a member of the mustard family, occurs on the Arctic Slope and Hulten (1968) lists it as being very rare, with only single specimens collected.

Two other members of the mustard family which may occur in the Brooks Range are also listed as endangered by the National Herbarium. <u>Lesquerella arctica</u> var. <u>Scammanae</u> and <u>Smelowskia borealis</u> var. <u>villosa</u> are small plants which grow on dry mountain slopes and ridges and on rockslides.

Fire Hazard

This route passes through two zones with different wildfire characteristics: Tundra and the Northern Boreal Forest (taiga). Tundra plant associations are considered to have low potential for wildfire, but fire does occur. For a discussion of tundra fires see section 2.1.1.6 (AAGPC applied-for route). Slaughter et al (1971); Rowe and Scotter (1973); Vierick (1973); and Strang (1973) indicate absence of fire in northern forest-tundra woodlands causes site degradation. Depth of thaw decreases; spruce and other trees are eliminated, and a moss/lichen association succeeds the forest. For these and other reasons, fire is now recognized as a necessary rejuvenating influence in the Boreal Forest.

Wildlife

The Interior alternative pipeline route follows the southwestern and southern boundary of the existing Arctic National Wildlife Range and bisects a portion of the proposed extension. Accordingly, the following discussion is based upon data presented in the Final Impact Statement on that area (APG 1974) and on information furnished by the Applicant (AAGPC, 1974a, V-B 1.2).

Dominant mammalian species associated with the Interior route include large mammals of widespread public interest--polar bear, grizzly bear, black bear, musk oxen, moose, caribou, Dall sheep, and wolves. Small mammals include arctic and red foxes, wolverine, lynx, otter, beaver, marten, coyote, mink, weasel, porcupine, and various hares. Among the smallest mammals are voles, lemmings, squirrels, shrews, and hoary marmot. A total of 44 species of mammals is found along the route.

Table 8.1.1.3-5 Major vegetative types along the interior alternative pipeline route

Vegetation Type	Arctic Coastal Plain	Arctic Foothills	Brooks Range	Southern Foothills	Western Porcupine Plateau
Sand dune and strand	B	D	D	D	D
Wet Sedge meadows	A	A	B	D	B
Tussock-dwarf heath tundra	A	A	D	D	D
Dwarf shrub-heath tundra	A	A	B	D	D
Tall willlow shrub	B	B	B	B	D
Shrub-sedge meadow	A	B	C	A	D
Herb-lichen tundra	B	B	B	B	D
Shrub tussock tundra	B	A	D	D	D
Sedge-cottongrass meadow	C	C	B	B	D
Dry sedge meadow	D	D	B	D	D
Willow-blueberry alpine shrub	D	D	A	D	D
White spruce shrub savannah	D	D	C	C	B
Boreal forest (white spruce, balsam poplar)	D	D	C	C	B
Barren-lichen rock	D	D	B	C	D
Heath shrub	D	D	D	B	D
Willow-dwarf birch shrub	D	D	C	A	D
Sedge-mountain avens meadows	D	D	D	D	D
Dwarf-medium tall shrub	D	D	D	D	A
White birch heath shrub	D	D	D	C	D
Heath-willow shrub	D	D	D	D	B
Tall willow-alder shrub	D	D	D	D	B
White spruce-sedge muskeg	D	D	D	D	B

Legend: A = Vegetation type occurs frequently and covers a large area

B = Vegetation type occurs frequently but is more limited in the area it covers

C = Vegetation type occurs infrequently and is limited in extent

D = Vegetation type absent or extremely limited

*Source: AAGPC, 1974a

Caribou

The Porcupine Caribou Herd (115,000 to 120,000 animals) frequents the entire area crossed by the Interior alternative route. The Arctic Coastal Plain in Alaska and Canada is the traditional calving area for this herd. The calving area and its importance to the Porcupine Herd is discussed in Section 2.1.1.7 (applied-for AAGPC route).

The Porcupine Caribou Herd winters south of the Brooks Range, principally in Canada, but also in Alaska. Mountain passes and river valleys through the Brooks Range are used as migration routes in seasonal movements of caribou between the calving grounds and the wintering areas. The Canning River is one of the important migration routes in Alaska used by the Porcupine Caribou Herd. It should be noted, however, that the frequency and numbers of caribou using passes through the Brooks Range in Alaska are unpredictable and appear to be directly related to whether most of the herd winters in Alaska or Canada. Refer to Figure 8.1.1.3-16.

Studies by the AAGPC (1974a) show that the Interior alternative routing in the vicinity of Strangle Woman Creek drainage between the Sheenjek and Coleen Rivers and Old Woman Creek (Figure 8.1.1.3-2) tends to be a major caribou crossing area. Additionally, the Interior alternative pipeline system is located in valleys which tend to become east-west migration routes of the Porcupine Herd as it moves along the south side of the Brooks Range in spring, fall, and early winter.

Dall Sheep

Important habitat for Dall sheep is associated with the Interior alternative pipeline route. The largest concentration of Dall sheep in the eastern Brooks Range--estimated to be at least 1,000 animals--is located in the Canning River drainage. Smaller populations of Dall sheep are located along Cane Creek and in the headwaters of Old Woman Creek. Studies by AAGPC (1974a) show that approximately 500 Dall sheep (50 percent of the total population in the Canning River drainage) wintered along the Interior alternative route. Lambing (mid-May to mid-June) is thought to occur close to the wintering grounds.

Summer range is not a critical factor in the sheep population dynamics, but winter range and lambing areas are important (ADF&G, 1973). Also extremely important in population distributions of Dall sheep are mineral licks. The Interior alternative route is associated with both winter range and lambing areas and the route is directly associated with six mineral licks (AAGPC, 1974a).

From November until April, sheep are concentrated on winter ranges which are generally found adjacent to the mouths of canyons.

In early winter as the snowline descends and lowlands become snow covered, sheep descend to their wintering ground on windswept ridges and promontories. At times during winter they climb to higher altitudes to find exposed vegetation. During this season, sheep are quite confined to these restricted ranges.

Dall sheep breed from late November through mid-December. Lambing occurs from mid-May to mid-June, with most lambs born prior to June 1.

With the approach of spring, sheep concentrate on south-facing slopes in valley bottoms where vegetation first becomes green, but may be seen in

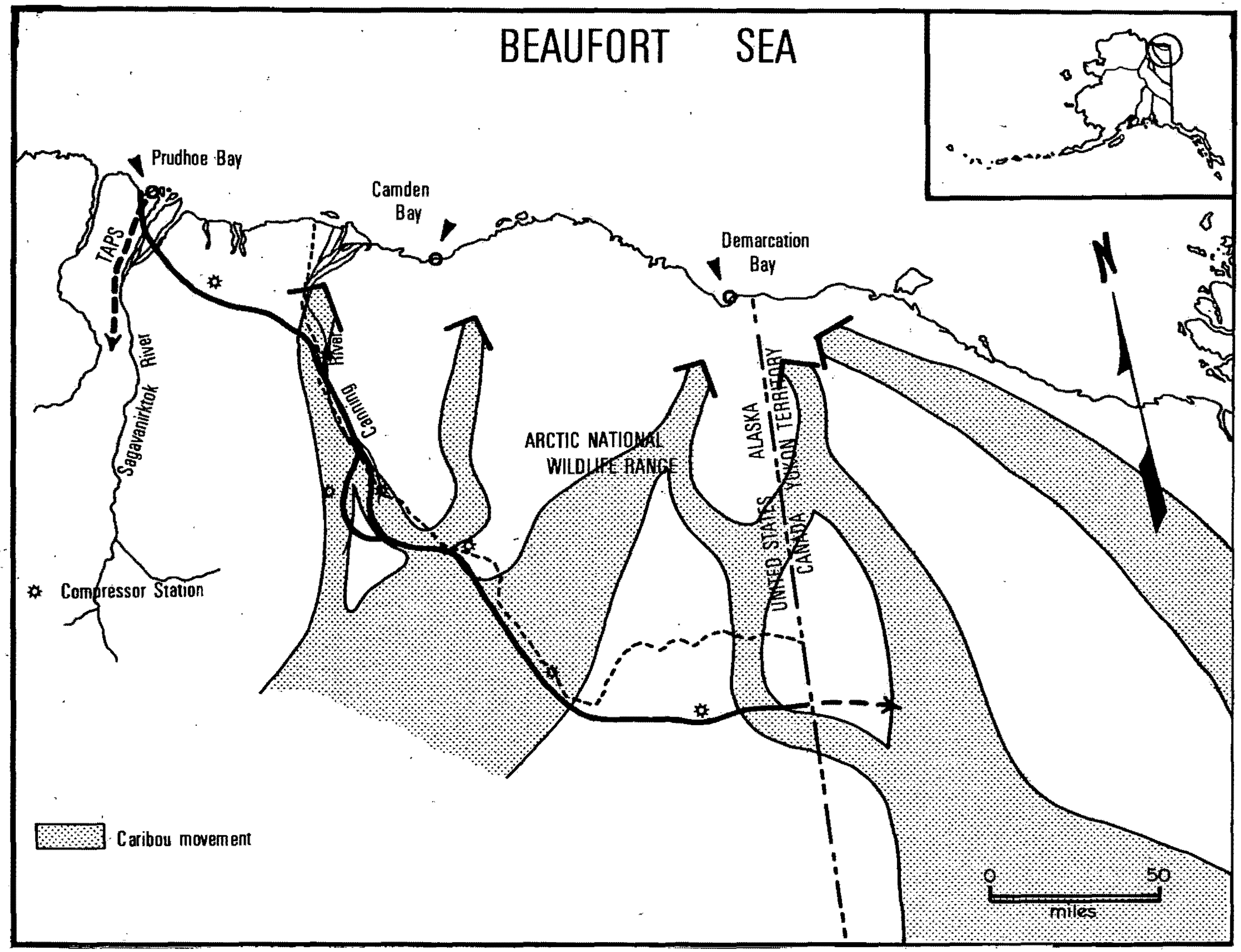


Figure 8.1.1.3-16 Caribou movement of the interior alternative pipeline route

valley bottoms at any time of the year. Dall sheep are seldom far from escape terrain.

During the hottest summer weather, sheep frequently climb to terrain above 6,000 feet where temperatures are cooler and insects less bothersome. During average summer weather they are frequently seen on green alpine meadows between 3,000 and 4,000 feet elevation.

During the fall (mid-August to mid-October), Dall sheep utilize low mountain slopes, alluvial fans, and valley bottoms, feeding within the shorter and less dense stands of willow. Summer range is also used during the fall. The Cane Creek area of the Interior alternative routing received its greatest sheep use during this period of the year.

Although sheep move throughout an entire drainage, the pronounced concentration appears to be in conjunction with mineral lick utilization. Sheep apparently travel many miles along established trails to reach a lick (AAGPC, 1974a).

Winter climate is the primary mortality factor although Dall sheep are subject to predation by wolves, coyotes, golden eagles, and lynx. Except for man, wolves are the only predators to significantly affect adult sheep.

Hunters annually kill over 100 rams in the entire Brooks Range. According to the FWS (APG, 1974), the harvest of Dall sheep within the Arctic National Wildlife Range is unknown, but believed to be fewer than 25 animals.

Musk Ox

A band of musk oxen was released near Barter Island in 1969. This constituted reintroduction of a species to its natural habitat following extirpation in the early twentieth century. The Interior route traverses summer range utilized by portions of this band north of the Brooks Range. Musk oxen are found in the upper Kavik and Canning Rivers west of the Shublik Mountains and Shublik Island during July, August, and early September.

During 1973, a band of musk oxen consisting of eight adults, two yearlings, and one calf was observed east of the Canning River. The southernmost observation of this group (AAGPC, 1974a) occurred in the vicinity of Red Hill about 10 miles east of the Interior route near the Canning River. An additional single individual was occasionally sighted about 10 miles north of the route near the Kavik River. A single sighting of a lone individual also occurred near Shublik Island during mid-August.

South of the Continental Divide, the Interior route traverses former musk oxen habitat. Currently, musk oxen do not exist in the Brooks Range or on the Porcupine Plateau in Alaska.

Moose

Distribution of moose on the northern flank of the Brooks Range is discussed in Section 2.1.1.7 for the applied-for AAGPC route.

Almost all moose habitat associated with the Interior route north of the Continental Divide, and much of the important habitat south of the Brooks Range, is concentrated in river valleys and streams and is in direct relation to the abundance of riparian willow stands.

The Interior alternative route first intersects winter moose habitat in the Kavik River Valley. South of the Continental Divide and east of upper Old Woman Creek, larger areas of less concentrated habitat occur in the form of broad flood plains, laced with ponds, lakes, and their inlet and outlet streams. Such areas provide particularly good moose habitat during the summer months.

Studies by AAGPC (1974a) confirm that habitat encountered along the Interior route is that of the Canning drainage. North of the Continental Divide, moose distribution is more limited by what are often widely separated sources of winter browse. Moose habitat exists at the mouth of Cane Creek and north-south within the East Fork Chandalar Valley. South of the Continental Divide, moose appear more evenly distributed and widespread. Here, excellent habitat such as Old Woman Creek, Strangle Woman Creek, Monument Creek, and Sheenjek and Coleen River Valleys are crossed by the Interior route. During late summer and fall when rutting groups form, it is common to encounter a few scattered groups containing as many as 12 animals in the headwaters of small side drainages and on the slopes of Index Mountain (Mile Post 205).

Bears

The barren-ground grizzly bear is probably best regarded as an "ecotype," or population adapted to the tundra environment. It is the most northerly and smallest in size of six loosely defined brown-grizzly bear "ecotypes" and inhabits the northern parts of Alaska and the Yukon in Canada from tree line of the Brooks Range to the Arctic Coast.

The grizzly bear is a wanderer, traveling in circuitous routes during the summer and sometimes returning to the same den in the fall. Its reproductive rate is low, and the animal matures more slowly in the Arctic than in its range farther south. Longer periods of parental care seem necessary. Females may not breed until they reach 6 years of age.

The grizzly bear is present throughout the entire region traversed by the Interior route, but density along segments of the route vary. These animals are less abundant on the Arctic Coastal Plain, which appears to be utilized primarily as mid-summer range, while the Arctic Foothills and Brooks Range are utilized more intensively during all seasons that bears are active. Major river valleys, such as the Kavik, are preferred habitat in the Foothills, although the entire region is used to a limited extent as a summer foraging area. Limited denning has been observed in the Foothills, where sites usually occur in river or stream banks.

The Canning River and Marsh Fork Valleys are important grizzly bear habitat. The valley bottoms, particularly the willow stands, are utilized intensively during the spring and fall for foraging and as a travel route to and from denning areas. Denning occurs from early October until mid-April for the majority of bears, though variation in timing is common. Naturally occurring rock caves or dug dens located on mountain slopes are utilized.

The East Fork Chandalar Valley is an important area for the grizzly bear. The region north and south of the Interior route crossing is utilized intensively during the spring and fall as a foraging area and travel route.

From the East Fork Chandalar River Valley to the Sheenjek River, the Interior route crosses an area which appears to be preferred summer range for grizzly bears. Studies by AAGPC (1974a) concluded that from mid-June until early August, grizzly bears have been observed in this habitat more frequently than any other place along the Interior route. Preferred denning habitat also is abundant in this area and consists of the southerly hillsides at or near the 3,000-foot contour.

Denning areas are found south of the Interior route on southerly hillsides from Old John Lake to the Sheenjek River.

In Alaska, black bear reach their farthest north distribution along the Sheenjek and Coleen Rivers near the Interior route. Black bear are not anticipated elsewhere along the Interior route. The Coleen and Sheenjek River valleys are utilized by black bear throughout their active period and some denning probably occurs. Populations of black bear in the vicinity of these river crossings are low, but rapidly increase to the south toward the Yukon Flats. It is through this latter area that the temporary road access will be built.

Polar bears come ashore to forage along Beaufort Sea beaches in spring and fall. Female polar bears also come inland as far as 25 miles to find maternal denning sites.

No known polar bear use takes place along the Interior route, although coastal portions between Prudhoe Bay and the Arctic Foothills must be considered potential polar bear maternal denning areas.

Fur Bearers

Arctic fox, red fox, wolf, coyote, wolverine, river otter, marten, mink, short-tailed weasel, lynx, beaver, muskrat, and arctic ground squirrels are found along the Interior route. There are, however, significant differences in the numbers and kinds of fur bearers between the north side of the Brooks Range and the Porcupine Plateau. In most cases, a species which is present along a particular segment of Interior route or within a specific geographical area is there the entire year.

The most widespread and characteristic species along the Interior route are red fox, wolves, wolverine, and short-tailed weasels. Arctic fox are presently abundant on the Arctic Coastal Plain and are undoubtedly the most important fur-bearing species in that area. Excellent populations of most fur-bearing species found in Alaska are present along the Sheenjek and Coleen Rivers (AAGPC, 1974a).

Throughout the entire length of the Interior route, important habitat occurs along the rivers and streams. Here predatory fur-bearing species and their prey concentrate their activities during most seasons of the year. Important denning areas for arctic fox, red fox, wolves, and arctic ground squirrels also are located in well-drained sites in river and stream valleys.

Birds

At least 142 species of birds have been recorded within the area traversed by the Interior alternative route. Most are migratory, spending only the summer in the vicinity of the area. These include golden plovers, wandering tattlers, yellow wagtail, dotterel, wheatear, and bluethroat. At least 31 species of waterfowl frequent tundra wetlands and coastal waters. Pintails, green winged teal, and oldsquaws are the most common breeding ducks. Canada geese, white-fronted geese, black brant, whistling swans, and snow geese as well as birds of prey including the arctic peregrine falcon (a threatened species) are found. Four resident upland species are found --

willow and rock ptarmigan and spruce and sharp-tailed grouse. Robins, warblers, kinglets, longspurs, and savannah sparrows are common.

Most birds of the north are migratory. A few, such as gyrfalcon, ptarmigan, and raven, are not conspicuous migrants, but are known to move on a pattern which may or may not be "scheduled." These movements are particularly true of ptarmigan (Irving et al., 1967).

According to AAGPC (1974a) the area from Prudhoe Bay to the Canning River Valley is perhaps the most productive bird habitat along the entire Interior route. The lakes and potholes along this segment of the Arctic Coastal Plain provide habitat for breeding waterfowl and shorebirds, especially the pectoral sandpiper, dunlin, semipalmated sandpiper, and red phalarope. This habitat type is similar to that all along the Coastal Plain described in Section 2.1.1.7 for the applied-for AAGPC route.

The upland tundra of the northern foothills of the Brooks Range is almost devoid of good waterfowl or shorebird habitat. Small songbirds like redpolls and the Lapland longspur frequent the area. However, populations of these birds are large and widespread.

Songbird species in the Brooks Range portions of the Interior route are few in number. However, some of the species present (e.g., gray-headed chickadee and wandering tattler) are relatively rare in North America.

The only species of bird found to be abundant at survey sites along the Interior route in the Brooks Range was the redpoll, a circumpolar finch often present around towns and villages (Gabrielson and Lincoln, 1959).

Raptorial birds are the most important component of the avifauna of this region of the Interior route. The Canning River Valley, with its steep sides, offers excellent nesting areas for a variety of raptorial birds, including the peregrine falcon.

South of the Brooks Range, and as far as the United States-Canadian border, songbirds in the vicinity of the Interior route are evenly distributed. Redpolls, tree sparrows, and white-crowned sparrows are abundant.

Birds associated with the riparian tall shrub willow vegetation include: willow ptarmigan, rock ptarmigan, semipalmated plover, least sandpiper, yellow wagtail, northern shrike, yellow warbler, common redpoll, and tree sparrow.

Birds likely to be found in tall willow-alder shrub vegetation are: olive-sided flycatchers, gray jay, American robin, varied thrush, Swainson's thrush, gray-cheeked thrush, ruby-crowned kinglet, Bohemian waxwing, yellow warbler, yellow-rumped warbler, blackpoll warbler, northern waterthrush, Wilson's warbler, rusty blackbird, white-crowned sparrow and fox sparrow (Schweinsburg, 1974a).

Birds associated with the heath shrub with lichen vegetation are: water pipit, rock ptarmigan, horned lark, rosy finch, and wheatear. In most situations, American golden plovers, Baird's sandpipers, and Lapland longspurs may occur. The wandering tattler occurs along the rock streams at high altitudes. Where taller shrubs grow, birds more typical of the spruce woods and knolls may occur, especially tree sparrows, white-crowned sparrows, redpolls, and American robins.

Birds commonly found in the spruce heath shrub savannah are: gray jay, American robin, varied thrush, gray-cheeked thrush, Bohemian waxwing, throughout the summer and leave prior to freezeup when all surface flow ceases.

Lakes on the Arctic Coastal Plain close to the Interior alternative route are generally small, shallow tundra ponds which are similar to those described for the AAGPC applied-for route in Sections 2.1.1.3, 5, and 7.

Between the Sagavanirktok and Canning Rivers these ponds and lakes are numerous, but they contain only a limited fish fauna, consisting primarily of ninespine sticklebacks. Grayling are occasionally found, but many of these lakes freeze completely to the bottom and can support no fish. (AAGPC, 1974a).

An unnamed deeper lake, located in the headwaters of the Canning Marsh Fork, west of Porcupine Lake, supports a resident population of dwarf arctic char.

Landlocked arctic char have been found in Red Fish Lake near Arctic Village and may occur elsewhere along the Interior route, but they are not thought to be abundant (AAGPC, 1975).

Lake trout inhabit the deeper lakes in the mountains and in the Chandalar Valley. As with grayling and char their growth rate is slow in the cold arctic waters.

The northern pike is a very common fish throughout the southern drainages and an important subsistence fish. It is more often found in shallow weedy lakes and is one of the large fish of the region, frequently attaining more than 20 pounds in weight. Arctic Village residents fish for them with nets, often in late fall when the fish can be frozen for storage.

Burbot, also known as inland or freshwater cod or ling, is the only member of the cod family found in freshwater. It is widely distributed in deep lakes and larger streams of the region, where it preys on whitefish. The fish frequents the bottom, staying in deep waters but moving into shallow waters to spawn in fall and early winter.

The round whitefish is one of the most widespread and common species of fish in northern waters. Lake and broad whitefish are less common. Cisco is also a common resident of lakes, rivers, and streams in the region and is an important prey fish of lake trout, pike, burbot, and loons. Whitefish are a very important subsistence fish and are taken primarily with gill nets. They occur in all major drainages and in the coastal lagoons.

The long-nosed sucker, inhabiting rivers, streams, and lakes is the most numerous rough fish of the region. It is the only northern cypriniform (minnows and suckers) existing in both Siberia and North America. This fish is reported to be better tasting than most other suckers. In some areas, it is frequently eaten dried or smoked.

Salmon are netted from the Chandalar River by villagers at Venetie, but the fish apparently do not migrate upstream as far as Arctic Village. Interviews with residents at this village showed that grayling and whitefish species constitute most of their year-round catch. These villagers fish primarily in the lakes and streams near Arctic Village, although they traveled as far east as Old John Lake and as far north on the Chandalar River as Vettatrin Lake.

For much of its length, the Interior route parallels small streams. These include Cane, Old Woman, Monument, Pass, and Strangle Woman Creeks.

The fish fauna in all these streams is very similar. Grayling are the predominant fish, and round whitefish and slimy sculpin are less common.

There appear to be no overwintering areas for fish close to the Interior alternative route. Only two such areas have been located in these small streams; a small overwintering site on a tributary of Pass Creek, and another site near the mouth of Strangle Woman Creek. Because small streams freeze solid during the winter it is likely that fish overwinter downstream in the larger tributaries of the Yukon and Porcupine Rivers.

Threatened Species

Three animals are endangered species: gray and bowhead whales and arctic peregrine falcon. A fourth, a mammal, polar bear, is subject to an international agreement directing nations to give special protection to polar bear denning areas. At this time only the United States has satisfied the agreement and it will not become effective until ratified by three of five nations having populations of polar bears.

Bowhead and gray whales are discussed in Section 2.1.1.7 and would be involved with the Interior alternative pipeline system to the extent shipping is used to transport materials and supplies to Prudhoe Bay. The polar bear is associated with this alternative in the Prudhoe Bay area.

Peregrine falcons nest in the Canning River drainage. Three peregrine nesting sites have thus far been located in this drainage (AAGPC, 1975). One of the larger areas of nesting habitat for this bird is also found along the Porcupine Ramparts, upstream from the probable crossing of the temporary access road to the Interior route from Circle, Alaska, via the Coleen River. According to the Forest Service (FNP, 1974), canyon or bluff areas along the Sheenjek and Coleen River areas also may be nesting habitat for peregrine falcons. Ospreys, an endangered animal in the lower 48 States, are found along the lower elevations south of the Brooks Range and may be associated with the temporary access road from Circle.

In Alaska, in addition to polar bears and ospreys, the Department of the Interior does not consider wolves, wolverines, or golden eagles as threatened or endangered species.

Invertebrates

The insects of Alaska are not scientifically well known, and systematic study of Alaskan species has only recently started.

The Alaskan insect fauna differs from that elsewhere in that it is dominated by the Diptera (mosquitoes, houseflies, etc.) both in number of species and number of individuals. It has been said that the total combined weight of the mosquitoes is greater than that of the caribou (Washburn, personal communication to L. W. Sowl).

The principal groups of Diptera, as measured by their impact on man, are the Culicoidae (mosquitoes), Tabanidae (horseflies and deerflies), Rhagionidae, Simuliidae (blackflies, etc.), and Ceratopogonidae.

Certain Diptera replace the Hymenoptera (bees, wasps, etc.) as pollinators in many sub-Arctic and Arctic areas and are important for this reason.

blackpoll warbler, tree sparrow, and white-crowned sparrow. Less common species are: solitary sandpiper, mew gull, common flicker, northern three-toed woodpecker, olive-sided flycatcher, common raven, ruby-crowned kinglet, yellow-rumped warbler, rusty blackbird, pine siskin, and dark-eyed junco.

Wet sedge meadows in the Brooks Range may be the major nesting habitat for the northern phalarope. The common snipe and the savannah sparrow are also found in this habitat, usually in the drier portions.

No major waterfowl staging or moulting areas have been reported along the Interior route (Schweinsburg, 1974; Salter and Davis, 1974; Kessel and S h aller, 1960), except where the route crosses the Coleen River.

Fish

The fish found in streams along the Interior route are listed in Table 8.1.1.3-6. These include species important for sport, subsistence, and commercial fisheries. In the Beaufort Sea drainages, these include populations of arctic char, grayling, lake trout, and round whitefish. In the Porcupine River drainages they include grayling, lake trout, pike, and several species of whitefish.

From Prudhoe Bay to the Continental Divide, the Interior alternative route crosses four large rivers; the Sagavanirktok, Shaviovik, Kavik, and Canning. These streams support large numbers of fish, but very few species. For a detailed discussion of fish on the Arctic Coastal Plain see Section 2.1.1.7.

Arctic char and grayling are the predominant and sometimes only fish present. Round whitefish are common in the Sagavanirktok and Canning. The only additional important species with sports, subsistence, or commercial potential are the lake trout found in two lakes near the Canning River and the whitefish found in the river deltas. Chum and pink salmon have also been caught in the Sagavanirktok River, but their numbers are few. The Alaska Department of Fish and Game reports catching only three salmon during their studies in this drainage.

Arctic grayling are the most abundant and ubiquitous sport fish in the area and occur in all drainages. Grayling prefer clear waters of streams and lakes and commonly school in pools below rapids. Spawning occurs in the tributaries in early spring. Growth rates are slow, and according to Department of Fish and Game data, it may require 8 years for a fish to reach 14 inches in length. Slow growth and ease of capture make them susceptible to local extirpation. For these reasons grayling cannot cope well with man's encroachment (APG, 1974). In fall, grayling leave the small streams and descend to the deep pools of larger rivers for the winter.

Both anadromous and resident populations of arctic char are present. Generally there are major runs of char in the larger rivers draining into the Beaufort Sea. Spawning takes place on river gravel beds in the fall. The fish overwinter in the deeper holes before returning to the sea.

In the vicinity of the Interior route, there are ground-water sources in all the large streams, particularly the Canning River. The springs are perennial and are critical to the survival of overwintering populations of freshwater fish in the Beaufort Sea drainages.

Grayling and ninespine sticklebacks are the abundant fish in tundra streams. Soon after flow begins in late May or early June, grayling leave their overwintering areas and enter these streams to spawn. They remain

Table 8.1.1.3-6 Freshwater fish species occurring in Beaufort Sea and northern river drainages along interior alternative route

Porcupine-	Fish Species	Spawning Period	Abundance Beaufort Drainage	Abundance N. Yukon Drainage
Arctic Char	Salvelinus Alpinus	F	**	*
Lake Trout	Salvelinus Namaycush	F	**	**
Round Whitefish	Prosopium Cylindraceum	F	**	**
Arctic Grayling	Thymallus Arcticus	S	**	**
Slimy Sculpin	Cottus Cognatus	S	**	**
Ninespine Stickleback	Pungitius Pungitius	S	**	
Chum Salmon	Oncorhynchus Keta	F	*	
Pink Salmon	Oncorhynchus Gorbuscha	F	*	
Arctic Cisco	Coregonus Autumnalus	F	*	
Least Cisco	Coregonus Sardinella	F	*	
Broad Whitefish	Coregonus Nasus	F	*	**
Burbot	Lota Lota	W	*	**
Humpback Whitefish	Coregonus Clumpaformis	F		**
Longnose Sucker	Catostomus Catostomus	S		**
Northern Pike	Esox Lucius	S		**

LEGEND: * Occasional
** Common

Spawning Periods are indicated: S (spring)
F (fall)
W (winter)

(AAGPC, 1974 a)

The lepidopteran fauna (butterflies and moths) of Alaska is also little known but seems to be impoverished both in species and total numbers. In the area north of the Brooks Range their available habitat is greatly reduced by the topography and microrelief of the land. In some areas they are virtually limited to the vicinity of pond and stream banks where the terrain offers protection from the wind and probably provides more suitable habitats for preferred food plant species.

Ecological Considerations

The ecological considerations in an arctic environment center around the transfer of energy and are particularly sensitive to the balance of heat wherein sun-permafrost-vegetation-animal life all interact. This critical interaction is discussed in Section 2.1.1.8.

These relationships are valid for the Interior alternative route except that fire on the south side of the Brooks Range is significant. Figure 2.1.1.8-1 shows this relationship.

Primary productivity in the taiga varies with vegetation type. The least productive plant communities are black spruce, muskegs, and bogs. Successional shrub thickets that occur on river flood plains and following fire are highly productive. White spruce, birch, and aspen stands are thought to be intermediate in productivity.

Few data exist for primary productivity for the Alaska taiga but an account by El Paso Alaska Company (1974) gives a general account and summarizes existing data.

Balsam poplar communities that follow shrub types in succession along rivers in interior Alaska (Viereck, 1970a) are also highly productive.... Thus, the early portion of the rejuvenation phase is much more productive than tundra systems and, as will be shown below, more productive than subsequent phases.

Aspen and birch types, while having higher standing crops than shrub types, have lower rates of annual production (slope of standing crop curve) than shrub thickets. They also have a lower annual production than balsam poplar types, as well as lower standing crops. Data of Johnson and Vogl (1966) indicate annual production on the order of 120 $g/m^2/yr$ but because of the nature of the data, these figures should probably be increased slightly (Van Cleve, personal communication).

Annual production of white spruce forests is less than that of the above types, and represents the transition between the rejuvenation phase and the senescent phase, which is characterized by open, low growing spruce forests and muskegs. The senescent phase again has a low rate of production with respect to the rejuvenation phase and also with respect to the white spruce type. This final phase may be similar in productivity to tundra types (Van Cleve, personal communication).

Economic Factors

There are no large industrial or major commercial activities directly associated with the Interior alternative route other then the Prudhoe Bay area where the gas will be pumped from the ground and readied for delivery to a natural gas transportation system.

The Interior alternative pipeline system in Alaska will be constructed in a region which is largely uninhabited. However, development and improvement of transportation facilities in this remote area of Alaska will affect economic factors in the following communities: Kaktovik, Arctic Village, Central, Chalkyitsik, and Circle. Economic factors in Anchorage, Fairbanks, and Valdez will also be affected as these will be used as major staging areas for receipt of construction materials and supplies for the pipeline system. Fort Yukon also may be affected because of its importance as a distribution center for rural Alaska communities.

Principal Economic Activities in Rural Communities

Kaktovik is a community of 150 people living on the Beaufort Sea coast and is described in Section 2.1.1.9.

The economic conditions for Arctic Village, Central, Chalkyitsik, Circle, and Fort Yukon are summarized in Table 8.1.1.3-7.

Trapping is the only significant industry in the area, in the sense of generating significant dollar revenue from a resource. According to data compiled from the joint FWS-Doyon, Ltd. subsistence survey, current prices of furs may have brought as much as $900,000 to the Yukon Flats area in 1973 (APG, 1974e).

Trapping activity has been on the decline since World War II. Fur prices did not rise for many years due to competition from synthetics and ranch furs. It appears that in recent years only a small percent of what could be taken on a sustained yield has been harvested. Many people who trap do not rely on it as their sole source of cash income and trapping has become a part-time activity or even a recreational pursuit for some persons.

Since early 1973, there has been a sharp rise in the world market for wild furs. Some fur prices, such as those for fox and lynx, have risen by as much as 200 percent over 1972. Many people who had given up trapping are now trapping again for the first time in several years. Preliminary data indicate that trapping activity increased further during the 1973-1974 season.

Some cash income is generated from arts and crafts production. No figures are available, but the amount of money brought in by this enterprise is not large relative to the overall economy of the area.

Most wage employment in the area is seasonal, with opportunities for work greatest during the short Alaskan summer. During the ice-free months of June, July, and August, a few people are employed by river freight companies. Employment in construction has been highly dependent on the existence of village housing projects in recent years although some persons travel to other areas for construction jobs. Local construction activities will continue to be important in the local economy, but they cannot be counted upon to provide a steady and permanent source of income. Actual figures for numbers employed in river freight and construction activities are not available.

During the hot summer months local residents are employed on an emergency basis by the Bureau of Land Management to fight forest fires. The number employed each summer varies directly with the number, frequency, and size of the fires. In 1971, 25 persons were employed by the Bureau of Land Management to fight fires, with income per person averaging $1,690. In 1972, 213 were employed for an average income per person of $805.

Table 8.1.1.3-7 Commercial facilities, Alaskan communities associated with the interior alternative pipeline system

Village	General Store	Lodge	Sawmill	Telephone	Electricity	Flying Service
Arctic Village	x	x	x			
Central	x	x	x			
Chalkysitsik	x					
Circle	x	x	x			x
Ft. Yukon	xxx	x		x	x	x
Kaktovik	x					

Source (ANWR, 1974 and YFNWR,1974)

A small percentage of the people are employed full-time year around, mostly by government agencies such as schools, post offices, and health and welfare agencies. A few people are employed by the village stores and by the businesses in Circle, Central, and Fort Yukon. In the future, a significant number of people will probably be employed by the businesses and services in which the Native corporations may be involved.

In addition to limited unemployment compensation payments and social security benefits, the residents receive three types of income assistance. These are B.I.A. welfare payments, food stamps, and State welfare payments which consist of Old Age Assistance, Aid to the Blind, Aid to the Disabled, and Aid to Dependent Children. Both the number of recipients and the average dollar payments per recipient have increased substantially in recent years (Table 8.1.1.3-8). This has probably lowered some people's incentive to fish and hunt, but for those who now utilize both, it has undoubtedly raised the material living standard.

Subsistence

Subsistence activities of people living at Kaktovik are discussed in Section 2.1.1.9 on the AAGPC applied-for route.

Subsistence income is the economic mainstay of people residing in the rural area south of the Interior alternative route. The subsistence diet is a varied one consisting of large and small animals, fish, fowl, berries, wild greens, and garden produce (Tables 8.1.1.3-9, -10, -11, and -12). Moose is the most important big game species in the Yukon River area while the caribou generally become more important within foothill regions of the Brooks Range. In Arctic Village (north of the Flats region) caribou is the most important subsistence resource. Salmon and moose are principal foods for people who reside along the Yukon River. Village residents usually travel inside a 40- to 50-mile radius of their village in pursuit of subsistence resources.

The numbers of each species that are taken can vary greatly from year to year, depending on many factors. In years when one animal is scarce, more may be taken of another species as a substitute; for instance, during years when moose are scarce, more rabbits may be taken. Or in years of poor salmon runs, harvest of ducks and geese may increase.

In July 1973 a joint survey was conducted by Doyon, Ltd., Native Regional Corporation and the Fish and Wildlife Service of the average numbers and amounts of all subsistence resources taken by residents of the Yukon Flats. Data received are not to be regarded as exact, but as rough estimates only. However, the data clearly show the importance of fish and wildlife or other resources to the local economy.

The "worth" of a moose or caribou, or of a fish or duck taken for personal consumption is a value not currently defined in the marketplace. This is because it is illegal to sell these commodities. An attempt has therefore been made to evaluate the gross dollar worth of these products, in terms of both Anchorage and Fort Yukon prices for substitutable items. Results of this evaluation, based on an annual per capita consumption of 1,300 pounds, show annual per capita gross dollar return from subsistence to be $1,735 (Anchorage prices) and $2,862 (Fort Yukon prices). Return from both subsistence and trapping would be $2,435 and $3,562, respectively. The actual return to the area's economy from trapping activities is about 20 percent greater than the value accrued by the trapper if a local fur dealer if involved. Such a middleman is typical on the Flats. This additional 20 percent has not been included in Table 8.1.1.3-13. In addition, berries,

Table 8.1.1.3-8 Welfare trends - State of Alaska

Alaska Department Health and Social Services*

Village	October 1967 Cases	Total $+	October 1968 Cases	Total $+	October 1969 Cases	Total $+	October 1970 Cases	Total $+	October 1971 Cases	Total $+	October 1972 Cases	Total $+
Arctic Village	7	$ 792	6	$ 842	12	$2,258	8	$2,130	11	$2,590	14	$2,586
Central	0		2	$ 192	1	(*)	2	(*)	3	(*)	3	$ 900
Chalkyitsik	8	$ 824	7	$ 721	12	$2,148	18	$4,045	11	$2,175	10	$1,883
Circle	3	$ 507	4	$ 379	5	(*)	4	$1,044	4	$ 979	6	$1,054
Ft. Yukon	43	$4,393	46	$5,849	56	$8,480	68	$15,122	77	$17,384	76	$15.187

Bureau of Indian Affairs++

Village	Fiscal 1967 Cases	Total $+	Fiscal 1968 Cases	Total $+	Fiscal 1969 Cases	Total $+	Fiscal 1970 Cases	Total $+	Fiscal 1971 Cases	Total $+
Arctic Village	15	$7,451	12	$7,933	11	$6,215	7	$4,263	28	$22,389
Central	0		0		0		0		0	
Chalkyitsik	67	$4,906	10	$2,357	41	$6,370	26	$29,056	26	$21,950
Circle	0		0		8	$6,625	4	$ 2,391	8	$11,702
Ft. Yukon	53	$16,571	84	$33,221	80	$24,989	72	$30,583	104	$67,479

*Alaska Department Health and Social Services, 1973 (from FNWR, 1974)
(*)Data withheld to protect confidentiality of individuals
+Each case is a family, not an individual
++U.S. Bureau of Indian Affairs, (from YFNWR, 1974)

Table 8.1.1.3-9 Subsistence harvest in the Yukon Flats - Porcupine area - Mammals

Resources Harvested	Doyon (Limited) Fort Yukon Subregion		Arctic Village	Circle, Circle H.S.	Chalk-yitski	Fort Yukon
Resource	Number	Pounds	Number	Number	Number	Number
Black Bear	120	18,000		2	24	44
Brown Grizzly Bear	38	8,550	5	-	-	11
Beaver	2,100	52,500	10	40	300	1,100
Caribou	1,060	159,000	300	2	213	315
Coyote	10	**		-	-	10
Fox (Arctic)	1	**	1	-	-	-
Fox (Red, Cross)	695	**	44	3	165	100
Hare	15,750	47,250	20	80	2,900	5,000
Land Otter	4	**	2	-	2	-
Lynx	1,517	**	20	42	300	500
Marten	1,537	**	80	26	300	500
Mink	1,919	**	3	16	273	1,000
Moose	429	300,300	18	14	50	200
Muskrat	43,460	86,920	1,000	50	5,000	28,000
Porcupine	126	1,260	20	-	41	10
Sheep (Dall)	59	5,900	50	-	8	-
Squirrel (ground)	1,990	**	100	-	220	1,000
Squirrel (tree)	260	**	10	-	-	-
Weasel	630	**	20	-	150	150
Wolverine	144	**	20	5	50	10
Wolf	166	**	25	-	70	10
Total	72,015	679,680	66,235	11,740	97,960	294,925

Prepared by the Resource Planning Team, Anchorage, Alaska, for the Joint Federal State Land Use Planning Commission, February, 1974. The information was obtained through the Doyon representative soliciting Native people in the communities listed. Chalkyitsik may be overstated.

** Fur bearers not used for human consumption

Table 8.1.1.3-10 Subsistence harvest in the Yukon Flats - Porcupine area - fowl and fish

Resources Harvested	Doyan (Limited) Fort Yukon Subregion		Arctic Village	Circle, Circle H.S.	Chalk-yitsik	Fort Yukon
Resource	Number	Pounds	Number	Number	Number	Number
Crane	10	100	-	-	-	-
Swan	1	18	-	-	-	-
Ducks	11,168	11,168	10	88	650	5,000
Geese	2,844	11,376	-	44	380	1,000
Ptarmigan	2,844	5,600	100	15	780	2,000
Spruce hen/grouse	3,135	3,135	-	115	230	2,000
Total	20,002	31,397	110	394	3,180	13,000
Blackfish						
Cod(ling)	190	1,900	50	10	30	-
Grayling	21,130	21,130	1,000	-	7,700	2,000
Pike	11,940	143,280	200	40	1,600	5,000
Coho/Silver	5,775	28,875	-	700	-	-
Chum/Dog	22,970	114,850	-	720	4,650	5,000
King/Chinook	8,100	137,700	-	450	150	5,000
Herring/Perch	-	-	-	-	-	-
Sockeye/Red	-	-	-	-	-	-
Sucker	4,210	4,210	50	25	2,520	1,000
Sheefish	7,400	66,600	-	-	1,670	5,000
Trout	150	300	150	-	-	-
Whitefish	31,450	157,250	2,000	250	4,200	15,000
Total	113,315	676,095	14,250	16,605	91,550	293,000

Prepared by the Resource Planning Team, Anchorage, Alaska, for the Joint Federal-State Land Use Planning Commission, February 1974. This information was obtained through the Doyon Representative soliciting Native people in the communities listed. Chalkyitsik may be overstated.

Table 8.1.1.3-11 Subsistence harvest in the Yukon Flats - Porcupine area - berry/produce

Resources Harvested Resource	Doyon Limited Fort Yukon Subregion Quantity	Arctic Village Pounds	Circle, Circle H.S. Pounds	Chalk-yitsik Pounds	Fort Yukon Pounds
Berries					
Blueberries	1,622	360	132	930	-
Blackberries	66	60	-	-	-
Cranberries	9,653	180	-	2,520	5,000
Crowberries	60	-	60	-	-
Currants	-	-	-	-	-
Raspberries	6	-	-	-	-
Salmonberries	180	180	-	-	-
Strawberries	6	-	-	-	-
Other	-	-	-	-	-
Total	11,593	780	192	3,450	5,000
Grasses/Roots/ Wild Veg.					
Total	32	-	-	-	-
Garden Produce					
Potatoes	12,500	-	600	1,300	5,000
Other	1,310	-	525	-	500
Total	13,810	-	1,125	1,300	5,500
Forest/Vegetation	Total	Amount	Amount	Amount	Amount
Fuel (cords)	1,700	200	85	200	100
Construction (logs)	13,840	3,000	600	1,500	3,000
Other (board feet)	2,400	-	-	-	-

Prepared by the Resource Planning Team, Anchorage, Alaska for the Joint Federal-State Land Use Planning Commission for Alaska, February, 1974. This information was obtained through the Doyon representative soliciting Native people in the communities listed. Chalkyitsik may be overstated.

Table 8.1.1.3-12 Subsistence harvest in the Yukon Flats - Porcupine area - recapitulation pounds

Resources Harvested	Doyon Limited Fort Yukon Subregion	Arctic Village	Circle, Circle H.S.	Chalk-hitsik	Fort Yukon
Resource	Pounds	Pounds	Pounds	Pounds	Pounds
Recapitulation					
Mammals	679,680	66,235	11,740	97,960	294,925
Wildfowl	31,397	110	394	3,180	13,000
Fish	676,095	14,250	16,605	91,550	293,000
Berries	11,593	780	192	3,450	5,000
Greens/Roots/ Vegetables	32	-	-	-	-
Garden Produce	13,810	-	1,125	1,300	5,500
Totals	1,412,607	81,375	30,056	197,440	611,425
Population, 1970	965	82	32	123	376
Native Enrollment, 1973	1,106	121	41	77	538
Per Capita 1970	1,464	992	939	1,605	1,630
Per Capita 1973	1,277	673	733	2,564	1,136

Prepared by the Resource Planning Team, Anchorage, Alaska, for the Joint Federal-State Land Use Planning Commission for Alaska, February 1974. This information was obtained through the Doyon representative soliciting Native people in the communities listed. Chalkyitsik may be overstated.

Table 8.1.1.3-13 Average yearly subsistence harvest estimates and approximate dollar vlue of meat, fish, skins, and berries - Yukon Flats socio-economic areas

Species/Food Item	Harvest 2/	Average Utilizable Weight	Equivalent $ Value per Pound of Meat, Fish, Berries, or Greens: Anchorage	Equivalent $ Value per Pound of Meat, Fish, Berries, or Greens: Ft. Yukon	Average Current $ Value of Skin	$ Value per Animal: Anchorage	$ Value per Animal: Ft. Yukon	Total $ Value: Anchorage	Total $ Value: Ft. Yukon
Big Game									
Moose	481	700	1.35	1.80	not determined	945.00	1,260.00	464,546	606,060
Caribou	1,062	100	1.35	1.80	not determined	135.00	180.00	143,370	191.160
Brown bear	32	225	1.35	1.80	not determined	303.75	405.00	9,720	12,960
Black bear	130	160	1.35	1.80	not determined	202.50	270.00	26,325	35,100
Mountain sheep	59	100	1.35	1.80	not determined	135.00	180.00	7,965	10,620
Total lbs. -- big game 475,500									
Furbearers									
Muskrat	43,409	2	.69	1.25	1.60	2.88	4.00	125,018	173,636
Beaver	3,223	20	.69	1.25	32.00	45.80	57.00	147,613	183,711
Land otter	4				45.00	45.00	45.00	180	180
Lynx	4,981				100.00	100.00	100.00	498,100	498,100
Fox	668				30.00	30.00	30.00	20,040	20,040
Marten	3,778				25.00	25.00	25.00	94,450	94,450
Mink	1,963				20.00	20.00	20.00	39,260	39,260
Ground squirrel	2,285	1	.69	1.25	.65	1.34	1.90	3,062	4,341
Tree squirrel	310	.5	.69	1.25	.65	1.00	1.28	310	398
Weasel	1,334				8.00	8.00	8.00	10,672	10,672
Snowshoe hare	21,912	3	.69	1.25	not determined	2.07	3.75	45,358	82,170
Wolverine	204				70.00	70.00	70.00	14,280	14,280
Wolf	151				80.00	80.00	80.00	12,080	12,080
Total lbs. -- furbearers 255,734									
Porcupine	149	10	.69	1.25		6.90	12.60	1,028	1,863
Total lbs - porcupine 1,490									
Waterfowl and Brids									
Ducks	10,947	1	.69	1.25		.69	1.25	7,553	13,684
Geese	2,779	3	.69	1.25		2.07	3.75	5,753	10,421
Ptarmigan	5,735	1	.69	1.25		.69	1.25	3,957	7,188
Spruce hen	3,253	1	.69	1.25		.69	1.25	2,245	4,066
Snowy owl	5	1	.69	1.25		.69	1.25	3	6
Total lbs. -- waterfowl and birds 28,777									
Fish									
Ling cod	180	5	1.00	1.50 5/		5.00	7.50	900	1,350
Burbot	30	7	1.00	1.50 5/		7.00	10.50	210	315
Char - lake trout	152	5	1.00	1.50 5/		5.00	7.50	760	1,140
Grayling	21,123	1	1.00	1.50 5/		1.00	1.50	21,123	31,684
Pike	15,821	10	1.00	1.50 5/		10.00	15.00	158,210	237,315
King Salmon	13,101	15	1.43	2.98 5/		21.45	44.70	452,616	943,216
Other salmon	80,748	4.3	1.09	1.89		4.69	8.13	522,713	906,089
Sucker	4,212	1	1.00	1.50 5/		1.00	1.50	4,212	6,318
Sheefish	7,209	9	1.00	1.50 5/		9.00	13.50	64,881	97,321
Whitefish	53,152	1.5	1.00	1.50 5/		1.50	2.25	79,728	119,592
Total lbs. -- fish 873,760									
Total lbs. and dollars Meat, Fish, Skins 1,596,981								2,988,240	4,370,763
Per capita lbs. and dollars Meat, Fish, Skins 1,302								2,435	3,562
Berries									
Blueberry	874		.87	1.30 5/				760	1,136
Cranberry	8,407		.87	1.30 5/				7,314	10,929
Crowberry	40		1.03	1.55 5/				41	62
Raspberry	24		.67	1.00 5/				16	24
Strawberry	12		.67	1.00 5/				8	12
Total lbs. -- berries 9,367									
Wild Vegetables and Fruit									
Mushroom	135		1.49	2.24 5/				201	302
Rhubarb	3		.39	.59 5/				1	1.75
Rose hip	45		.49	.55				22	25
Wild onions	1		.49	.75				.50	.75
Spinach	1		.50	.75 5/				.50	.75
Fireweed	1		.50	.75 5/				.50	.75
Total lbs. -- Wild Vegetables and Fruit 186									
Garden Produce 4/									
Potatoes	19,776		.29	.33				5,735	6,526
Carrots	825		.39	.60				321	495
Cabbage	400		.34	.50				136	200
Turnips	370		.38	.57 5/				141	211
Lettuce	295		.46	.56				136	165
Rhubarb	140		.39	.59 5/				55	83
Cauliflower	140		.56	.84 5/				78	118
Onions	85		.34	.51 5/				29	43
Beets	65		.49	.74 5/				32	48
Rutabagas	60		.36	.54 5/				22	32
Cucumbers	50		.33	.50 5/				17	25
Tomatoes	50		.68	1.02 5/				34	51
Radishes	50		.29	.44 5/				15	22
Broccoli	15		.58	.87 5/				8	13
Swiss chard	10		.49	.74 5/				5	7
Spinach	5		.50	.75 5/				2.50	3.75
Total lbs. -- garden produce 22,385									
Total lbs. and dollars Fruits and Vegetables 31,928								15,131	20,637
Per capita lbs. and dollars Fruits and Vegetables 26								12	17

1/ Approximate dollar values are in terms of Anchorage store prices for similar products if the wild game, fish, or fruits and vegetables were not available.

2/ Harvest data are for a period of several years, and are rough estimates only. Data was obtained by door to door surveys in 7 of the villages, and by holding village meetings in the other three. Doyon Ltd. and BSFW, 1973.

3/ Big game prices are based on average price of beef; furbearers, waterfowl, and game bird prices based on price per lb. of whole chicken; fish prices based on average price per lb. of canned salmon or close equivalent fish. All prices from Gambell Street Safeway Store, Anchorage, and from the Northern Commercial Company store, Ft. Yukon, Feb. - July 1973. Fresh or frozen food from outside the region is not sold in villages other than Ft. Yukon, Circle, and Central; it is desired, it must be air freighted at a cost of 5 - 8 cents/lb, or transported by boat or snowmachine from Ft. Yukon.

4/ About half of this comes from Central, where there are only about 35 people.

5/ Estimated price based on Ft. Yukon store price survey, FWS, July, 1973, which showed that Ft. Yukon prices averaged about 50% higher than Anchorage prices. Item was not for sale at time survey was conducted.

some plants, and garden produce have a per capita gross dollar worth of $12 (Anchorage prices) and $17 (Fort Yukon prices). All dollar values are approximate (APG, 1974b).

Cash expenditures that are now necessary in order to successfully compete for subsistence resources include guns, shells, snow machines, boats and motors, gas and oil, and maintenance costs. Since trappers and commercial fishermen require basically the same equipment as subsistence users, it can probably be assumed that subsistence is in general a profitable activity from an economic point of view.

Principal Economic Activities in Urban Areas

Fairbanks and Anchorage are the major transportation hubs for shipment of supplies throughout the state and would also serve in that capacity during construction of the Interior alternative pipeline system. Valdez is being converted from a small fishing village to the terminus for the trans-Alaska oil pipeline system and, as such, is a significant index to economic activity in the State. Accordingly, a brief look at Valdez is important in projecting Alaska's future.

Reconstructed after being destroyed in the 1964 earthquake, Valdez is planned to accommodate a population of up to 2,500 people. According to the National Bank of Alaska (1974) almost 1.1 billion dollars in construction contracts were awarded for building the Valdez oil terminal, pump station, oil tank farm, and modular housing. In the past year the number of people living or working in Valdez grew from an estimated 1,100 to more than 4,000. By spring 1975, schools were overcrowded, public accommodations full, and housing nonexistent. One index of economic activity in Alaska is the cost of housing since it reflects costs and availability of construction materials, utilities, and wages. In June 1973 a 1-bedroom apartment rented for approximately $190 a month. The same apartment in November 1973 cost $260. More recently statewide publicity was given to the rental costs in Valdez and other communities associated with the trans-Alaska oil pipeline system with a view of determining whether rent controls were desirable. One example cited was the increased monthly rent of a 2-bedroom apartment at Valdez: Unfurnished, the apartment rented for $286 a month (plus tax) in December 1974; on January 30, 1975, notice was given that on March 1 the rent would be $520 (plus tax); on March 30 notice was given that the building had been sold and the apartment would be vacated on May 1. The tenants, school teachers, were permitted to stay the month of May for $1,600. The rent, reportedly, was renegotiated for $940 with the provision that two new tenants move in for the month of May.

Real estate in Valdez has shown similar marked upward spirals with houses formerly selling for $17,000 now going for $40,000; while a trailer-sized lot formerly selling for $400 now costs $10,000.

Fairbanks and Anchorage have experienced increased impacts from pipeline construction, but because of their larger size have been somewhat better able to absorb the increases. See Section 2.1.1.9 for additional discussion of statewide economic factors.

Sociological Factors

Population

The population growth of the State, North Slope Borough, and Kaktovik is discussed in Section 2.1.1.10.

Table 8.1.1.3-14 summarizes population data of the rural communities associated with the Interior alternative pipeline system.

During the period 1960 to 1970 the population as a whole increased by 4 percent, although the Native population dropped from 1,196 in 1960 to 1,079 in 1970. The decline in the Native population resulted from emigration from the area--usually to Fairbanks or Anchorage.

Approximately 90 percent of the area's residents are Kutchin Indians who belong to the Athabascan tribes. Non-Native residents live principally in Fort Yukon, Circle, and Central and consist primarily of school teachers and persons involved in various business enterprises. Chalkyitsik, located on the Black River 43 miles northeast of Fort Yukon, has close ties with Fort Yukon and is at least partially dependent on resources of the proposed refuge area. Arctic Village, has few ties with the Yukon Flats area, and subsistence resources utilized by this village are distant from communities farther south. Central is a small community on the Steese Highway which has cultural ties with Fairbanks.

Education

All communities except Central have State-operated schools. Central has no school. All schools include the first through eighth grade, and some schools have kindergartens. There is a high school in Fort Yukon, with about 80 students and 9 teachers. Some of the high school students are drawn from the other villages in the Flats area and are boarded in Fort Yukon. Other area residents attend high schools elsewhere in the State or in other states. Boarding expenses are borne by the State Boarding Home Program or by the BIA.

Housing

Almost all houses in the Flats area villages are built of logs and finished with local and imported lumber. Most are one or two rooms--typical size is about 20 x 20 feet. In many cases the logs are of too small a diameter to provide adequate insulation, even when chinked with moss or fiberglass, so the interior walls of houses are paneled with plywood or with pieces of cardboard.

Utilities

Although every village has electricity at the school, Fort Yukon has the only village-wide utility system. In other villages most people use gasoline lanterns for light. Radios and phonographs are operated by batteries. Propane, oil, or wood stoves are used for cooking. Most families burn wood for heat; a few burn oil. Some people have gasoline washing machines.

At Fort Yukon, sanitation facilities are limited to one sewage lagoon treatment system. The community center, the school and teacher facilities in Fort Yukon and the other villages have running water and flush toilets. Otherwise, water is hauled from nearby rivers and lakes, and waste is dumped.

Although Fort Yukon has a telephone system, communication between villages is by radio transmitter during certain times each day, and by mail one to three times per week. The hospital in Tanana can be reached by radio

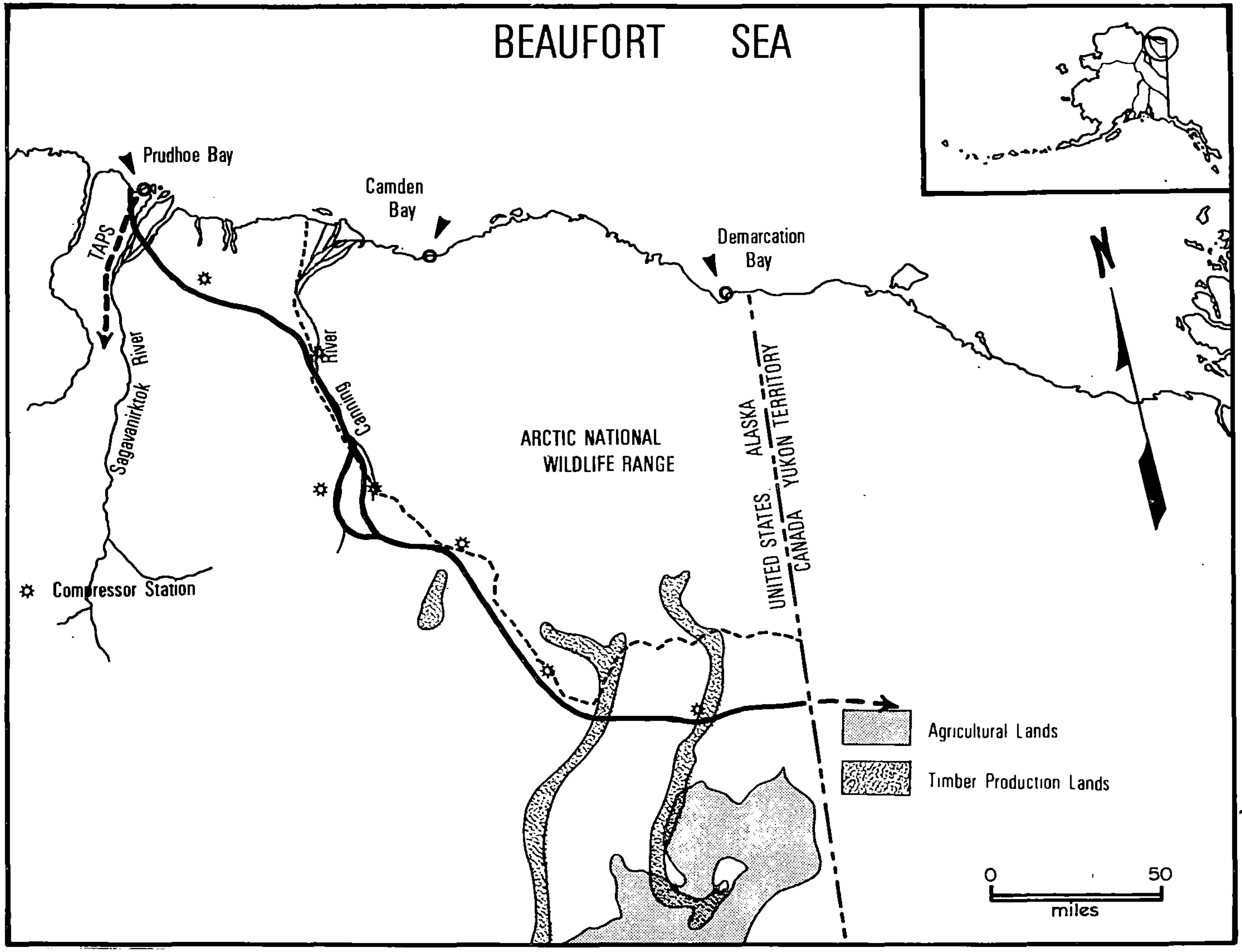


Figure 8.1.1.3-17 Agriculture and timber lands of the interior alternative pipeline route

Land Use

Existing Land Uses

The Interior alternative pipeline system originates in the Prudhoe Bay area where the discovery of petroleum reserves has led to rapid development by industry. The first 90 miles are located primarily in this area. Land uses in this segment of the Interior alternative route are discussed in Section 2.1.1.11 for the AAGPC applied-for route.

The remainder of the route is located almost exclusively in the transportation and utility corridor withdrawn by the Secretary of the Interior in 1972.

Except for the Prudhoe Bay area, the Interior route is through an uninhabited, undeveloped area. Land uses primarily are controlled by restricted access (see preceding discussion). These uses include sport and subsistence hunting and fishing, outdoor recreation, and mineral exploration. The first 90 miles of the route are across State lands and the balance of the route is on Federal lands and within a transportation/utility corridor withdrawn by the Secretary of the Interior on March 9, 1972.

Associated with the Interior route are Federal, State, and Native-owned lands. Refer to Figure 8.1.1.3-18.

Federal lands include the withdrawn corridor; proposed additions to the Arctic National Wildlife Range to the west of the corridor; the proposed Yukon Flats National Wildlife Refuge to the south and west; and the proposed Porcupine National Forest to the south; all under the administration of the Bureau of Land Management. Other Federal lands proposed for special management are the Porcupine National Scenic River and the Sheenjek National Wild River with the proposed Porcupine National Forest. That portion of the Sheenjek River within the Arctic National Wildlife Range also has high potential for addition to the Wild and Scenic Rivers System. All Federal lands proposed for addition to the Arctic National Wildlife Range, the proposed Yukon Flats National Wildlife Refuge, and Porcupine National Forest have been recommended for study to determine their suitability for inclusion in the National Wilderness Preservation System. The existing Arctic National Wildlife Range is federally administered by the Fish and Wildlife Service. The proposed Yukon-Charley National Rivers are located upstream from Circle on the Yukon River.

State-owned lands are situated between the Federal transportation/utility corridor and the existing Arctic National Wildlife Range. These lands have high mineral values.

Native ownerships was discussed in Section 8.1.1.3.

Potential Land Use

The status of land use planning is described in section 2.1.1.11 for the AAGPC applied-for route.

Over 200 miles of this route, while not designated as such, is in a de facto wilderness condition. The route is now designated as a transportation corridor across Federal lands and would not likely included in a designated Wilderness Area.

Travel is severely curtailed during spring and fall when ice on rivers is unsafe and snow is insufficient or soft.

Table 8.1.1.3-14 Population estimates of rural communities associated with the interior alternative pipeline system

Community	1974 Population	Percent Native
Arctic Village	131	96 +
Central	35	0 +
Chalkyitsik	80	91 +
Circle	63	65 +
Kaktovik	150	83 ++
Ft. Yukon	614 +++	88 +

Source ANWR, (1974) and YFNWR, (1974)
+Primarily Indian
++ Primarily Eskimo
+++ Excludes 150 military personnel

satellite communications in case of emergency. RCA-Alaska Communications is presently working to install one radio phone in every village in Alaska.

Transportation

Seasonally maintained state gravel highways connect Central and Circle with Fairbanks. The gravel road to Prudhoe Bay is not open to the public, but investment of public highway funds in the new highway bridge crossing the Yukon River suggests it will become a public highway at some future time. The state highway to Circle is not maintained during winter months. There are no other highway connections to the vicinity of the Interior alternative pipeline system in Alaska.

Aircraft and riverboat are the principal means of transportation north of the Yukon River. Each community has an airstrip.

The Yutana Barge Lines, the only licensed company on the upper Yukon River, makes four or five freighting trips per year from Tanana to Fort Yukon. It makes no trips east of that village. Approximate season of operation is May 20 to October 1. In addition, bonded freight is shipped from Dawson or Whitehorse via the Yukon and Porcupine Rivers to Old Crow. This navigational use of the Yukon and Porcupine Rivers by Canada is guaranteed by the Treaty of Washington between the United States and Great Britain, dated May 8, 1871. The treaty includes protection of the free passage of fish which spawn in Canada.

The Interior alternative project calls for a 175-mile long temporary access road to be constructed between Circle and the Coleen material site on the pipeline system. This proposed road would cross lands prospectively valuable for forestry and agricultural purposes. The proposed Porcupine National Forest, according to the Forest Service (PFNF, 1975), contains commercial timber (principally white spruce and balsam poplar).

The same temporary access road would also provide access to a region where 5.3 million acres of land are classified by the Soil Conservation Service as having 50 percent or more of the area suitable for crop or forage production.

Figure 8.1.1.3-17 shows the approximate location of the above timber and agricultural areas in relation to the Interior Alternative pipeline system.

Improved access and a supply of energy in the form of natural gas may also stimulate development of mineral resources (See Section 8.1.1.3)

Sudden socio-economic changes including large influxes and out-migrations of people are not new to Alaska (Sections 2.1.1.9 and -10). However, the magnitude and quickness of change associated with the recent development of energy resources in remote areas of Alaska are new. For example a 345-mile long, two-lane gravel road that was constructed from the north side of the Yukon River to Prudhoe was built in a single construction season. This is approximately equivalent to building a highway from Washington, D.C., to Detroit, Michigan. Because the perception of the future in Alaska is dim and threatening, the Governor established the Alaska Growth Policy Council to provide a forum for public discussion which will lead to a policy for growth.

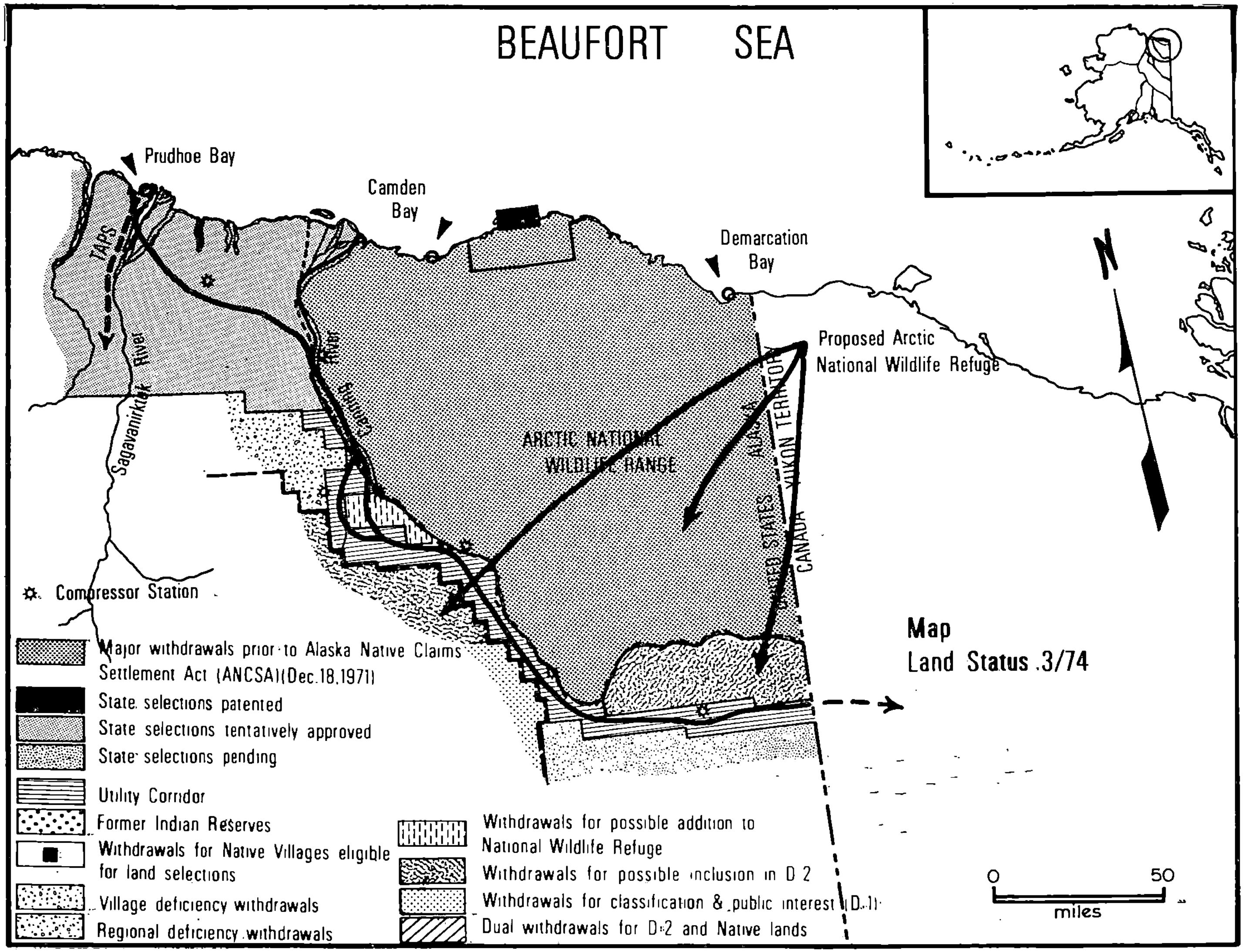


Figure 8.1.1.3-18 Land status of the interior alternative pipeline route

The existing ports at Prudhoe Bay will be used as a receiving point for construction and supplies as would large modern facilities at Anchorage and Valdez.

Historic, Archeological, and Unique Area Values

Historic Values

There are no known historic areas along the Interior alternative pipeline route. The temporary access road, however, does involve historic areas such as Circle and Fort Yukon. Leffingwell Camp (a site on the National Register of Historic Places) is described in Section 2.1.1.12. This area would be involved if shipping of supplies and materials to Prudhoe Bay were along the Beaufort Sea coast from the Mackenzie River in Canada. Otherwise, it would not be involved.

Archeological Values

The archeology of the Interior alternative route is not well understood because little work has been done in the area. A number of sites have been identified in very preliminary investigations. Sites range from recent to an estimated 27,000 years of age. Intensive investigations along the trans-Alaska oil pipeline system to the west combined with sporadic reports by people passing through the area (hunters, fishermen, prospectors, State officials, etc.) lead AAGPC (1974a) to conclude the route on the south side of the Brooks Range has fairly high archeological potential. Although the area south of the Continental Divide is often considered as the territory of the Kutchin Indian cultures, recent research along the trans-Alaska oil pipeline system suggests Eskimo cultures also came south of the Continental Divide.

AAGPC (1974a) notes the following areas along the Interior route as having special archeologic potential:

Kadleroshilik River (M.P. 35): similar to Sagwon and Franklin Bluffs where sites were found in archeological studies for trans-Alaska oil pipeline system.

Shaviovik (M.P. 40) and Kavik Rivers (M.P. 50 to 75)

Knob (Cop) (M.P.80): excellent hunting observation point between Kavik and Canning Rivers

Canning River (M.P. 90 to 95): moose concentration area, warm spring, similar to rich archeological find areas at Galbraith Lake (on trans-Alaska oil pipeline system) and Anaktuvuk Pass (100± miles to west)

Cane Creek and Red Sheep Creek (M.P. 155): Old caribou corrals, sheep hunting area

Old Woman Creek - Index Mountain - Monument Creek (M.P. 180 to 230): Many caribou corrals, permanent camps

Grayling Lake (M.P. 240)

Pass Creek (M.P. 250): overlooks divide between Sheenjek and Coleen Rivers

Strangle Woman Creek (M.P. 280): Series of knobs overlooking confluence of Coleen River and Strangle Woman Creek

In summary the probability is very high that important archeologic values are directly associated with the Interior alternative pipeline system.

Unique Areas

Recent studies contracted by the National Park Service were undertaken by the Tundra Biome Center (University of Alaska), the Arctic Environmental Information and Data Center (University of Alaska), the Lawrence Radiation Center, and David Robert Detterman of the U.S. Geological Survey to determine if there might be areas warranting natural landmark status. These studies show that the following area should be considered:

Shublik Springs--Located on the east bank of the Canning River, 3 miles north of its junction with Cache Creek, the Shublik Springs maintain a temperature of 50° F all year. Their flow has been measured at more than 35 cubic feet per second, and they flow throughout the year. Because of the relative warmth, plants which generally do not grow this far north can be found near the springs. (Detterman, USGS). The Interior Route is much closer than the applied-for route to the Shublik Springs area.

The Joint Federal-State Land Use Planning Commission has identified the Marsh Fork of the Canning River as having such high values that it should be one of the few areas in the State "...closed to all development uses, including mining and oil and gas production, and other uses which would alter the existing ecology..." because of its "...high wildlife values and potential as a scientific study area." (JF/SLUPC, 1973). The Canning River option would not impact the Marsh Fork but would cross part of the Arctic National Wildlife Range.

Other areas listed by the Commission as having potential value for establishment as scientific or ecological preserves associated with the Interior alternative route are: Old John Lake (a large, high arctic oligotrophic lake); lichen stands in shrub and caribou winter range; and the upper Coleen River where one of the northernmost stands of white spruce is found on the southern slopes of the Brooks Range.

Recreation and Esthetics

The Interior route traverses an area with significant recreation and esthetic values. The area, except for the Prudhoe Bay area, is de facto wilderness. The Marsh Fork of the Canning River has extremely high wilderness-wildlife-recreation value and the Canning River is within the Arctic National Wildlife Range. On the south side of the Continental Divide, the Sheenjek River has been proposed for addition to the National Wild and Scenic Rivers System because of its recreation, esthetic, and wilderness values.

The AAGPC (1974a) notes the Interior alternative route is illustrated by a diversity of land forms and habitats.

The Joint Federal-State Land Use Planning Commission has identified the area traversed by the Interior alternate route as one where hunting is rated high to good; this is suitable terrain for winter sports, sightseeing, and boating. The overall high-quality recreation and esthetic values are emphasized by the fact that the Interior route is adjoined by the Arctic National Wildife Range to the east and north, units of the proposed Arctic National Wildife Refuge on the west, and the proposed Yukon Flats National Wildlife Refuge and the proposed Porcupine National Forest to the south.

The current demand for recreation and recreational development in the area is not great. It is expected to increase as recreational opportunities decrease in more accessible areas of Alaska.

Air Quality

Except for the Prudhoe Bay area described in Section 2.1.1.14 for the AAGPC applied-for route, the Interior alternative route crosses land without industrial development. There are no residential areas. Accordingly, air quality must be considered good.

Smoke from seasonal forest fires reduces air quality and may become so dense that air travel is restricted.

Environmental Noise

Because there is no industrial development (except for the oil and gas development activities in the Prudhoe Bay area) there is no industrial noise. Roads are absent: hence, the only transportation noises now present are the sound of occasional airplanes.

Environmental Impacts Caused by the Interior Alternative Pipeline Route, Alaska

The following is a summary of major impacts expected if the Interior alternative route is selected for construction of a gas transmission system.

Permafrost--Impacts would be similar to those for the applied-for route, except that south of the Brooks Range where the route crosses areas of discontinuous permafrost. Frost heave forces associated with frost bulb formation around the pipe in such regions of continuous permafrost and the proposed mitigating measure (surcharge) has yet to be demonstrated. Unchecked frost heave forces increase the possibility of differential pipe loading and threaten pipeline integrity.

Erosion--The impact of construction in the steep-walled valleys of the Brooks Range where slopes are unstable will result in such forms of erosion as mass wasting, and solifluction. This will increase the possibility of differential pipe loading and threaten pipeline integrity.

Climate--Severe storms occur in the mountain valley and over the Continental Divide. These will restrict air access and inhabit travel necessary for construction, maintenance, and repair of the pipeline and its facilities.

Transportation--The Interior Route would require more overland travel than the applied-for route. Water withdrawal for snow road building and maintenance would result in impacts on water quality and fish as described for the applied-for route.

Wildlife--Portions of the Interior Route cross boreal forest that is susceptible to fire. Increased presence of man and his activities is likely to increase the incidence of fires.

Wildlife--Caribou--The Interior Alternative Route crosses migration routes and winter range of the Procupine Caribou Herd. Construction, maintenance, and repair activities will produce impacts that would result in herd displacement and reduction.

Dall Sheep--Areas crossed by the Interior Route are prime Dall Sheep habitat, especially in the Marsh Fork-Canning River option. Impacts from pipeline related activities would reduce sheep populations as a result of increased year-around disturbance, increased access, and migration route interference, and would result in reduced habitat quality and behavior change.

Fish--Impacts on fish would be serious and similar to those discussed for the applied-for route.

Impact from water withdrawal and those on vegetation, fish, and subsistence would be serious and similar to those discussed for the applied-for route. Following is a more detailed discussion of major and other impacts that could result from construction of the Interior alternative route pipeline system.

The following description of environmental impacts of the Interior route will, therefore, treat only those impacts which are different from those expected for the applied-for AAGPC route. Refer to the applied-for route for a discussion of mitigating measures. Sections 5, 6, and 7 should also be consulted.

Impact of the Interior Alternative Route on Climate

Construction, operation, and maintenance of the alternative Interior route AAGPC pipeline system would have little effect on the climate along the route, but those activities would cause micrometeorological changes similar to those expected on the applied-for route. (See Section 3.1.1.1, Climate.)

Impact of Climate on the Interior Alternative Route

Cold winter temperatures, darkness, fog, blowing snow, and high winds create adverse weather conditions which have adverse effects on the people and machinery used to construct the proposed pipeline system. The expected problems would be similar to those expected for the applied-for route and described in section 3.1.1.1.

One substantial difference is the requirement for considerably more overland transport of pipeline materials for this alternative route. A 175-mile-long temporary snow and ice access road from the small town of Circle, on the Yukon River, north to the pipeline would depend on large quantities of snow in an area with only 6 to 10 inches of precipitation annually. The impacts of questionable snow availability for road construction have been described in Sections 3.1.1.1, 5 and 6 for the AAGPC applied-for route. One difference concerns the use of drift fences to accumulate snow. Wind velocities along the Yukon River may not be sufficient to employ this method of accumulating snow. Sufficient water should be available from the Yukon River to remedy this by use of manufactured snow.

Another major difference of the Interior alternative pipeline system is its location in mountain valleys through the Brooks Range and the necessity to cross the Continental Divide in an area of rugged topography. Adverse weather conditions as when a storm front moves inland from the Beaufort Sea will restrict or prevent air access to substantial portions of the pipeline system. For example, during extended periods of inclement weather, maintenance and repair personnel stationed at Prudhoe Bay would need to be stationed at the operational compressor station (M.P. 118), use alternative means (foot or all terrain vehicles) to inspect and/or repair the system north of the Continental Divide in the Canning River area (M.P. 80 to 142), or delay inspection or repairs. Similar requirements will be caused by inclement weather south of the Continental Divide.

South of the Continental Divide winds are less severe than those in the north (Section 8.1.1.3). Therefore, periods of ice-fog in winter months are likely to last longer.

In summary, climate and weather conditions along the Interior alternative pipeline system could delay construction schedules, operation, and repair procedures--especially in the mountainous portions of the pipeline system (M.P. 80 to M.P. 170).

Impact of the Interior Alternative Route on Topography/Landscape

An impact of the Interior alternative route would be on the terrain, including the topography, underlying permafrost soils, waters, and vegetation which make up the present natural landscape.

There is no way to build a 293- to 298-mile long pipeline, 6 compressor stations, 8 airstrips, and 125 miles of permanent road in mountainous terrain without leaving scars and altering the topography. Extraction of 8.1 to 8.5 million cubic yards of gravel and rock from the many borrow sites will further alter the landscape, as will the large buildings and towers required at compressor stations and communications sites.

These impacts will be similar to those described in section 3.1.1.2 for the applied-for AAGPC pipeline system, with the exception that the Interior route passes through more areas of bedrock where scars will be essentially permanent.

Impact of the Interior Alternative Route on Geology

Construction and operation of a chilled gas pipeline along the Interior route would have little impact on the geology of the region other than possible local effects on slope stability.

The approximately 100 miles of this route which cross the Brooks Range would climb over 4,000 feet in a distance of about 45 miles before descending on the south side of the mountains. Canyon walls along the two route options slope into the Canning River at gradients approaching 80 percent, and bedrock is exposed along most of the distance. Blasting there to prepare a road or a pipe ditch could precipitate rockfalls and landslides on the steep slopes. Removal of large volumes of borrow material may also result in undercutting natural slopes with a resulting loss of slope stability.

Construction of a pipeline, access roads, and airfield would have an impact on mineral resources of the area by providing easier access and exploration for minerals in already identified areas of potential deposits in the Canning River and Chandalar River drainages. (See Sections 3.1.1.9 and 11 for additional discussion of mineral developments.)

Permafrost

The entire Interior Route would be located in a region of continuous permafrost and the problems outlined in Section 3.1.1.3 concerning permafrost impacts on the applied-for AAGPC route will also affect this alternative. About 172 miles will be in areas with low ice content, about 112 miles in permafrost with high ice content, and some 11 miles will be in permafrost with ice scattered or in layers.

Bedrock areas within the mountains, while permanently frozen and technically permafrost, are not subject to the same impacts as are ice-rich soils. Thus, the pipeline should cause fewer adverse impacts on permafrost when crossing the Brooks Range.

Because the Interior route on the south side of the Brooks Range is in the transition zone between areas of continuous and discontinuous permafrost, the active layer will be deeper. The frost bulb, therefore, may not be located entirely in permafrost. This increases the possibility of frost heave along the buried chilled pipeline. These conditions will be more pronounced in river and stream valleys or on south-facing slopes.

Since 2 years will be used to construct the pipeline, portions of the trench will be exposed to thermal degradation which will initiate thaw consolidation, thermokarst formation, and solifluction. This may not be a significant problem as bedrock and talus slopes are more stable than fine grained soils of the Arctic Slope, southern Brooks Range, and Porcupine Plateau. The Applicant proposes to undertake summertime construction in the segments across the Brooks Range where thaw stable permafrost is expected. Although bedrock is stable when permafrost is thawed, talus (cone) slopes in the Canning River often have ice. The pipeline system will cross these slopes on their lower extremities. Therefore, on a worst case condition, it is conceivable that an ice lens exposed by pipeline construction will melt, causing local subsidence and thereby upsetting the equilibrium of the loose rocks comprising a talus slope. The talus slope could then slide downward to a new equilibrium, threatening pipeline facilities and pipeline integrity. The probability of this happening is not known, but cannot be discounted.

Except for the Brooks Range, discussed above, impacts of slope instability and of frost heave on the pipeline would be similar to those discussed in Section 3.1.1.3 for the applied-for route. Refer to section 4.1.1.3 for mitigating measures.

Earthquakes

Northeastern Alaska has a relatively low probability for occurrence of severe earthquakes. The effect of earth-quakes on the Interior alternative pipeline system is expected to be no greater than that on the segment of the trans-Alaska oil pipeline system from Prudhoe Bay across the Brooks Range.

Impact of the Interior Alternative Route on Soils

In permafrost terrain, disturbance or removal of the plant cover (and peat layer) causes thawing of the permafrost and deepening of the active thaw layer. In ice-rich, fine-grained soils, thawing could lead to settlement, instability, and erosion. The main consideration, therefore, in trying to minimize impact on the soils along the route is to avoid disturbance to the vegetation protecting those soils. Coarser grained granular soils are more stable when thawed, and some well-drained gravels are highly stable.

About 25 percent of the Interior route passes through rock land and some 6 to 13 percent of the route is through well-drained gravel soils. The remaining two-thirds of the route is on poorly drained and fine-grained soils which would cause troubles when thawed. Also, about 40 percent of the route is through ice-rich permafrost. These conditions will cause construction and maintenance problems leading to adverse soil impacts much like those described for the applied-for AAGPC route in Section 3.1.1.4.

Since construction on this route would extend over 2 years, portions of the ditch excavated and backfilled in the 2 years prior to operation and chilling will be subject to thawing each summer. Establishment of an organic cover adequate to properly insulate and protect the soil may take 5 years or more, it is unlikely that this method alone will prevent thawing, settling, or erosion.

Soil entering streams would affect water quality and have secondary effects on fish and subsistence fishermen.

Attempted repair or maintenance activities during the summer without permanent access roads would cause even more damage and loss of soil than the original construction, due to the impacts of vehicles on thawed soils. (See Sections 3.1.1.4 and 3.1.1.16.)

Impact of the Interior Alternative Route on Water Resources

Water Quality

There are no reliable long-term water quality data for either ground water or surface waters along the Interior route, but because of the present natural conditions of the region, water quality is assumed to be excellent. There is now no development in the area, and no industrial chemicals, pesticides, or sewage are in the water. Any pipeline construction and operation activities are destined to lower the present water quality. See section 3.1.1.5 for a discussion of the impact on water quality by the applied-for AAGPC route, which also applies to the Interior alternative route.

Operation of large construction camps on this route would be over a 2-year period. This would pose potentially greater water quality problems from camp sewage, fuel storage, vehicle maintenance, and other activities, which might permit various pollutants to enter either ground water or surface waters. Reduction of present water quality within those streams south of the mountains would be more serious than for streams along the applied-for route since those streams enter the Yukon River, and the Yukon River drainage supports a diversity of both sport and subsistence fisheries.

Accidental spills of sewage or fuel products into these streams would also have adverse impacts on the small human communities downstream at places like Fort Yukon, Arctic Village, and Venetie.

Excavation of at least 8.5 million cubic yards of borrow, much of it from gravel bars within river flood plains, could contribute to increased turbidity and could temporarily lower the quality of water in those streams. This would probably be a short-term effect. Continued erosion from the pipeline ditch and/or road embankments would be a more serious source of water quality degradation.

The Applicant proposes to build some 190 miles of temporary snow-ice roads to transport supplies to the construction sites. This construction will require large volumes of water during the late winter when water supply is questionable. Large quantities of water would be required for hydrostatic testing of the pipeline. Withdrawal of water from shallow lakes and streams may have serious secondary impacts on fish and other aquatic organisms and may lower water quality by concentrating minerals in the remaining water.

Borrow Material Excavation on Stream Hydraulics

Borrow excavation of some 8,500,000 cubic yards from river flood plain gravel bars would have a significant local effect on stream hydraulics and cause local adjustments in the stream profile, channel locations, and other physical characteristics until a new equilibrium is reached. This could have secondary impacts on fish spawning areas and fish populations. See Sections 3.1.1.5 and 4.1.1.5.

Surface Drainage

Since the Interior alternative route will run approximately less parallel to the major streams north of the Continental Divide, it will not have the same impacts on surface drainage north of the Brooks Range as the applied-for route would have. However, south of the Brooks Range the Interior route would intersect each major drainage between the East Fork of the Chandalar River and the Yukon border, with resulting impacts similar to those anticipated for the applied-for AAGPC route on the Arctic Slope. Surface water movement could be intercepted, diverted, and impounded by the pipeline ditch and its berm. Soils upslope from the line would become more hydric, while those downslope would become more xeric, with concomitant effects on plant species able to grow there (see Sections 3.1.1.5 and 6).

The Applicant proposes to construct cross-drains through the ditch berm to maintain present surface drainage conditions, but the chilled pipeline, with its associated frost bulb, may cause icings in the drains, thus preventing water movement across the line.

Water diverted by the ditch and berm from small drainages to larger ones may contribute to accelerated erosion and downstream problems.

Collection of snow for snow-ice road construction could affect the following season's runoff pattern. Melting of the roads later in the spring than the surrounding area, will temporarily cause meltwater to be impounded and diverted upslope from the snow road.

Impacts of a buried, chilled pipeline on ground water movement and streambeds are described in Section 3.1.1.5. Also see section 4.1.1.5 for mitigating measures.

Impact of the Interior Alternative Route on Vegetation

The Interior route lies in an area which has been previously largely neglected by botanists. As is true for the applied-for AAGPC route, the most detailed descriptions of plant communities available for the area traversed by the Interior route are those conducted by consultants to Alaskan Arctic Gas Pipeline Company. Those studies (Hettinger, Janz, and Wein, 1974) describe 30 terrestrial vegetation types encountered, but no work has been done on aquatic vegetation.

The most obvious differences in the vegetation along this route are the alpine tundra communities in the Brooks Range and the occurrence of spruce, birch, and balsam poplar trees on the Porcupine Plateau, none of which is encountered along the applied-for AAGPC route.

Some 3,000 acres of existing tundra and boreal forest vegetation would be destroyed by construction of permanent roads, airfields, compressor stations, communication sites, borrow pits, and other structures. An additional 5,000 acres would be disturbed during construction by the use of the temporary work pad, snow-ice roads, and temporary winter trails. Secondary impacts resulting from construction and operation of the pipeline would affect an additional, but undetermined, area through changes in various physical conditions of the plants' environment. These secondary impacts, which modify habitats, would result in greater long-term changes in plant communities and the functioning of tundra and boreal forest ecosystems than the seemingly more severe short-term construction impacts.

Tundra Vegetation

The severest direct impact of the construction of permanent roads, airfields, compressor stations, communications sites, borrow pits, and other structures would be a permanent loss of those sites and the plants uprooted, cut off, or buried on the 1,500 acres affected. The loss of net annual primary production from these acres, while locally significant, will be insignificant in relation to net production in the surrounding areas.

Excavation of a pipeline ditch would destroy plants and the insulating mat of living and dead vegetative material along most of the 297 miles of the Interior alternative route from Prudhoe Bay to Canada except where the plant cover is already broken by areas of exposed rock, recent slides or slumps, and areas of intense frost action. The ditch would transect an uncounted number of plant communities and result in the loss of individual mosses, lichens, sedges, grasses, herbs, and shrubs from at least the 1,000 acres excavated, and probably cause a loss of much of the plant cover on the 4,300 acres of adjacent work pad area where plants would be broken and mashed by machinery or covered by excavated dirt.

Removal of the insulating plant cover and exposure of bare soil along the alternative pipeline route would induce local changes in the microclimate and initiate a series of impacts on the soil leading to various forms of soil instability and erosion discussed in Section 3.1.1.3 Geology, 3.1.1.4 Soils, and 3.1.1.5 Water Resources for the applied-for AAGPC route. See section 4.1.1.6 for mitigating measures.

As part of the transportation system necessary for the movement of pipe and heavy material it would be necessary to build temporary snow-ice roads which would receive heavy use during the winter, and a lesser mileage of temporary winter trails which would be used for only one or two round trips each. Some 500 acres would be occupied by these roads.

Surface vehicle travel during the winter causes much less disturbance of the tundra soils and vegetation than at other times of the year. But even in winter, varying amounts of damage will occur. The extent of damage depends on the depth of snow cover, microrelief of the site, vegetation type involved, amount of soil moisture, and depth of organic layer. When the interactions of these site variables are added to those of vehicle ground pressure and number of trips, it is evident that selection of road locations will be important in determining the ultimate effects on vegetation.

Snow collection and general construction clearing within river flood plains may result in damage, or destruction, of riparian willow shrubs. Willow sprout readily, so such damage will have little long-term effect on the riparian communities, but a short-term loss of such shrubs could have a severe local adverse impact on moose confined to those river valleys during the winter (Section 3.1.1.7, Wildlife).

Boreal Forest Vegetation

The Interior route alternative would pass through Boreal Forest vegetation south of the mountains on the Porcupine Plateau. Considerable clearing would be required where the pipeline ditch and other facilities would pass through the black spruce, white spruce, paper birch, and balsam poplar stands encountered from the East Fork of the Chandalar River east to Canada.

Also, some 190 miles of temporary access road would be built from the small town of Circle, on the Yukon River, north past Fort Yukon and up the Coleen River to pipeline Mile Post 264. Most of this route would pass through lowland spruce-hardwood and bottomland spruce-poplar forests.

Many of the impacts on Boreal Forest vegetation will be similar to those described for tundra vegetation, and removal of the plant cover will have similar impacts on the underlying soils and permafrost. Construction through forest stands will, however, require the removal and disposal of much larger quantities of plant material than in treeless areas. Clearing for any purpose in forest stands presents several potential problems which must be dealt with in order to reduce environmental impact of the action. Some items to be considered are: 1) method of clearing (by hand or mechanical means); 2) type and size of equipment used; 3) time of year; and 4) method of disposal of cleared material (burning, burying, chipping, etc.). Due to lack of access, the timber to be removed is considered to be noncommercial.

Under some conditions, clearing the right-of-way could cause more long-term impacts on the Boreal Forest ecosystem than the actual ditch construction would cause. If large concentrations of recently cut spruce trees are allowed to accumulate along the pipeline or roads they could serve as breeding sites for various species of detrimental forest insects. Bark beetle populations frequently build up in such spruce slash and then fly out to kill adjacent green trees. Forest fires resulting from slash burning, warning fires, and equipment operation are an ever-present hazard in right-of-way clearing through the Boreal Forest.

Operational Impacts of the Interior Alternative Pipeline System

A pipeline ditch and berm would be constructed along this route during a 2-year period, but the structures would remain to modify the physical environment for many years. It is the long-term effects of the pipeline presence and operation which will have indirect but long-term effects on the vegetation along this route. Site changes will include changes in soil moisture, surface drainage, soil temperature, nutrient availability, microrelief, and depth of the active thaw layer.

The cold buried pipeline and the mound of excess material over it could, at various places, impound, impede, and divert the normal flow of surface and subsurface water. (See Section 3.1.1.5, Water Resources.)

Impacts on vegetation from these site changes will be similar to those described under Section 3.1.1.6 for the applied-for AAGPC route.

Maintenance and Emergency Repair Impacts

Emergencies may require pipeline repairs during the summer when the ground is not completely frozen. It is during the period when the root zone is thawed that all arctic plants are most susceptible to damage from disturbance.

Problems and impacts associated with such emergency activities on the Arctic Coastal Plain and Arctic Foothills have been described for the applied-for AAGPC route in Sections 3.1.1.6, Vegetation and 3.1.1.16, Pipeline System Repairs.

Summer activities, particularly those engaged in under emergency conditions, increase the hazard of wildfire occurrence in the Boreal Forest.

Unique or Threatened Plant Communities

The National Herbarium of the Smithsonian Institution has compiled a list of endangered plant species which includes 35 species found in Alaska. One of these, Thlaspi arcticum a member of the mustard family, occurs on the Arctic Slope and Hulten (1968) lists it as being very rare, with only single specimens collected. Virtually the entire known range of this plant is the relatively small area between the Canning River and the Firth River north of the Brooks Range. Construction of a pipeline system through the restricted range of this endangered species could modify or destroy its habitat enough to lead to its extinction.

Two other members of the mustard family which may occur in the Brooks Range are also listed as endangered by the National Herbarium. Lesquerella arctica var. Scammanae and Smelowskia borealis var. villosa are small plants which grow on dry mountain slopes and ridges and on rockslides.

The Interior pipeline system alternative route would transect a largely undisturbed continuum of arctic ecosystems and vegetation types from the Arctic Ocean south to the interior of Alaska. We are at a time in the development of Alaska's arctic resources when much of the area is still relatively unaffected by human activities. It is an ideal time to identify and establish a series of research natural areas in Alaska, and it is still possible to select those areas which appear to have the most potential value. This is in marked contrast to situations elsewhere, in which research natural areas are selected from the remnants left after many years of development.

If no pipeline is built east of the Canning River, it should still be possible to establish an ecological reserve system for the Arctic that would provide areas for future studies and serve as an ecological base from which to monitor changes brought about by future developments in Alaska (Sections 3.1.1.6 and 12).

Abandonment of the Interior Alternative Route Pipeline

The continuing discovery, development, and depletion of new gas reservoirs in northeastern Alaska may span a period of 50 years during which gas would be moved to market through an Interior route pipeline system.

Methods chosen after that time for salvage or abandonment of the 310,000 tons of steel pipe within Alaska would impose a new series of impacts on the tundra and Boreal Forest environments. The pipeline right-of-way surface and subsurface should have stabilized under a well-developed plant cover and a temperature regime influenced by the operating gas pipeline. When gas flows cease, shifts in the seasonal patterns of soil temperature fluctuations near the pipe would occur so that the patterns more nearly resembled those in soils remote from the pipe. This would lead to changes in ground water drainage, soil moisture, and soil temperature with related shifts in plant community species composition as significant as those resulting from the initial construction.

If steel pipe were salvaged, excavation and removal would cause environmental impacts severer than those caused by the original construction. A wider ditch would be required to free the pipe from the permafrost and borrow material would be required to level the resulting trench. A period of soil instability, thaw consolidation, and erosion would follow. A concurrent revegetation program would be required to heal the wounds opened by the new excavation and would result in a new mosaic of plant communities different from those found on the operating pipeline berm.

Wildfire

Fires are more likely to occur in the Boreal Forest vegetation of the Interior route than along the applied-for AAGPC route. The rate of fire spread and resistance to control would also be greater on this route alternative.

The potential for man-caused fires along the route increases to the southeast as the route descends from the Brooks Range and traverses vegetation types with more abundant fuels. It is likely that the number of fires in the Porcupine Plateau area would increase due to construction and operation of a pipeline there.

The impact of such fires would depend upon many factors, including time of year, type of fuel, and local meteorological conditions. The presence of a gas pipeline system in this area would require additional diligence on the part of Bureau of Land Management personnel to handle the possible increase in fire incidence. The presence of the project would provide opportunity for earlier detection of wildfire.

The potential of pipeline or equipment failure must also be considered a potential threat to increasing the severity of forest fire.

Forest fire also threatens the pipeline in that facilities on the surface, such as block valves or compressor stations, could be damaged to the extent that the throughput of gas would be reduced or stopped. If the fire involved a large area (a condition not uncommon in roadless areas of interior Alaska), several facilities essential to pipeline operation will be damaged and thereby compound repair problems.

Impact of the Interior Alternative Route on Wildlife

Construction, operation, and repair of a natural gas pipeline system on the Interior alternative route would have a variety of impacts on wildlife much like those described for the applied-for AAGPC route in Section 3.1.1.7, Wildlife. In many cases the differences in impacts are a matter of the season during which animals would be affected or the duration of the disturbance. Most of the impacts described in Sections 31.1.6 and 8.1.1.3, which modify vegetation, also create secondary impacts on wildlife by modifying habitat and thus changing the available food and cover for many species.

Arctic mammals are particularly vulnerable to disturbance by humans because of their high visibility in the low tundra vegetation. Many wildlife species found in the Arctic are unique to that region and provide a focus of interest for the newcomer to the North. This curiosity value results in considerable harassment and disturbance by persons who have the freedom of movement provided by aircraft and all-terrain vehicles. Species such as the grizzly and polar bears, wolf, wolverine, and musk ox are most detrimentally affected by aircraft harassment because their uniqueness and low population density increase the likelihood that individual animals will be repeatedly hazed as people attempt to photograph them and observe them closely. Refer to section 4.1.1.7 for mitigation of impacts.

Caribou

The Porcupine Caribou Herd of from 115,000 to 120,000 animals is an international resource shared with Canada. A gas pipeline on the Interior route would bisect the winter range of that herd and have both direct and indirect effects on the caribou population and its habitat. The animals, which bear their calves each spring on the Arctic Coastal Plain in Alaska, return to the Porcupine River basin in Canada and Alaska for the winter where they are an important source of food and hides for people living in those rural areas. Pipeline impacts of the applied-for route on caribou were described in section 3.1.1.7, Wildlife, and that discussion applies also to the winter range associated with the Interior route.

The caribou is a herd animal adapted to constant movement during the year over largely undisturbed wilderness areas. Unlike migratory birds, which remain on a summer territory for several months and spend the winter on definite wintering areas, the caribou are constantly on the move in search of food and trying to avoid insects and predators. Because of its location across these traditional travel routes between winter, summer, and traditional calving areas, an Interior pipeline route would be crossed at many locations by caribou, and the same animal is likely to have to cross the line four to eight times in any 1 year. Clearly, this alternative route has great potential for adverse impacts on caribou movement.

Since a gas pipeline would be buried, it may not present a significant barrier to caribou movement, but other visual and auditory disturbances could affect caribou behavior and delay or deflect their movements. Construction activities, aircraft noise, and compressor station noise are among the types of impacts described for the applied-for route in section 3.1.1.7 which would also occur here. Such disturbances would be more difficult to avoid on this alternative route because:

1) The Interior route is 100 miles longer in Alaska;

2) Construction would take longer and involve more workers;

3) Numbers of caribou appear at intervals throughout the year and scheduling of construction activities to prevent disturbance would be difficult; and

4) Six compressor stations would be required and two would be in critical habitat areas in the Marsh Fork of the Canning River and Old Woman Creek-Koness River wintering area.

An Interior pipeline route would cross the Brooks Range via either the Main Fork of the Canning River or the Marsh Fork of the Canning River. Caribou winter in the upper drainage and use both forks as migration routes, but the majority seem to use the Marsh Fork. A pipeline in either fork of the Canning River would parallel caribou migration trails through these restricted valleys. A compressor station would be required near the confluence of the two forks and will add another disturbing feature to the migration route.

Construction, operation, and repair activities at any time of the year in this area could disturb caribou, and aircraft traffic in the Canning River canyon would have adverse effects on the animals.

Both fixed-wing and helicopter aircraft disturb caribou at all seasons. This disturbance would occur the length of the line, but would be concentrated at the 8 airstrips and 16 helicopter landing pads.

Large numbers of caribou winter near the Interior route on the Sheenjek and Coleen Rivers where they would be vulnerable to hazing by aircraft. In midwinter, when the daily energy balance of a caribou is precarious, harassment by aircraft or snow machine can cause the animal to expend more energy than it can acquire from the available forage, thus placing the animal in a negative energy balance. Repeated harassment will lead to death of that individual. It is a crime in Alaska to harass wildlife with aircraft.

In spring most of the animals wintering in Alaska south of the Brooks Range would cross the pipeline route near the Sheenjek and Coleen Rivers while moving northeast on their way to the Arctic Coast. Some animals from the Old Crow area in Canada cross into Alaska and would cross the pipeline near Strangle Woman Creek and the Coleen River.

In August many of the caribou would again cross the pipeline route when heading south toward Arctic Village. Some would again cross the line in October on their way into Canada for the winter.

In summary, the construction and operation of a 297-mile-long natural gas pipeline on the Interior alternative route would be expected to have serious impacts on caribou behavior along most of the route by interfering with their seasonal movements. The concentration of facilities and human activity could cause the Porcupine Herd to abandon their traditional winter ranges south of the pipeline. This could reduce the population of the herd by forcing them to use less suitable range. Similarly, facilities and activities at the Chandalar crossing (M.P. 163) could deflect migration movements and thus deflect caribou entirely from the south side of the Brooks Range. The Porcupine Herd would be subject to increased harassment and hunting because more people would have easier access to them. This could have secondary adverse impacts on the Native hunters in Arctic

Village, Old Crow, and other villages who depend on the caribou for the greater share of their food.

Moose

Moose are dispersed widely over the Interior route area during the summer. In winter the moose are closely associated with a narrow band of riparian plant communities along the river valleys. Winter weather, limited winter food supply, and predators are factors which limit the moose population. Impacts of pipeline construction and operation would be similar to those described in Section 3.1.1.7 for the applied-for AAGPC route, but will be pronounced on moose wintering in the Shublik Spring and Cache-Eagle Creek areas along the Canning River. Impacts on moose could cause a reduction of population of unknown magnitude south of the Brooks Range. The most critical moose winter habitat is in the upper Canning River and in Strangle Woman Creek near the east end of the route. The impact on moose caused by use of the temporary winter access road north from Circle would also tend to reduce the population by an unknown amount.

Musk Ox

A small herd of musk oxen is found near the Kavik River. In winter they depend on range in windswept areas or with a thin, soft snow cover. Compaction by snow machines or other modification of the new cover by snow fences, road embankments, and pipeline berms may prevent musk oxen from feeding in those areas.

Musk oxen are extremely shy animals and would be adversely affected by people and airplanes as described in Section 3.1.1.7 for the applied-for AAGPC route. It is expected that the band at Kavik could be eliminated from its present range or severely reduced in number because of the compressor station and human activity concentrated in that area.

Dall Sheep

Dall sheep may be the most severely affected of the various ungulate species encountered along the Interior route, and virtually all of the impacts occur in the Canning River drainage. There seems to be no way to construct and operate a pipeline there without affecting this white mountain sheep.

A population of some 1,000 sheep occurs within the Canning River drainage and a smaller one in Cane Creek. From November to April, the sheep are concentrated on winter ranges near the mouths of canyons and are quite confined to the restricted ranges during that period. In 1973 about 50 percent of the sheep wintered adjacent to the Marsh Fork route option, while about 36 percent were found in the Canning River route option. The Interior route would cross six important traditionally utilized sheep trails and one mineral lick while passing within 1/2 mile of five other licks.

A compressor station on the Marsh Fork route option would be located in an area intensively utilized by sheep during all seasons of the year, and it is also close to three important mineral licks.

Lambing occurs in the same general areas as the wintering areas.

In summary, construction, operation, and repair of a pipeline at any time of the year would tend to reduce sheep populations of the Canning

River, Marsh Fork, and Cane Creek areas because of increased year-round disturbance, increased access, and interference with migration routes. This would reduce the quality of habitat and change habits from the natural. Effects of disturbance are discussed more fully in Section 3.1.1.7, Wildlife for the applied-for AAGPC route.

Wolf

Impacts on wolves would be similar to those described in discussion of the applied-for AAGPC route (Section 3.1.1.7, Wildlife). Harrassment by aircraft may not be as much a problem along this route since the mountainous terrain tends to limit aircraft maneuvers. Forest cover toward the eastern end of the Interior route would also lend some protection to wolves.

Arctic Fox

Impacts on the arctic fox population along this route would be insignificant. Only a few dozen miles of the route would have any effect on the species and that is in an area now being developed for oil and gas production from the Prudhoe Bay Field.

Grizzly Bear

Grizzly bears roam over the Interior route in spring, summer, and fall in greater numbers than are found along the applied-for AAGPC route. Adverse effects of pipeline activities on grizzly bear den sites and behavior as described in Section 3.1.1.7 for the applied-for route apply as well to this alternative.

The Canning River Valley seems to be an important grizzly habitat, with bears using the willow stands in the valley bottom extensively in spring and fall. The East Fork of the Chandalar Valley is also an important grizzly bear spring and fall range, while the area eastward to the Sheenjek is preferred summer range. The Interior route intrudes on all these known grizzly bear habitats and a decline in grizzly numbers seems to be an inevitable consequence of pipeline operations on that route.

The Interior alternative route would be much more detrimental to grizzly bear populations in northeastern Alaska than would the applied-for AAGPC route.

Black Bear

The farthest north distribution of black bears in Alaska reaches up the Sheenjek and Coleen River Valleys as far as the Interior route. Populations there are low, but their curiosity would lead some of these bears into inevitable conflicts with humans at camps, garbage dumps, etc. Some of these nuisance bears would be shot, but the effect on the black bear population would be minor.

Polar Bear

Polar bear are associated with the Interior route only in the vicinity of Prudhoe Bay. Impacts in the portion of the route between Mile Posts 00 and 80 on polar bear maternal denning are possible, but known denning sites are to the east of the Interior route. Overall the Interior route is considered likely to have little impact on polar bears since it crosses an area of the Arctic Coastal Plain where human activities are already prevalent.

Smaller Mammals

Construction of a pipeline system on this route would result in the destruction of habitat and the deaths of many thousands of small mammals with restricted home ranges. The effects of pipeline activities as described for the applied-for AAGPC route in Section 3.1.1.7 would be similar to those along this route.

Marine Mammals

The Interior alternative system will use established port areas at Prudhoe Bay, Anchorage, and Valdez. These port areas are presently in use and no new impacts are expected to be caused by the Interior alternatives pipeline system.

Birds

The probable effects of a pipeline along the Interior route are very different from those expected on the applied-for AAGPC route. This route would traverse only about 40 miles of Arctic Coastal Plain waterfowl and shore bird habitat in an area which is being developed rapidly for oil and gas production. Impacts on waterfowl from natural gas pipeline operations would be minor in that area.

The proposed route does cross waterfowl habitat on the Coleen River, and the temporary winter haul road from Circle to the Coleen River would pass through more than 100 miles of waterfowl habitat in the Yukon Flats. If this route is used only in winter, there would be no conflict with waterfowl use of the area.

The two major sources of potential impacts on bird populations are from a direct loss of habitat and disturbance as a result of pipeline activity. Birds found along the Interior route would be temporarily excluded from nesting on the pipeline crown until vegetation was re-established. The higher-altitude regions are low in bird production along the Interior route. Birds affected in the Arctic Coastal Plain and Arctic Foothills Provinces would be mainly the Lapland longspur and shore birds. In the Porcupine Plateau and Brooks Range Provinces, shore birds, ptarmigan, and perching birds would lose some nesting and feeding habitat, particularly in areas of riparian growth. Not only do these riparian areas provide good nesting cover, but terrestrial nesting birds, after they hatch, retreat from the sparsely vegetated valley sides and ridges to the riparian valley bottoms. These areas provide both a food source and protected area for adult and newly fledged birds. Therefore, the less riparian habitat destroyed during pipeline construction, the less impact to terrestrial birds.

Loss of habitat would probably be less critical for most birds, in view of the small percentage of their habitat which would be lost from construction of the pipeline along the Interior route. However, raptor habitat is confined to sites along river valleys and pipeline construction along the Interior route would have the potential to physically disturb established raptor cliff-nests, particularly along the Marsh Fork of the Canning River, and Monument Creek. Peregrine falcons (an endangered species) nest in these areas. Construction within at least 2.5 miles of nesting cliffs should be avoided between March 1 and August 15, because cliff-nesting raptors are building nests, laying eggs, incubating, or raising young during this period, and disturbance could cause them to abandon the nests. Harassment of nesting falcons, hawks, or eagles, or the taking or shooting of these raptors is prohibited. The limited availability of nesting cliffs might prevent renesting by a pair of birds forced to leave their original site, in the same or later years. Also, because cliff sites are traditional, raptors prevented from nesting might not accept another site unless it, too, is traditional.

Activities along the Marsh Fork Option and the Canning River Option would have different impacts on cliff-nesting raptors. It is possible that construction along the Main Fork of the Canning could disturb or destroy (insofar as use by the falcons is concerned) the nests of three pairs of peregrine falcons known to nest along this alignment. Three cliff-nests, which were inactive in 1972, are located along this alignment. If these nests were used during the year of construction, they could be disturbed or destroyed by construction activities. Construction along the Marsh Fork alignment of the Canning River might also disturb or destroy a gyrfalcon nest known to occur along this alignment. Six inactive cliff-nests were located along the Marsh Fork in 1972. In 1973 one active peregrine site, one active gyrfalcon site, and one active roughleg site were located. Three golden eagles were known to nest here in 1973 as well.

Winter construction activities in these areas would also induce man/bird interactions. Gyrfalcons, in particular, can be attracted to activities that cause ptarmigan to flush from cover.

Thus, while avoiding the impacts on swans, geese, seaducks, and shore birds, the Interior route would have serious long-term detrimental effects on falcons, eagles, and hawks in the Canning River vicinity.

Fish

Discussions of impacts on fish from gravel excavation in streams; from spills of petroleum, methanol, and other pollutants; and from winter use of springs and unfrozen water during pipeline construction as discussed in Section 3.1.1.7 for the applied-for AAGPC route apply equally to this route.

Probably the most serious unavoidable impacts on fish along this route would occur in the Canning River where the pipeline would parallel the river for more than 50 miles. Construction activities there would affect spawning, rearing, and overwintering areas for grayling and arctic char, with the Marsh Fork containing the most large ground-water sources and open water throughout the winter. The Marsh Fork includes the most heavily utilized arctic char spawning areas in the entire Canning River drainage.

South of the Brooks Range the pipeline route would intersect the Chandalar, Sheenjek, and Coleen Rivers and many of their smaller tributaries. Silt and toxic chemicals reaching these rivers from the pipeline activities would have detrimental effects on fish populations and eventually the subsistence fishing success of people living in villages such as Arctic Village and Venetie on the Chandalar and Fort Yukon at the mouth of the Porcupine River.

Invertebrates

This route is not expected to have any significant long-lasting impact on invertebrate populations in northeastern Alaska.

Long-term Secondary Impacts on Mammals, Birds, Fish and Invertebrates

Any assessment of the impact of a project of this magnitude on the previously undisturbed ecosystems of northeastern Alaska must consider the potential impact of future developments. The approval of an Interior route pipeline would serve to stimulate extensive exploration in the surrounding area and further development which would result in an ongoing complex of human presence, disturbance, and habitat destruction.

Although thresholds are generally unknown for arctic animals, the capacity of many wildlife species to absorb and adjust to increased disturbance diminishes with each additional disturbance, and a general reduction in wildlife population numbers and species diversity can be expected as a result of increased development and disturbance. The eventual disappearance of wilderness-dependent and rare species would follow human occupation of the route.

Impact of the Interior Alternative Route on Ecological Considerations

Considerations of impacts on tundra ecosystems are described in Section 3.1.1.8 for the Arctic Coastal Plain and Arctic Foothills. Similar considerations apply to Alpine Tundra in the Brooks Range and tundra systems in the Porcupine Plateau south of the mountains. All have low heat budgets and short growing seasons.

This route would pass through a northern segment of the Taiga zone as was noted in the earlier discussion of vegetation. Many of the problems and impacts on Tundra ecosystems are shared with Taiga systems, but there are two important additions. Forest fire and insects both play important roles in the functioning of a Taiga ecosystem. Both are natural constituents of the ecosystem that can sometimes be influenced by human activities, which could cause a local imbalance in the system.

Spruce trees cleared from the right-of-way should be chipped or burned immediately to prevent a buildup of beetle populations which could escape into surrounding live trees and kill them over a wide area (Section 8.1.1.3, Vegetation).

Impact of the Interior Alternative Route on Economic Factors in Alaska

Construction, operation, and repair of the Interior alternative pipeline system in Alaska will produce short- and long-term economic impacts different from those described for the applied-for AAGPC route in Section 3.1.1.9. Important differences involve the size work force in Alaska, duration of peak employment, and probable development of other resources.

The economic impacts of the Interior alternative route as developed by the University of Alaska econometric model (Scott, 1975) described in section 8.1.1.1 include: a property tax of $22 million, construction employment of 2,738, a capital value (pipe and compressors) of $1.1 billion, an increase in gross state product of $115.5 million, a total state employment effect of 11,300, an increase in real wages and salaries of $95.6 million, population growth of 15,700, an addition to personal income statewide of $274.6 million with an increase in per capita income of $238 and a total addition to state revenues of $105.1 million. All figures are for 1980.

It is important to note that the economic effects in Alaska caused by the Interior alternative pipeline system primarily involve relocation of work from Canada to Alaska. For example, the Interior alternative will require the permanent work force at Prudhoe Bay to be increased by 11 workers to operate and maintain the compressor station located at Mile Post 118. The AAGPC (1974a) points out that at least 4 of the 11 would have been stationed in Canada as a result of the compressor station location at Mile Post 225 (in Canada) on the applied-for AAGPC route. At the same time the applied-for AAGPC pipeline system requires construction and operation of four compressor stations in Alaska. Therefore, it is expected that the permanent work force at Prudhoe Bay will increase if new compressor stations are added in Alaska.

In total, the pipeline link between Prudhoe Bay and the main pipeline system up the Mackenzie River Valley in Canada requires eight compressor stations at ultimate designed throughput of 4.5 bcf/d; the Interior route alternative requires nine compressor stations. The applied-for AAGPC system placement of compressors is four each in Alaska and Canada; the Interior Route requires five in Alaska and four in Canada. Total miles for the two segments are 492.3 miles for the applied-for route and 537.5 for the Interior route. Thus, total economic effects will be similar for the two routes. Distribution of these effects are not the same for Alaska. The construction boom in Alaska associated with the Interior route is 2.5 times greater than that of the proposed route (Kruse et. al., 1975) with property taxes accruing to the State of Alaska also nearly 2.5 times greater.

Employment

During construction of the Interior alternative pipeline system the AAGPC (1974a) estimates that twice as many workers would be required as would be used with the applied-for route (5,000 vs. 2,400). The schedule for completion of the Interior alternative route proposes peak construction activity over a 2-year period (peak employment for the applied-for AAGPC system is 6 months). Operation of the initial compressor station at M.P. 118 on the Interior route will require 11 more people to be stationed at Prudhoe Bay. Increased employment (double) and longer duration of peak employment (4 times) means that economic effects caused by the Interior gas pipeline system will be more pronounced at Fairbanks (Section 3.1.1.9), because supplies for most of the Interior system will funnel through Fairbanks for the system south of the Brooks Range (145 miles) and for all supplies not shipped by barge to Prudhoe Bay.

Employment opportunities will also occur at Anchorage and Skagway as these two areas become receiving points for supplies. Circle will also have increased employment opportunities because of its key location as a storage and distribution point for the temporary road to the Coleen River area supply depot on the Interior route (M.P. 264). Because of their small size it is expected that both Skagway and Circle will experience economic effects similar to that described for Valdez in Sections 8.1.1.3 and 10. Overall employment opportunities at Skagway, Circle, Fairbanks, and Anchorage are unknown. It is assumed that Anchorage, because of its larger size and diversified economy, will experience less employment impact than that caused by peak employment with construction of the oil pipeline (a total of 31,300 workers throughout the state). Conversely, Fairbanks' central position as a major distribution area for Circle and Prudhoe Bay supplies suggests impacts similar to those caused by the oil pipeline.

Because more workers would be needed for a longer period to build the Interior alternative than the applied-for AAGPC route, it is expected that employment through secondary jobs could be substantial in Alaska--perhaps as many as 7,500 (approximately double the secondary and indirect jobs expected by AAGPC with peak employment of 2,400 workers for 6 months). This is approximately 40 percent of the peak employment needed to build the oil pipeline system from Prudhoe Bay.

Long-term employment opportunities for residents of Kaktovik (pop. 150) and Arctic Village (pop. 131) are expected to be minimal because of their relative distance from the pipeline (approximately 100 and 60 miles respectively). However, it is expected that there will be better opportunities at Arctic Village because of its location on the south side of the Continental Divide as the only populated area close to the pipeline system.

In summary, employment opportunities during construction will be approximately 5,000 workers for 2 years with associated secondary and indirect jobs of 7,500. This is approximately equal to 40 percent of peak employment caused by the oil pipeline. Fairbanks is expected to experience employment similar to that caused by the oil pipeline. Anchorage will be less affected. Skagway and Circle will experience change similar to that now happening at Valdez as a result of the oil pipeline construction program.

Potential Development of Associated Resources

The Interior alternative route is associated with three significant resources on the south side of the Brooks Range; Yukon-Kandik Oil and Gas Province, minerals, and timber-aqriculture. These resources are now undeveloped. The first drilling exploration program for oil and gas in the Yukon-Kandik is scheduled to commence in early 1976. The program plans for at least four exploratory wells to be drilled in an initial effort to discover petroleum reserves in the geologic basin.

The Interior alternative pipeline system requires use of a temporary access road northwest across the Yukon Flats area from Circle. Experiences with the construction of the oil pipeline system from Valdez suggest the probability that this temporary road would become a permanent road. Accordingly, the following analysis is based upon the long-range possibility that there will be a permanent road from the Yukon River north to the Coleen area. The immediate short-range view suggests the Interior route will result in construction of several air-strips in the presently remote area on the south side of the Brooks Range. It is not necessary that an integrated surface transportation system be developed since the Yukon and Porcupine Rivers are navigable streams large enough to accommodate movement of large bulk goods by barge when they are ice free. Both rivers historically have been and still are used for commercial navigation (Section 8.1.1.3). Therefore, all that would be required to stimulate development of mineral and agricultural products would be access to the Porcupine or Yukon Rivers.

Oil and Gas--The Interior alternative pipeline system would provide direct transportation for gas reserves associated with the Prudhoe Bay Field Oil Pool. Its routing in a southerly direction from Prudhoe Bay to the exit of the Canning River (Mile Posts 00 to 90) will serve to encourage development of the eastern Beaufort Sea Province or the Marsh Creek anticline.

The Interior alternative pipeline system will be located to the north of the Yukon-Kandik Province on the south side of the Brooks Range. The Yukon-Kandik Province embraces a 19,504 square mile area estimated by the State to contain 1.67 billion barrels of recoverable oil and 11.37 trillion cubic feet of recoverable gas (Open File 50, 1974). The AAGPC (1974a) notes that there may be sufficient prospective value for oil and gas in the Province to warrant a separate pipeline. The center of the Kandik Basin (a triangle formed by the United States-Canada border, Yukon River, and Porcupine River) is 120 miles south of the Interior route and will be crossed by the temporary access road between Circle and the Coleen River supply depot. Accordingly, the Interior alternative will stimulate additional exploration in the eastern part of the Yukon-Kandik Province and especially the Kandik Basin because it will involve improvement of surface access to the area (temporary access road) and will provide a means for quickly transporting any gas found to domestic markets.

Minerals--A natural gas pipeline would probably not have major impact on the development of mineral and energy deposits in Alaska. Also, a mining venture is not a large consumer of energy for a cross country pipeline company to service. For example, a large company mining 100,000 tons of ore and waste and concentrating 40,000 tons of copper ore each day would consume approximately 16,100 Mcf/d (thousand cubic feet per day) for heat and power. Adding smelting and refining capabilities at the concentrator site would bring total heat and power requirements to approximately 28,000 Mcf/d. By contrast, the City of Anchorage consumed about 58,000 Mcf/d in 1971 and the Collier ammonia and Phillips-Marathon liquid natural gas plants consumed about 101,000 Mcf/d. Large petrochemical plants producing ethane, propane and isobutane commonly consume 400,000 Mcf/d, with the largest plants consuming over 1,500,000 Mcf/d. For a pipeline company transmitting 2,000,000 Mcf/d, a mining company probably is not a large enough consumer to consider servicing.

The primary impact of a natural gas pipeline in the development of mineral and energy deposits lies with an accompanying permanent road. The development of small, high-grade deposits or large, low-grade deposits within 50 miles either side of a pipeline road would be enhanced. However, a permanent road which originates on the North Slope and goes into Canada without passing through a supply point, such as Fairbanks, would have marginal utility for mining companies. The creation of a snow-ice road to be used during the construction of the pipeline and then left to melt, as has been proposed, would have no impact on the development of mineral and energy resources.

The course of mineral development could be altered by the State of Alaska. Should the State take its royalty from natural gas production in kind, it may make the natural gas available for mineral ventures. The State must make its request for natural gas when the reserves are being committed in order to have a supply to distribute. A State policy to connect any permanent natural gas pipeline road to the road system within Alaska via proposed corridors would aid in the development of mining. If the State of Alaska desires mineral development, there could be impact on the mining industry from the natural gas pipeline and road; otherwise, the pipeline will have little or no impact on mineral development.

Timber-Agriculture--Improved access, such as that necessary to construct the Interior alternative pipeline system, will provide both short- and long-range stimuli to the development of a forest-products industry to the south of the route. The primary stimulus will be the improvement and/or construction of a temporary road from Circle to the Coleen River. This 175-mile long road intersects a significant proportion of the commercial timber, especially in the Coleen River Valley.

The region south of the Interior alternative system has been identified as having considerable potential for commercial agricultural uses. Much of the lowland areas suitable for agriculture also supports the best timber stands. These potential agricultural lands are directly associated with the temporary access road between Circle and the Coleen River. A substantial portion of the area between Circle and Chalkyitsik has 50 percent or more of its area considered suitable for agriculture. Similar areas, but climatically marginal, are located north of Chalkyitsik and the Interior route. The bulk of these lands are located along the upper Porcupine River and the Coleen River (PNF, 1974). These potential commercial agricultural areas will become more attractive to economic development with improved access which will result from the construction of the Interior alternative route.

State and Local Revenue

Income to the State of Alaska and to the North Slope Borough from construction, operation, and maintenance of the Interior alternative system would be slightly higher than that expected for the applied-for AAGPC route, and costs to those governments would also be somewhat higher, but each would be spread over a longer period of time. The cyclical nature of employment for two winter and two summer periods would increase unemployment rolls during the slack periods in the cycle.

The long-term prospective development of oil and gas, minerals, timber, and agriculture south of the Interior route (between Circle and the Coleen River storage depot) will be accelerated. In turn, the short-range revenues to State and local governments would increase. These increased returns will also be accompanied by increased costs as more people move into remote and uninhabitated regions of Alaska.

Cost of Transportation

The cost of transportation associated with the Interior alternative route will be increased in a manner similar to that described for the applied-for AAGPC route in Section 3.1.1.9. The primary increased costs will result from competition for use of available air transportation but will also place heavy competitive factors on rail and highway transportation because of supplies being shipped to Anchorage and Skagway for rail and highway movement to Fairbanks and then by highway to the south side of the Brooks Range and, in some instances, by highway to Prudhoe Bay.

Transportation patterns and effects on the State's local economies would be significantly different from those of the applied-for AAGPC route, with much of the material needed for the Interior route coming into Alaska at Skagway and Anchorage and moving over land through Fairbanks to the small town of Circle at the end of the Steese Highway. This would affect everyone using the various highways involved, the ports and railroads, and the tranportation of all other materials competing for space on those transportation modes.

Alaskan Native-owned Resources

The Interior route would affect Native-owned resources on the north side of the Brooks Range in a manner comparable to that described for the applied-for AAGPC pipeline system in that Native-owned gas if discovered will be available for transportation to domestic markets (Sections 2.1.1.3 and 3.1.1.9).

South of the Brooks Range substantial areas along the Yukon and Porcupine Rivers are owned by local Native Village Corporations and the Doyon, Ltd. Regional Corporation. These Athabascan Indian corporations own forested areas, lands suitable for agriculture, most of the Kandik Basin with its prospective oil and gas deposits, and substantial portions of the total Yukon-Kandik Province. Current exploration is underway in this area with Doyon, Ltd. contracting for at least four exploratory wells to be drilled.

The Interior alternative pipeline system will stimulate development of these areas should the Native owners so desire. As with any development in remote, undeveloped areas, there will be significant changes in the existing way of life. It is not known if that some Native-owned areas will forego economic development in favor of retaining cultural and social values.

Summary of Economic Changes in Alaska Caused by the Interior Alternative Route

The Interior alternative route will require employment of 5,000 direct and an additional 7,500 secondary and indirect jobs for approximately 2 years during peak construction in Alaska. This equals approximately 40 percent of peak employment in Alaska caused by construction of the trans-Alaska oil pipeline system.

Fairbanks will experience continuation of the economic factors caused by building the oil pipeline. Circle and Skagway will experience change comparable to that now observed at Valdez.

Circle will suffer the greatest impacts of any populated area in the State as a result of its position at the end of the Steese Highway. Circle will become a staging area for men and equipment moving north to the Coleen River. Pipe joints will be stored and welded into double joint lengths before being trucked the 175 miles north to the Coleen River.

The Interior route will stimulate more exploration of the Yukon-Kandik Province for oil and gas and mineral development south of the Brooks Range. It is expected that a forest-products industry and commercial agriculture will be developed between Circle and the Interior route in direct proportion to the extent the 175 mile long temporary access road is improved.

Impact of the Interior Alternative Route on Sociological Factors

The Interior alternative pipeline system is located in the North Slope Borough on the north of the Continental Divide and in an unorganized borough on the south. It is recognized that the overall cultural values of the Eskimos and the Athabascan Indian are different, but both Native Groups place heavy importance on natural values. However, because the area south of the Brooks Range is remote, the sociological factors described in Sections 3.1.1.9 and 10 for the North Slope Borough are considered typical of those along the route as a whole.

Impacts expected on population in Anchorage, Fairbanks, and at Prudhoe Bay would be similar to those described in section 3.1.1.10 for the applied-for AAGPC route. Kaktovik would not be affected by this alternative route, but villages south of the Brooks Range would probably notice some changes in their populations. Arctic Village, Circle, Chalkyitsik, and Fort Yukon are the communities closest to the route, but even they are 40 to 120 miles from the alternative pipeline system. Improved access into the area resulting from pipeline construction is a major factor in anticipated impacts on communities there.

The communities most likely to suffer sociological problems are Circle (small community on the left bank of the Yukon River and at the end of the Steese Highway) and Chalkyitsik (a small community between the Porcupine and Yukon Rivers). Those impacts may be temporary, but will last at least 2 or 3 years, and will certainly adversely affect the present residents' lifestyle. Any changes in lifestyle are likely to be long-lasting.

Fort Yukon may also notice population increases from the operation of the temporary access road, since it will be near the halfway point on that 175-mile route.

Most of the needs for housing and community services will occur in Fairbanks and Anchorage where there would be adequate capacity following the completion of the trans-Alaska oil pipeline. Circle and Chalkyitsik, however, will be caught with no housing, public services, or other amenities required for the workers involved in pipe storage and welding, transportation, and temporary road construction and operation. Impacts on these areas would be major.

Subsistence

Kaktovik, because of its distance (approximately 100 miles) from the Interior route will not be affected by the route unless the Porcupine Caribou Herd is affected in its winter range. Since this is possible, residents at Kaktovik could be forced to seek a substitute to replace the 100 caribou consumed each year for subsistence.

People living at Arctic Village (pop. 131) are heavily dependent upon caribou for food and subsistence use. Annually, residents at Arctic Village consume 300 caribou, 5 grizzly bear, and 18 moose. These animals could be affected by the Interior alternative system in the vicinity of Arctic Village to the extent that these people would have to seek substitutes for up to 300 caribou and 2 or 3 grizzly bears and up to 9 moose possibly displaced by the pipeline system. Substitution would be other wild game or a heavy reliance on imported foods.

Similarly, people living at Chalkyitsik could be required to supplement their subsistence use of up to 213 caribou and 16 moose possibly displaced by the Interior route or the temporary access road to the Coleen River.

Fort Yukon residents consume annually 44 black bear, 11 grizzly bears, 315 caribou and 200 moose for subsistence purposes. They may need to find substitutes for up to 50 percent of these, since the Interior route will affect the Porcupine Herd and local moose and bear populations where residents hunt along the Porcupine or Yukon Rivers upstream from Fort Yukon and inland to the east.

Because of its location on the south side of the Yukon River, Central is expected to suffer little impact on subsistence uses. Circle conversely will suffer a marked difficulty in reaching its annual subsistence harvest of 2 black bear and 14 moose because of the influx of people stationed there during the 2-year construction period.

Overall, the Interior alternative system will adversely affect subsistence use of approximately 1,000 Alaskans residing in rural areas. See section 4.1.1.10 for mitigating measures.

Impacts of the Interior Alternative Route on Land Use

The Interior alternative pipeline system lies in northeastern Alaska to the south of the applied-for AAGPC route; most of the land-use planning impacts described for that route Section 3.1.1.11, also apply to the Interior route since for both routes, construction, operation, and repairs will take place in undeveloped remote areas of Alaska.

In summary, State, Federal, or local land use plans have not been completed. The construction, operation, and repair of the Interior alternative pipeline system will cause a commitment of land uses prior to the establishment of a comprehensive statewide land use plan or policy for the Arctic as recommended by the Joint Federal-State Land Use Planning Commission for Alaska.

Existing Land Uses

State-owned lands in the Prudhoe Bay vicinity are already committed to oil and gas production and construction and operation of this natural gas pipeline would complement and enhance those activities.

In all locations along the other 207 miles of this route, gas pipeline construction and operation would have significant adverse impacts on present land use. Those lands are now in a natural condition and used largely for the production of wildlife species which depend for their well-being on extensive areas free from disturbance by man. The wildlife, in turn, provide the base for a subsistence hunting and trapping economy and lifestyle unique to rural Alaska.

Wilderness

Aircraft traffic, compressor station noise, and compressor exhaust vapor plumes all would intrude on the adjacent wilderness and lower the quality of its intended solitude. Other impacts on wilderness are described in Section 3.1.1.11 for the applied-for AAGPC pipeline system.

Impacts of the Interior Alternative Route on Historic, Archeological and Unique Area Values

There are no known historic villages, cabins, or other sites along the Interior alternative route. However, there are remains of prehistoric stone fences used in caribou hunting, which could be destroyed during pipeline construction. The temporary access road will adversely affect historic features at Circle, Fort Yukon, and the Porcupine River by improving access to them.

The area traversed by the Interior route is characterized by a distinct lack of archeological information. On the basis of investigations in adjacent areas, however, it seems that most of this route is extremely sensitive archeologically, particularly on the south side of the Brooks Range. The relatively high occurrence of excellent vantage points and bedrock outcroppings adjacent to major streams indicates good probability that archeologically productive sites are there. The Interior alternate route traverses the region of prehistoric fluctuating cultural boundaries; this fact is important to interpretation of the archeological record.

Information about archeology obtained along the Interior pipeline alternative route would increase knowledge of the prehistory of the region which may have been occupied over 27,000 years ago. Available ethnographic information indicates that a number of sites will be found along this route and if they cannot be avoided by construction activities, they may be lost.

Section 3.1.1.12 for the applied-for AAGPC route outlines the responsibilities of the government and contractors under provisions of the National Historic Preservation Act of 1966, Executive Order 11593, and the Archeological and Historic Preservation Act (P.L 93-291), and points out some of the impacts of these requirements on pipeline construction schedules. Construction of roads, airstrips, and heliports along the pipeline route in a formerly roadless area will make archeological sites accessible to large numbers of people. Unauthorized disturbance and vandalization would be possible if sites are not properly protected and supervised.

Probable impacts on unique areas between Prudhoe Bay and the Canning River are described for the applied-for route in Sections 3.1.1.6 and 12. South of the Brooks Mountain Range, research natural areas have also been proposed on the Yukon Flats and the upper Coleen River, neither of which is yet located precisely. The impact of construction and operation of a natural gas pipeline along the Interior route on unique areas south of the Brooks Range is unknown.

Impacts Caused by the Interior Alternative Route on Recreation and Esthetic Resources

The area through which the Interior route passes is now a de facto wilderness. There are no roads; access is usually by light aircraft or by foot from Kaktovik on the north or Arctic Village and Fort Yukon on the south. There are no developed recreation sites or public use areas.

Hunting and wilderness hiking are the chief recreation pursuits, with some fishing also taking place in the area of this route. Present recreation use of the area is very light, and impacts of a pipeline system on recreation would be similar to those described for the applied-for AAGPC route in Section 3.1.1.13.

The new airfields will make it easier and safer for persons to fly into the area in pursuit of various recreation goals. This will at the same time increase the pressure on wildlife, soils, and water quality while diminishing the "wildness" of the area.

In summary, construction and operation of a pipeline on this route would reduce the quality of dispersed recreation available.

Esthetic impacts would also be similar to those described for the applied-for AAGPC route in Section 3.1.1.13. Structures would not be as visible at great distances on the Interior route as they would be on the unbroken expanse of the Arctic Coastal Plain. Water vapor plumes towering above the six compressor stations would be visible even to observers out of sight of the pipeline itself. Noise resulting from compressor station and aircraft operation and construction and repair activities will extend the degradation of the existing quality of solitude (Section 8.1.1.3, Environmental noise).

Impacts of the Interior Alternative Pipeline System on Air Quality

Air quality is excellent, and any construction or industrial activities which release exhaust emissions would degrade the presently near pristine condition of the air.

The present condition of air quality in northeastern Alaska with respect to Federal and State regulations and the impact of pipeline construction and operation are discussed in detail in Section 3.1.1.14.

Vehicle exhaust emissions, unless adequately controlled, would cause a definite short-term decrease in air quality along the route during the 2-year construction period. There would also be some chronic low-level pollution beyond that time from the aircraft and surface vehicles used in pipeline surveillance, operation, and maintenance activities.

The potential for long-term air quality degradation relates to operation of six compressor stations along the Interior route within Alaska.

Impact of the Interior Alternative Pipeline System on Environmental Noise

The first 60 to 80 miles of the Interior alternative route would pass through an area where exploration and development of the Prudhoe Bay oil field is introducing an increasing amount of noise from heavy machinery to the once quiet Arctic Slope. Impacts of these activities are described in Section 3.1.1.15 for the applied-for AAGPC route.

At the point where the alternative pipeline route starts up the Canning River, it enters an area which is still in a natural state and where the noise of man and his machines is rarely heard. The sources of pipeline construction and operation noise and its impacts are discussed in detail in Section 3.1.1.15. They would be of a similar type and magnitude for this route except that the confined, mountainous terrain will concentrate and magnify noise created during construction, operation, and repair. Construction noise will, however, extend over two winters and two summers instead of only one winter construction season as on the applied-for route.

As mentioned in the discussion of wildlife, the Interior alternative route will pass through important Dall sheep winter and lambing range in the Brooks Range along the Canning River and caribou migration and winter range in the Porcupine Plateau south of the Brooks Range. Noise from construction activities and aircraft operations would disturb these animals and cause habitat relocation or reduced utilization (Sections 3.1.1.15 and 8.1.1.3).

Noise occurring during two summer construction seasons will also affect mammals and birds not present in the area during the winter.

Since the Interior route avoids caribou calving and post-calving areas, there will be no impact from noise emissions of pipeline inspection flights on these activities (AAGPC, 1975). This route crosses a major caribou winter range in Alaska and stations that will be located in confined areas may interfere with migratory movements (AAGPC, 1975 and McCourt, et al., 1974).

Impact Caused by Repair of the Interior Route Alternative Pipeline System

A generalized discussion of the various problems anticipated with respect to repair activities on the applied-for AAGPC route was presented in Section 3.1.1.16. The same problems and impacts would be encountered on the northern portion of the Interior route alternative where it crosses the Arctic Coastal Plain and the Arctic Foothills. Many of the same problems would also be encountered along the rest of the route across the Brooks Mountain Range and the Porcupine Plateau, but there would also be new impacts associated with those areas.

Brooks Range Segment

Winter conditions in the Brooks Range are severe and would seriously hamper repair activities at that time of year. Cold, darkness, winds, and snow would interact to take a cumulative toll of men and machines working in the mountain canyons and passes, but the impact of repair activities at that time would probably be minor considering the thaw stable bedrock and gravels along that segment of the route.

Existing air-cushion vehicles (ACV) will not operate within the mountainous segment of the route, so equipment and material would have to be transported on other types of all-terrain vehicles (ATV). This would be unlikely to cause impacts in either summer or winter as long as the ATV's remain on the thaw-stable areas of rock and gravel.

The greatest impacts of repair activities along the Canning River in either summer or winter will fall on the Dall sheep, caribou, moose, and grizzly bear that will be disturbed by the helicopters, ATV's, blasting, and other activities and noises along one of their most important seasonal ranges. (See also Sections 8.1.1.3. Wildlife, and 3.1.1.16, Pipeline System Repair.)

Summer repairs along the Canning River could have adverse impacts on fish spawning areas, and winter repairs requiring water from springs could be detrimental to the fish using those springs as overwintering habitat.

Airplanes, helicopters, and other disturbances within the Canning River canyons could have severe impacts on the already endangered peregrine falcons nesting there in the spring and summer. (See Sections 3.1.1.7, Wildlife and 8.1.1.3, Wildlife.)

Porcupine Plateau Segment

Pipeline repair activities on the Porcupine Plateau south of the Brooks Range would have impacts on soil, water, and vegetation similar to those described for the applied-for AAGPC route of the mountains. (See 3.1.1.16, Pipeline System Repairs.)

Repair activities would also have many of the same impacts on wildlife, but on this alternative there are likely to be no polar bear, arctic fox, musk ox, snow geese, sea ducks, and very few other waterfowl to be affected. Impacts on caribou would be more general and could occur all during the year, but there would probably be more animals affected during the winter along this segment of the Interior route. (See 3.1.1.7 Wildlife.)

Protection of streams and water quality is very important in this area since most of the downstream waters crossed are either salmon spawning streams or tributaries to such streams. Erosion from pipeline excavations which deposits silt in those streams could kill salmon eggs, or reduce spawning habitat, and thus reduce the fish available to people in villages all the way down the Yukon River to its mouth.

8.1.1.4 Fort Yukon Alternative Pipeline Route

Introduction

The Fort Yukon alternative gas pipeline route generally follows an alignment considered for transporting oil from Prudhoe Bay in 1972. That alternative involved construction of a "trans-Canada resource railroad route" (SITF, 1972). The trans-Canada resource railroad route involved construction of approximately 2,700 miles of widely spaced, double track, standard gauge railroad from Prudhoe Bay to northern Montana. In Alaska the rail routing from Prudhoe Bay came south along the Sagavanirktok River to its headwaters where a 6-mile tunnel would have been required to cross under the Continental Divide. On the south side of the Divide the railroad route continues down the Chandalar River Valley into the lowlands of the Yukon Flats crossing the Porcupine and Black Rivers upstream from Fort Yukon; and at Woodchopper the route intersects the north bank of the Yukon River and proceeds along the river to the United States-Canada border.

The application by AAGPC (1974a) considered and developed a conceptual gas pipeline alignment along the general route of the "trans-Canada resource railroad." It should be noted, however, that there is no proposal to construct a Fort Yukon gas pipeline and that detailed engineering or environmental studies have not been made. The following description of the alignment is based upon location data provided by the applicant. Data relating to environmental, social, and economic factors are extracted from recent information assembled by the Joint Federal-State Land Use Planning Commission for Alaska and final environmental impact statements prepared by the Alaska Planning Groups of the Department of the Interior (1974) for the proposed Yukon Flats National Wildlife Refuge, Porcupine National Forest, and the Yukon-Charley National Rivers.

Although detailed, site-specific data are lacking for the Fort Yukon alternative gas pipeline route, there are sufficient similarities between environmental, social, and economic factors described for the applied-for route, Interior Alternative gas pipeline route, and the trans-Alaska oil pipeline. Thus, overall impacting mechanisms can be assessed in a manner to permit comparison of the Fort Yukon Alternative gas pipeline route with the applied-for and other alternative routes.

Description of the Alternative Fort Yukon Pipeline System

Location

The Fort Yukon alternative routing considered by AAGPC would involve construction of approximately 495 miles of gas pipeline in Alaska. The first 110 miles proceed southward from Prudhoe Bay on the same alignment as the trans-Alaska oil pipeline system. At Mile Post 110 the Fort Yukon route swings southeasterly from the oil pipeline and road to proceed up the Ribdon River Valley to the Continental Divide. After crossing the Continental Divide (at an elevation of 4,900 feet), the alternative Fort Yukon route proceeds down the Wind River Valley to the East Fork of the Chandalar River, across the former Venetie Indian Reservation to the Yukon Flats. The Porcupine River is crossed just upstream (northeast) of its confluence with the Yukon River near the community of Fort Yukon. The route then continues southeasterly along the north bank of the Yukon River. In many places the routing is directly on the bank of the Yukon River. Figures 8.1.1.4-1, 2, 3, 4, and 5 show the route and location of conceptual compressor stations as developed by AAGPC.

An alternative routing considered by AAGPC avoids the Wind River and the former Venetie Indian Reservation by using the Chandalar River Valley (Figures 8.1.1.4-6 and 7). The Chandalar option is 545 miles long or 50 miles longer than the Wind River Option.

Facilities

For purposes of evaluating the Fort Yukon alternative gas pipeline, it is assumed that the size and quality of pipe will be the same as that described in section 1.1.1.1 through 1.1.1.9 for the applied-for AAGPC route.

It is further assumed that the Fort Yukon alternative pipeline system will be designed to deliver a maximum throughput of 2.25 bcf/d initially. Based upon the requirements for compressor stations for 2.25 bcf/d throughput on the Interior alternative system (one at Mile Post 118) it is assumed that at least two stations would be required for the Fort Yukon alternative: one on the north side of the Brooks Range (probably in the Ribdon River valley) and one near Fort Yukon. With a throughput of 4.5 bcf/d, a total of 11 compressor stations will be required for the Wind River Option and 12 for the Chandalar River Option. It is also assumed that the Fort Yukon alternate pipeline system will require construction of airfields and communication sites similar to those described for the Interior alternative pipeline system. Table 8.1.1.4-1 summarizes the approximate location of compressor stations along the Fort Yukon route required for a throughput of 4.5 bcf/d.

Construction, Operation, and Repair Procedures

It is assumed that equipment and supplies will be assembled and distributed along the Fort Yukon alternative about as described for the Interior alternative in 8.1.1.3. The major difference will be that more supplies will be moved through Fairbanks because of an increased amount of construction in Alaska. Approximately 110 miles of the Fort Yukon route is directly accessible from a new road to Prudhoe Bay along the oil pipeline. It is assumed that Circle will be a primary receiving and storage area for the route south of the Brooks Range in a manner similar to that described for the Interior Route. Additionally, Eagle is expected to also become a major supply depot because of its location on the Yukon River near the United States-Canada Border and road access from the Alcan highway.

It is assumed that construction, operation, and repair methods similar to those described for the applied-for route (1.1.1.1) and the Interior alternative route (8.1.1.3) will apply here.

An estimated 14.4 million cubic yards of gravel will be required to construct the Wind River option of the Fort Yukon alternative gas pipeline system in Alaska. More than 15 million cubic yards of gravel will be used to construct the 50-mile longer Chandalar River Option.

Table 8.1.1.4-1 Location of compressor station complexes

Chandalar River Option (545 miles)*		Wind River Option (495 miles)*	
Compressor Station		Compressor Station	
Site No.	Mile Post	Site No.	Mile Post
1†	44	1†	44
2†	88	2†	88
3	126	3	126
4	172	4	165
5	227	5	220
6	272	6	263
7	321	7	302
8	350	8	346
9	396	9	383
10	432	10	435
11	485	11	480
12	530		

* Distance from Prudhoe Bay to United States-Canada Border
† Common compressor station sites. Site No. 3 is not common, although milepost mileage is the same.

Construction Schedule

The AAGPC evaluated the Fort Yukon alternative pipeline system on the basis of delivering gas from Prudhoe Bay on approximately the same time schedule as that of the applied-for route. (See Sections 1.1.1.1 through 9.). Based upon data provided for the Interior alternative (8.1.1.3) it is concluded that year around construction will be used and that peak construction would be over a 2 year period.

Table 8.1.1.4-2 compares the seasonal mileage production and spread requirements to complete the total 3,044-mile-long Fort Yukon alternative (Wind River Option) with the 2,629-mile-long route applied for in Alaska and Canada across the Arctic National Wildlife Range.

Work Force

Based upon the estimated work force of 5,000 direct jobs required to construct the 298-mile-long Interior alternative pipeline system in Alaska (see 8.1.1.3), it appears that between 7,000 and 8,000 construction jobs will be required to build the 495-mile-long Fort Yukon alternative (Wind River Option) in Alaska. It is assumed that construction in Alaska will involve at least two full years, and probably 3 years. Therefore, it is expected that a substantial amount of secondary and indirect employment will result in Alaska. However, it is not possible to estimate secondary or indirect employment without knowing where and when construction will be under way in Alaska should this alternative be selected.

As discussed in the Interior gas pipeline alternative (8.1.1.3), it is expected that the total number of jobs associated with construction of the Yukon (Wind River Option) will not be substantially increased, but rather that work will be transferred from Canada to Alaska. This transfer of workers may be offset since connections to the Mackenzie oil and gas fields would still require construction of a connecting pipeline in Canada.

Direct permanent employment in Alaska resulting from the Wind River Option of the Fort Yukon alternative is estimated to be 55 at the 2.25 bcf/d throughput and two operating compressor stations in Alaska. Direct total employment would be increased at least twofold at a throughput of 4.5 bcf/d since 11 or 12 operating stations will be in Alaska.

Costs

The AAGPC (1974a) states that to reach full capacity, the total 3,044-mile-long Fort Yukon alternative (Wind River Option) will cost approximately $1.4 billion ($917,100 more than the 2,268-mile-long applied-for route). Increased costs are based upon the more difficult terrain encountered in crossing the Brooks Range and the extra 415 to 465 miles in the total Fort Yukon alternative pipeline system.

Operating and maintenance costs are expected to be $22,900 more annually on the Fort Yukon route than on the total applied-for route because the alternative is longer and requires more facilities.

Description of the Environment of the Fort Yukon Alternative Pipeline System

The following description builds upon previous discussions of the Alaskan segment of the applied-for AAGPC route and its Offshore, Coastal,

Table 8.1.1.4-2 Comparison of construction schedules for the total Fort Yukon alternative route (Wild River option) with the total length of the applied-for route which would be deleted

Construction Period	Route: Applied-for Spreads	Route: Applied-for Miles	Ft.Yukon Alt. Spread	Ft.Yukon Alt. Miles
First winter	9	700†	9	595††
First summer	5	737†	9	924††
Second winter	9	700†	9	584††
Second summer	-	---	9	941††
Third winter	8	492§	-	---
Third Summer	-	---	-	---
TOTAL	31	2,629	36	3,044 §§

* Source AAGPC (1974a)
† Construction in Canada
†† Construction location unknown
§ Includes 195 AAGPC construction in Alaska (see 1.1.1.1 through 1.1.1.9)
§§ Includes 495 AAGPC construction in Alaska

and Interior alternative pipeline routings within Alaska. Accordingly, the reader will be referred to prior detailed discussions as appropriate.

Climate

The Fort Yukon alternative route transects portions of two of Alaska's four major climatic zones: The Arctic and the Continental. Figure 8.1.1.4-8 displays the approximate zonational boundaries.

The northernmost approximate 170 miles of the Fort Yukon route are within the Arctic Zone, discussed in Section 2.1.1.1. The remainder crosses the northern portion of the Continental Zone for approximately 325 miles.

The Continental Zone is generally semiarid and has relatively clear skies and extreme temperature ranges between summer and winter. Extremes will range from about 100° F in the area south of the Brooks Range to lows of from -60° to -75° F in both areas. Figures 8.1.1.4-9 and -10 show generalized temperature means along the Fort Yukon Alternatives.

Average annual precipitation ranges from 10 to over 20 inches along this route. Fort Yukon, Alaska, averages 10 inches or less, while Eagle approaches 20 inches per year. Refer to Figure 8.1.1.4-11 for generalized precipitation rates along the Fort Yukon Alternative.

Wind speeds generally range from about 3 to 7 miles per hour. However, winds in excess of 50 miles per hour have been reported when storm conditions funneled winds through canyons.

Ice fog, normal fog, or blowing snows can cause locally dangerous conditions throughout the entire area.

Topography

The Fort Yukon alternative pipeline system crosses seven physiographic provinces in Alaska: Arctic Costal Plain, Arctic Foothills, Brooks Range, Porcupine Plateau, Yukon Flats, Ogilvie Mountains, and Eagle Trough (Figure 8.1.1.4-12).

The Arctic Coastal Plain and Arctic Foothills are described in detail in 2.1.1.2.

Brooks Range

Upon leaving the Arctic Foothills in the vicinity of the confluence of the Ribdon River with the Sagavanirktok River, the Fort Yukon alternative leaves the trans-Alaska oil pipeline corridor and gradually ascends the broad valley of the Ribdon River and then up a sequence of southern tributaries to cross the Continental Divide in a pass at an altitude of about 4,900 feet. The route then would descend the south side of the Continental Divide through the broad valley of the Wind River. Peaks and ridges on either side of the route rise steeply 2,000 to 3,500 feet above the valley floor, cresting at altitudes higher than 6,500 feet in the center of the range. The route traverses an intensely glaciated segment of the Brooks Range, and small glaciers persist at altitudes above 5,000 feet on north-facing slopes that adjoin the route between the Ribdon River and the Continental Divide.

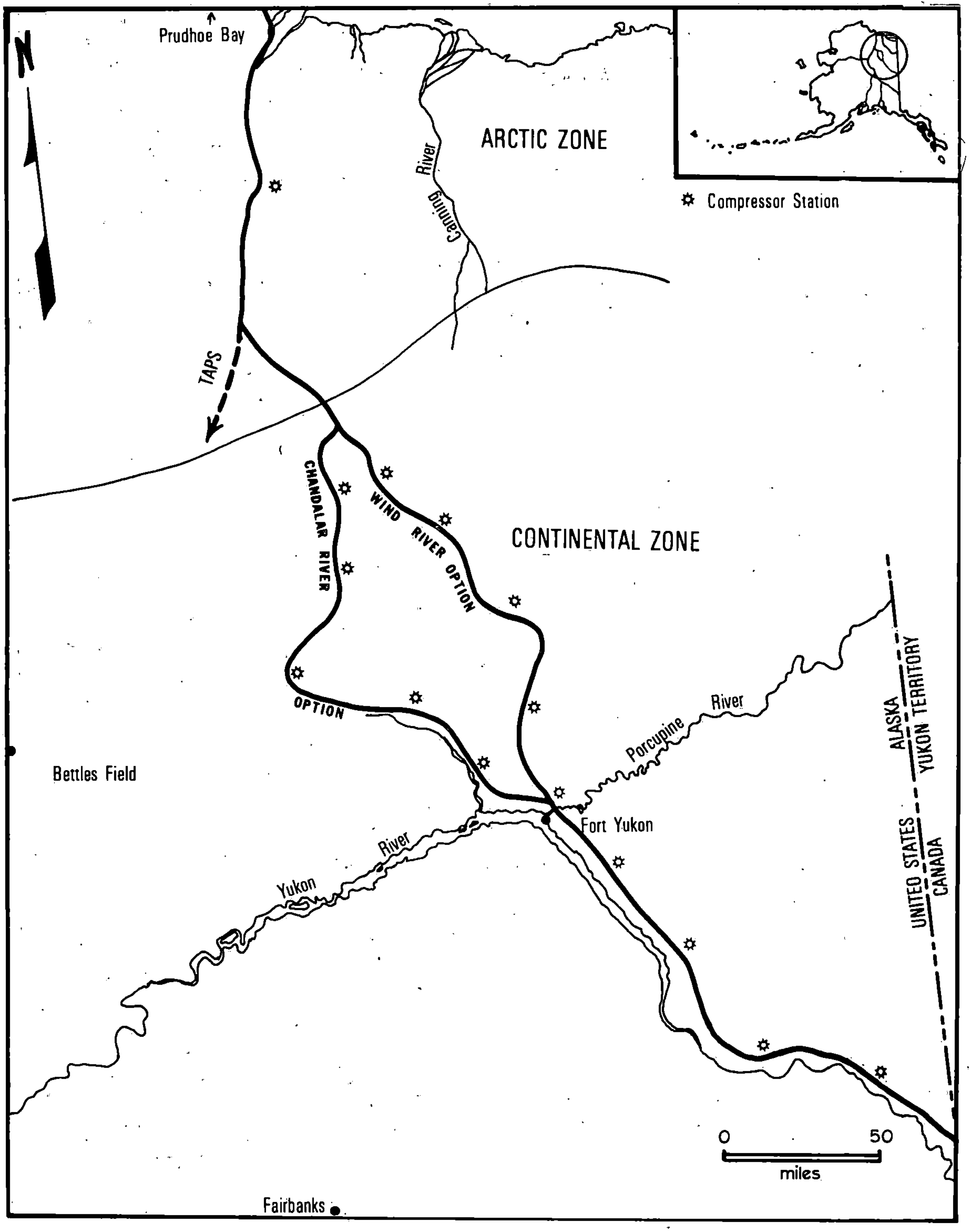


Figure 8.1.1.4-8 Climatic zones of the Ft. Yukon alternative pipeline route

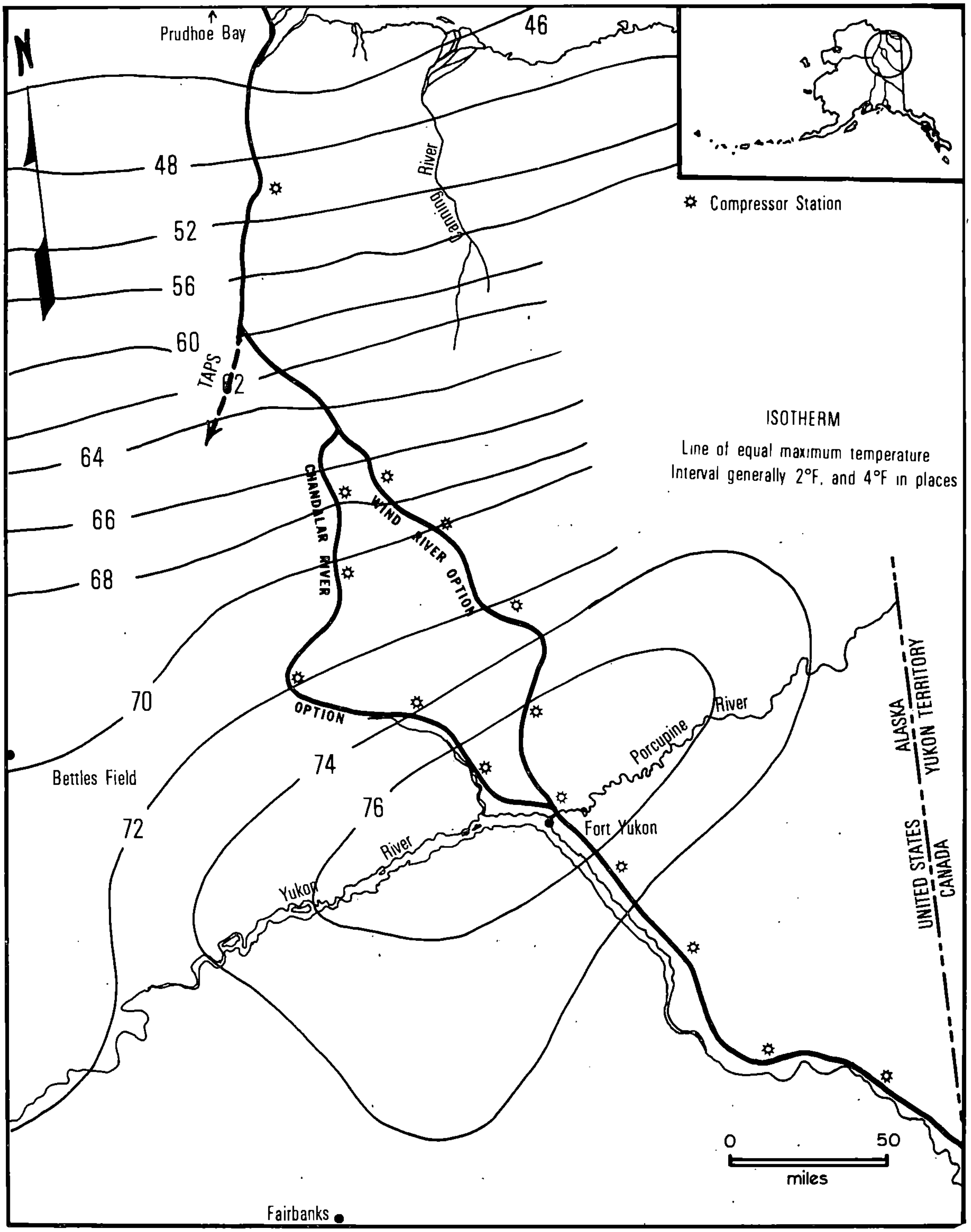


Figure 8.1.1.4-9 Summer temperatures in °F along the Fort Yukon alternative pipeline route

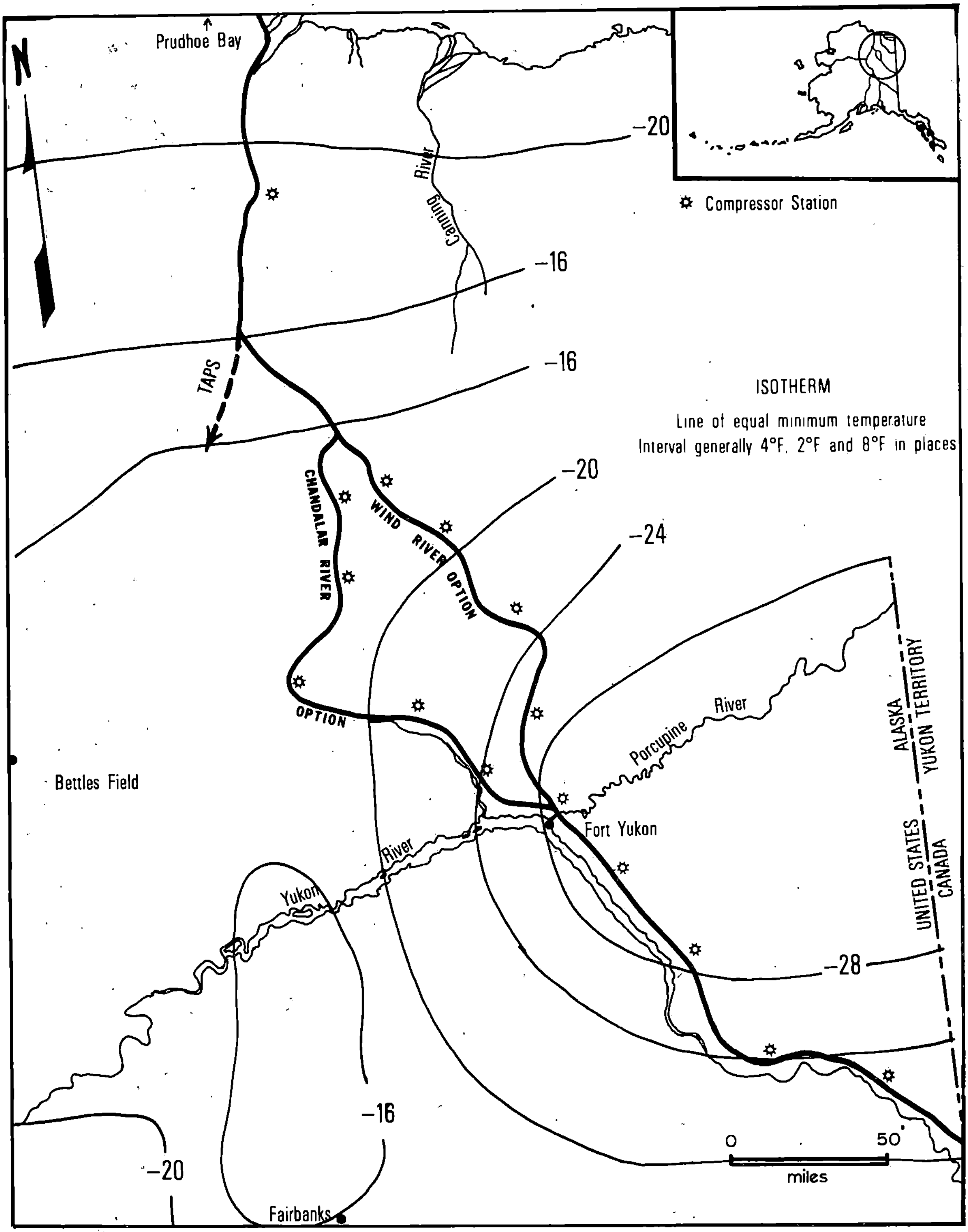


Figure 8.1.1.4-10 Winter temperatures in °F along the Fort Yukon alternative pipeline route

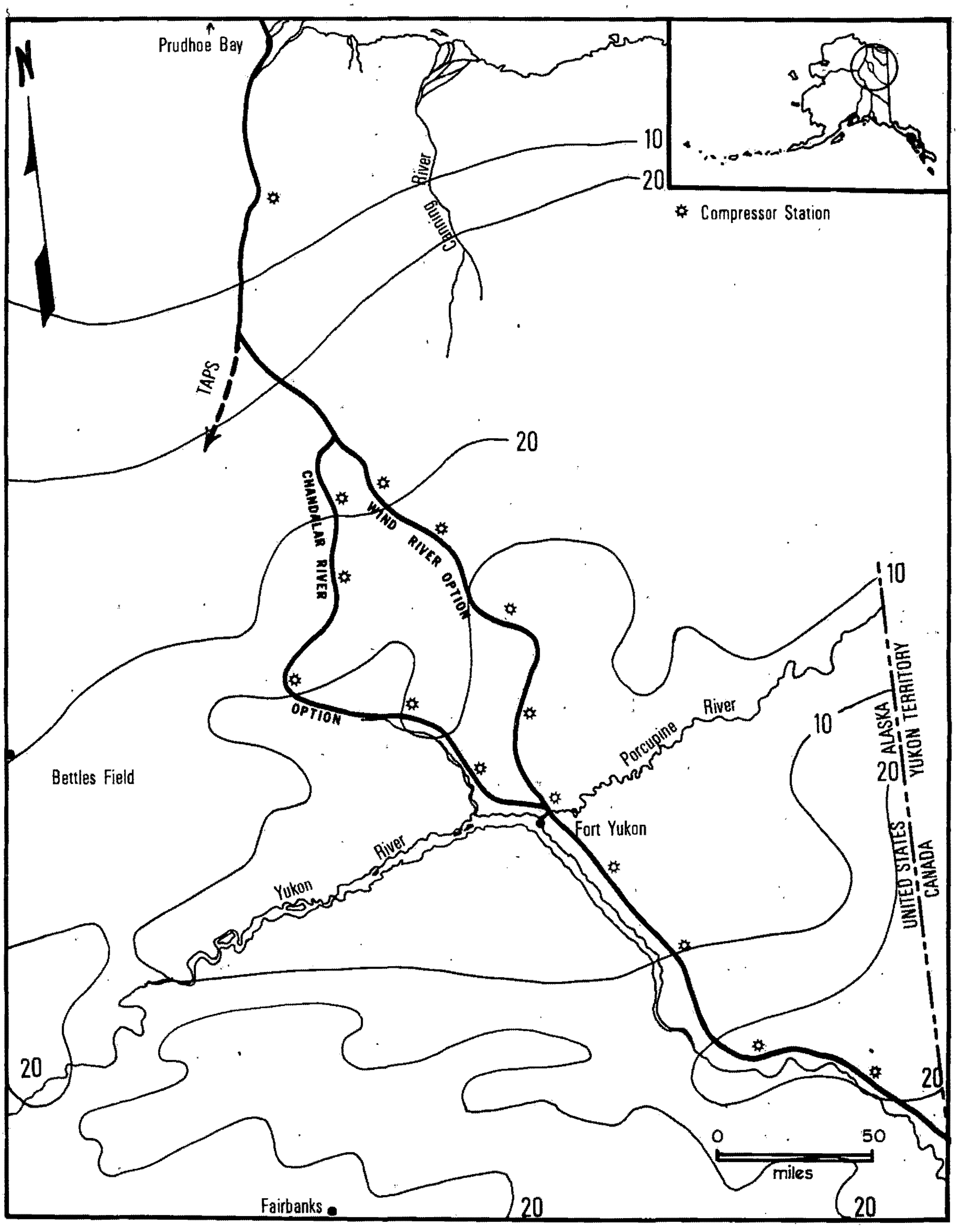


Figure 8.1.1.4-11 Mean annual precipitation in inches along the Fort Yukon alternative pipeline

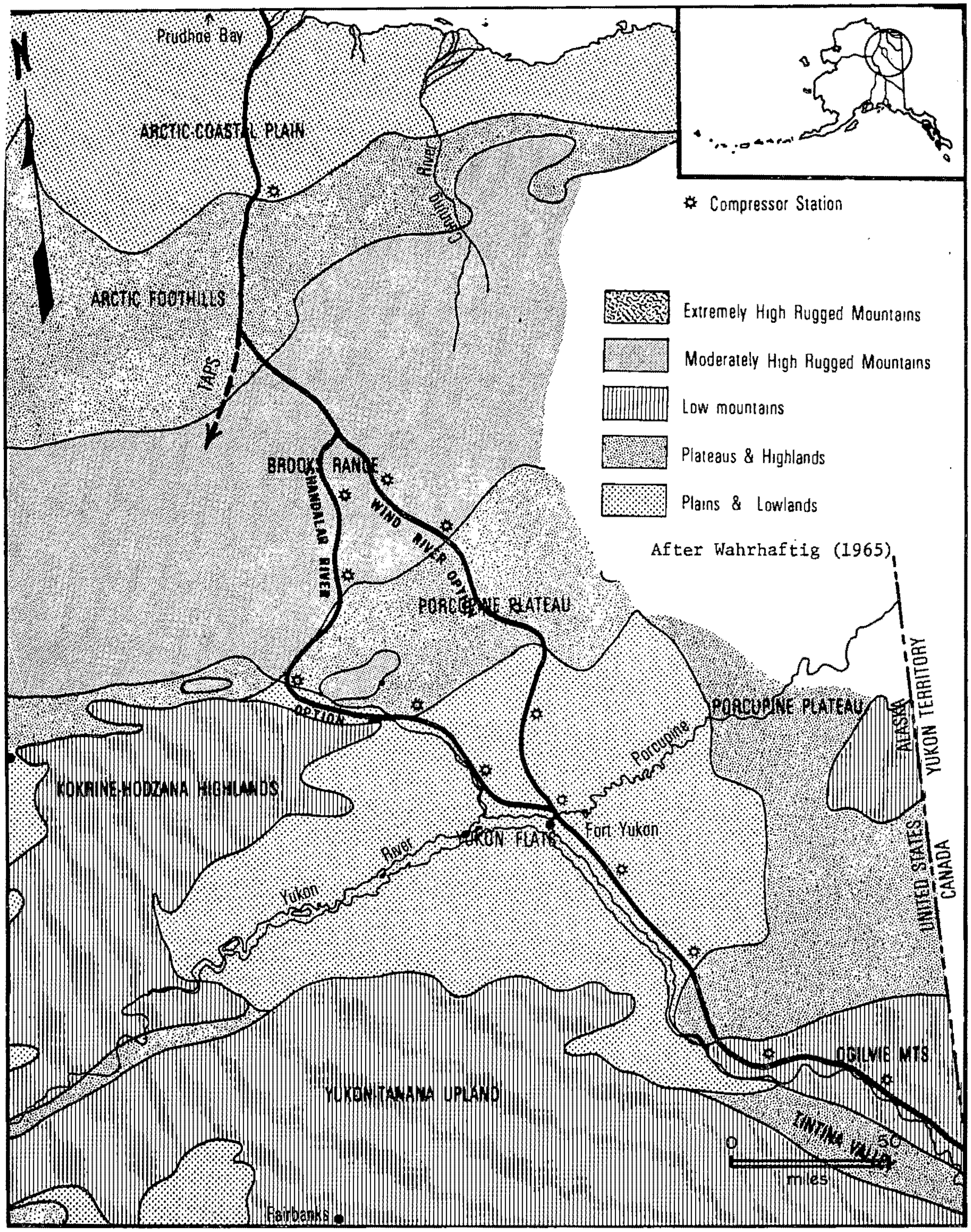


Figure 8.1.1.4-12 Physiography of the Fort Yukon alternative pipeline route

Throughout the lower 15 miles of the Ribdon River Valley, the route crosses hummocky morainal hills, interrupted by the interlacing channels and gravel bars of the river. From 15 to 20 miles up Ribdon River Valley, the braided channel network broadens to a width of nearly two miles, occupying almost the entire valley bottom. The series of tributary valleys leading to the Continental Divide gradually narrows and the stream is increasingly confined to a single, sharply incised channel; the 10-mile segment of the route between the Continental Divide and the Wind River Valley is similar. Along the Wind River, the valley bottom is 2 to 3 miles wide and has hummocky morainal topography with many small lakes. The Wind River meanders through the valley in a more or less confined channel.

Porcupine Plateau (northern segment)

South of the Brooks Range, a 45-mile segment of the alternative Fort Yukon Route crosses the Porcupine Plateau, dropping from the Plateau to the Yukon Flats near Flood Lake. The northern 20 miles of this segment lie within the broad valleys of the Wind River and the East Fork of the Chandalar. The southern 25 miles cross the grain of a hill-and-valley terrain where altitudes range from 1,200 to 2,500 feet and local relief between adjoining ridges and valleys ranges from 500 to 1,000 feet.

The route crosses an area formerly covered by ancient valley glaciers flowing southward from the Brooks Range. The topography in the lower Wind River and East Fork Valleys is similar to the hummocky morainal terrain in the upper Wind River Valley. After crossing the East Fork, the route passes over a series of morainal ridges to Bob Lake and then crosses stream-dissected bedrock hills that have been glaciated.

Yukon Flats

The Fort Yukon alternative route extends more than 100 miles across the flat, monotonous terrain of the Yukon Flats. The route descends from an altitude of about 1,200 feet near the Flood Lakes to about 450 feet at the Porcupine River crossing near Fort Yukon. Southeast of Fort Yukon, the route follows closely along the west bank of the Yukon River, climbing gradually to an altitude of about 500 feet near Circle, where it leaves the Yukon Flats and reenters the Porcupine Plateau. Surfaces are very poorly drained; many streams, sloughs, and filled channels are crossed, and muskegs are extensive.

The northernmost 28 miles of the route cross terraces, ancient alluvial fans, and the modern flood plain of the Christian River. Slopes are generally smooth and almost imperceptible except in a dissected bluff that separates an ancient alluvial terrace from the flood plain of the Christian River, about 5 miles southeast of the Flood Lakes.

After leaving the alluvial complex of the Christian River, the route enters an area of undulating topography about 6 miles broad. The area of undulating topography extends northeastward from Tivehvun Lake and contains many small lakes from 1/2 to 1-1/2 miles across, separated by broad swells and ridges that stand 20 to 50 feet higher than the lakes. The swell-and-swale topography lies at the foot of the broad alluvial fan complex of the Sheenjek River, a large stream from the Brooks Range that joins the Porcupine River upstream from the Porcupine crossing. The hillocks may be ancient sand dunes, or they may be remnant topography between thermokarst depressions induced by springs at the foot of the Sheenjek fan.

After leaving the hill-and-swale topography on the lower part of the Sheenjek River fan, the alternative Fort Yukon Route crosses the flood plain of the Porcupine River. The flood plain is a broad belt of intertwining sloughs, ox-bow lakes, and active distributary channels that extends more than 12 miles north and 1 mile south of the main channel of the Porcupine River. The entire flood plain is susceptible to occasional flooding.

From Fort Yukon to Jefferson Creek, the route lies on a low terrace of the Yukon River; though poorly drained, the surface probably lies above levels ordinarily reached by flood waters. The topography consists of a long, monotonous, ramplike slope along most of the 55 miles occupied by this segment of the route, but areas of sand dunes (mostly stabilized) are crossed just east of Fort Yukon and between 12 and 30 miles to the southeast. Relief in the dune tracts consists of sand ridges that stand 10 to 50 feet above the intervening depressions.

Porcupine Plateau (southern segment)

Beginning at a point 9 miles downstream (north) from Circle village and continuing to a point opposite the village, the Fort Yukon Route includes a strip of Yukon River flood plain and a parallel strip of the Porcupine Plateau. The two provinces are here separated by a bluff about 200 feet high, defended by bedrock but capped by thick loess (wind-blown silt). The route then crosses the rolling topography of the Porcupine Plateau for about 28 miles, crossing the drainage basins of Paddle Creek and the Little Black River before entering the more rugged terrain of the Ogilvie Mountains.

The northwestern 20-mile segment of the alternative route crosses an upland of very modest relief, in which the broad interfluves lie at altitudes of 1,000 to 1,200 feet and the widely spaced minor valleys are incised to depths of 50 to 100 feet. Many of the small tributaries west of Paddle Creek head in small lakes and ponds that lie 50 to 100 feet below the level of the interfluves.

The Paddle Creek and Little Black River drainage basins are separated by a broad bedrock ridge that rises to altitudes of 2,000 to 2,200 feet. The valley of the Little Black River is broad and marshy. Drainage is only slightly better there than in the Paddle Creek basin. The route ascends bedrock ridges on the east side of Little Black River Valley and enters the Ogilvie Mountains at an altitude of 2,000 feet.

Much of the route through the southern segment of the Porcupine Plateau extends through a region deeply mantled by loess. Silty sediments here may extend to depths in excess of 100 feet. The presence of scattered open-system pingos attests to the circulation of ground water through discontinuous permafrost, and the minor relief of tributary streams and small lakes seems to be largely of thermokarst origin.

Ogilvie Mountains

The Fort Yukon route crosses rugged stream-carved terrain for 15 miles before again reaching the Yukon River and then follows the river closely for a final 55 miles through the mountains to the Alaska-Yukon border. The initial 15-mile segment crosses the grain of rugged terrain, passing over a series of ridges with crest altitudes of between 3,500 and 2,500 feet into intervening valleys that lie 750 to 1,500 feet lower.

In the final 55-mile segment, the Fort Yukon alternative crosses several 6- to 8-mile stretches in which the river is separated from the

Ogilvie Mountains by low, flat alluvial terraces. The route locally crosses the grain of narrowly spaced, steep stream-carved ridges and valleys having a relief as great as 1,500 feet. Several large rivers, including the Kandik, the Nation, and the Tatonduk, are crossed.

Eagle Trough

The Eagle Trough lies immediately south of the Ogilvie Mountains and consists of a fault-controlled valley containing most of Yukon River between the United States-Canada border and the Yukon Flats to the west. The Eagle Trough is a fault-related lowland surrounded by rounded, eventopped ridges with gentle side slopes.

Geology and Soils

Mineral Resources

The Fort Yukon alternative route involves the same oil and gas deposits as those described in the Interior alternative pipeline system (8.1.1.3). The major difference is that the Yukon-Kandik Province is crossed on its southern margin; whereas, the Interior route is located to the north. Refer to Figure 8.1.1.4-13.

Scattered deposits of subbituminous coal are found along the Yukon River in the vicinity of the route. Late-Cretaceous to Tertiary sediments extend along the Eagle Trough. An outcrop of Devonian bituminous coal covers about 1 square mile near the mouth of the Nation River. Coal from this site, reported to be of coking quality, was used to fuel river steamers at the turn of the century. An estimated 2,000 tons of coal were mined. Oil shale having a yield of 4.8 gallons of oil per ton is also found in the vicinity. Refer to Figure 8.1.1.4-14.

Mineral deposits associated with the Fort Yukon alternative are significantly different from those described on other pipeline routings. The routing through the Brooks Range is close to the Chandalar Mining District where economic mining activities have been carried out for more than 60 years, principally for gold. There are prospects for development of other minerals, especially lead-zinc-silver in rhyolite formations. There is also potential of antimony, copper, and uranium. This is part of the same contact between magnetic zones described in 8.1.1.3 on the Interior Route.

The Eagle Trough near the United States-Canada border is also heavily mineralized, with long standing production of placer gold and silver along the south side of the Yukon River near the Fort Yukon alternative route.

Phosphate deposits are known to occur along the Yukon River where the alternative route leaves Alaska. No additional information on mass, quality, or economic feasibility is available.

Gravel deposits associated with the Fort Yukon alternative pipeline system are not well known. It is assumed that there are adequate deposits to provide the estimated 14.4 million cubic yards needed during construction.

Bedrock

The Brooks Range segment of the Fort Yukon alternative passes through an area of abundant bedrock exposures on the steep mountain sides. The

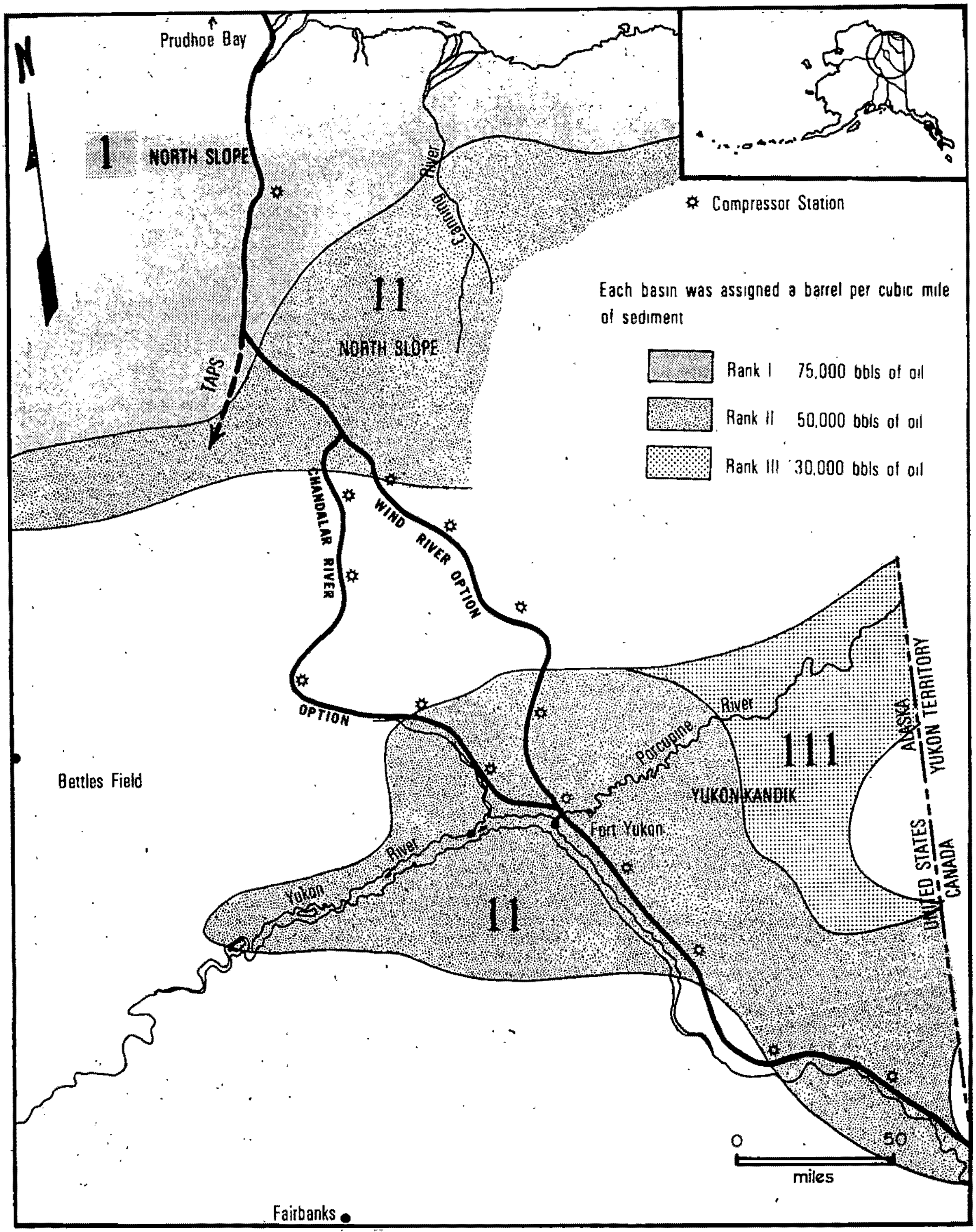


Figure 8.1.1.4-13 Petroleum provinces and basins of the Fort Yukon alternative pipeline route

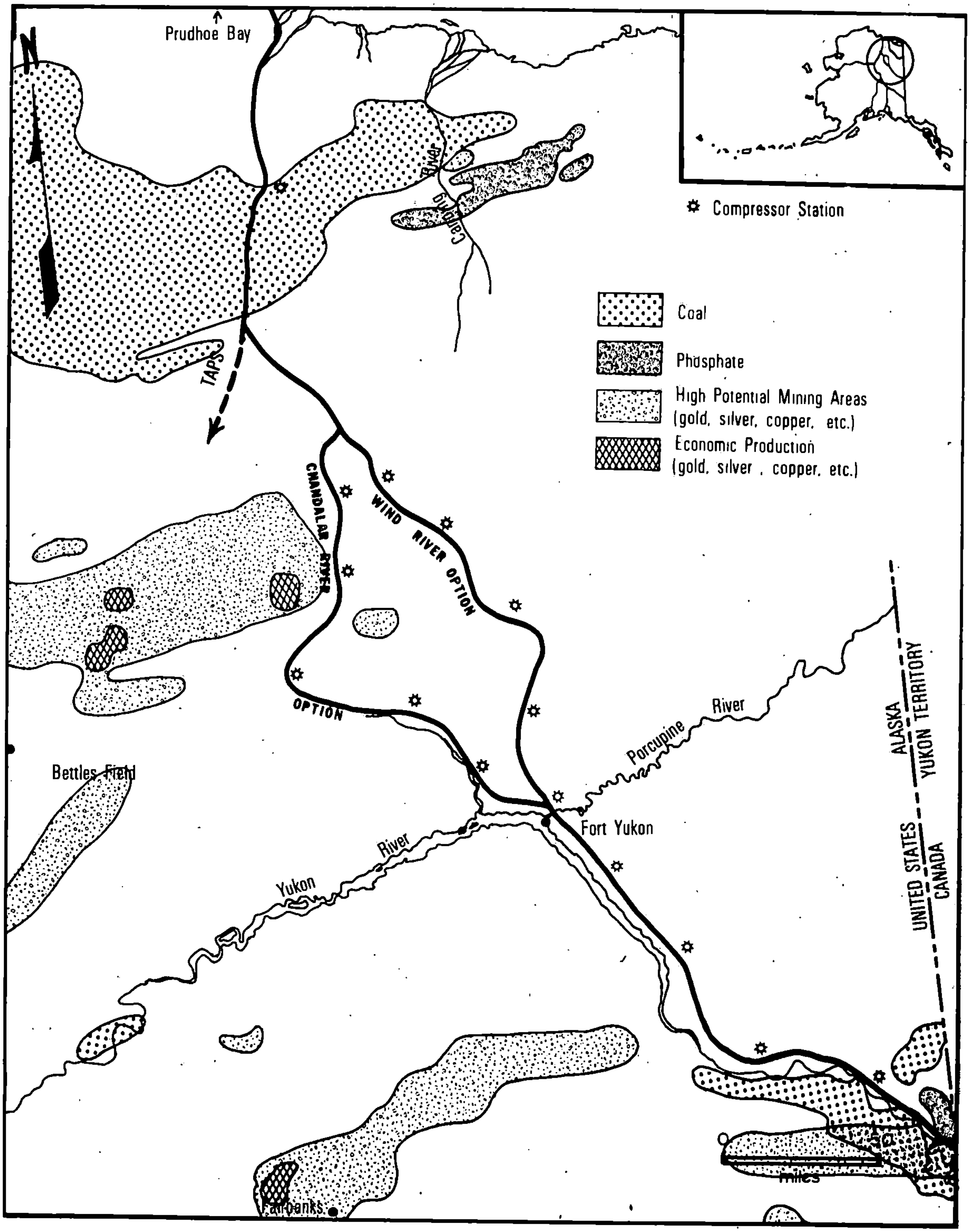


Figure 8.1.1.4-14 Minerals of the Fort Yukon alternative pipeline route

lower slopes are mantled by talus and the valley bottoms are floored with glacial and glaciofluvial deposits of unknown but locally substantial thickness. The bedrock consists of a complex of Paleozoic and Mesozoic sedimentary rocks. Refer to Figure 8.1.1.4-15.

Bedrock is generally mantled by colluvium, and exposures are scarce in the northern Porcupine Plateau segment. However, the bedrock probably lies at depths no greater than 5 or 6 feet on upper slopes and summits. The bedrock consists of Paleozoic sedimentary rocks in the northern part of this segment and of Jurassic volcanic and mafic plutonic rocks in the southern segment. Bedrock is deeply mantled by Quaternary alluvial and aeolian sediments in the Yukon Flats. In the southern segment of the Porcupine Plateau, bedrock consists of Paleozoic volcanic rocks and argillite, but exposures are rare; bedrock is covered by colluvium in the highest ridges and by thick wind-blown silt elsewhere.

Bedrock is generally within a few feet of the surface on the ridge-and-valley topography of the Ogilvie Mountains. Though the slopes are covered by thin colluvium in most places, exposures are numerous. The bedrock consists of Precambrian, Paleozoic, and Mesozoic sedimentary rocks. Bedrock is covered by a few tens of feet of alluvial gravel on the Yukon River terraces. Research is needed to establish whether or not swelling shale may be present.

Surficial Deposits

Except for a reconnaissance of the Yukon Flats (Williams, 1960), there have been no studies of the surficial deposits along the Fort Yukon alternative route. Statements about the surficial deposits are inferences based on study of the topographic maps and on analogies with surficial deposits in generally similar terrain in central Alaska. The information available is inadequate for sound planning, and much more thorough study of the surficial deposits will be needed before specific plans for pipeline construction can be developed for this alternative route.

Through the Brooks Range and the portion of the Porcupine Plateau northwest of Brown Grass Lake, the route passes over glacial and glaciofluvial deposits. Flat areas in the valley bottom are underlain by well-sorted stream gravel, hummocky areas by unsorted glacial till, some moderate side slopes by solifluction debris, and steep side slopes by talus. The gravel areas should provide stable foundations, but the glacial till in the more hummocky areas may be ice-rich and consequently subject to liquefaction and excessive differential settlement when stripped of vegetation and allowed to thaw. The glacial till is probably finer grained and more sensitive in the down-valley areas and relatively coarse grained and insensitive in the valley-head areas near the Continental Divide. The steeper side slopes in the Brooks Range are at the angle of repose, and oversteepening due to side-slope cutting might lead to avalanches and rock slides. Slow soil movement due to solifluction and creep can be expected on moderate slopes throughout the Brooks Range.

Based on comparisons with similar areas near Fairbanks, hillslopes and summits between Grass and Flood Lakes are believed to be covered by a mantle a few feet thick of poorly sorted colluvial stony silt grading down into weathered, easily excavated bedrock, and then, at depths of 10 to 12 feet, into firm bedrock. The slopes and summit areas probably offer stable foundations, and slope movements there are likely to be minimal, even after excavation. The lower slopes and valley bottoms are probably mantled to depths of several tens of feet with frozen, ice-rich mixtures of silt and

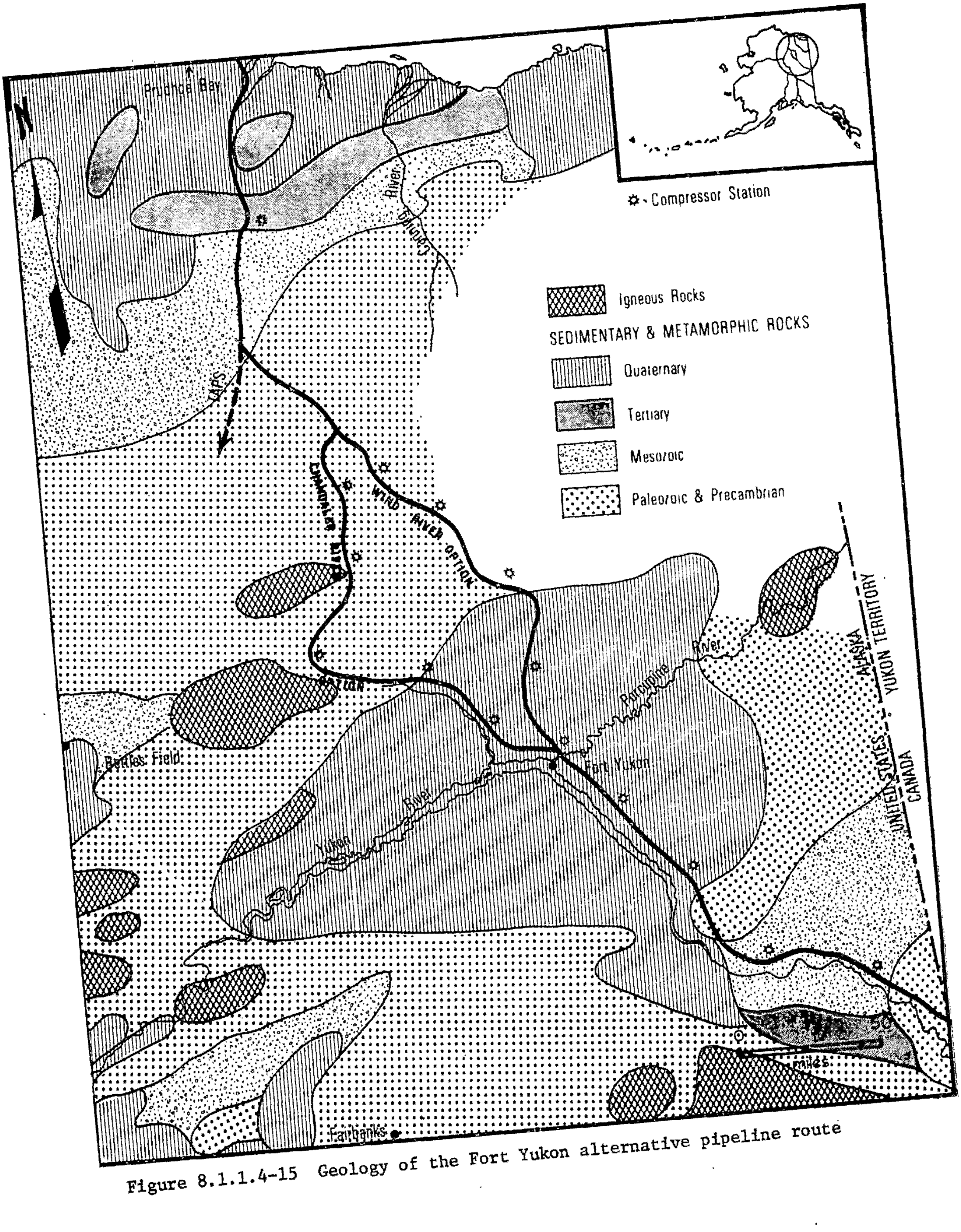


Figure 8.1.1.4-15 Geology of the Fort Yukon alternative pipeline route

fine gravel. Soils subject to liquefaction and excessive differential settlement are likely to be encountered.

The very limited available information suggests that sandy gravel lies near the surface over large areas of the Yukon Flats but is mantled by turf and peat several feet thick in much of the northern part. Fine-grained mantle achieves thicknesses of at least 50 feet, however, near the Yukon and Porcupine Rivers. The areas of relatively shallow gravel are laced with filled channels in which ice-rich peat and silt reach thicknesses of several tens of feet. Drainage is very poor and the water table is near the surface, resulting in extensive muskegs and marshy areas.

Ice-rich wind-blown silt is thought to be present to depths of several tens of feet in the high terrace between Flood Lake and the Christian River, and thick ice-rich peat and silt may be present in the swell-and-swale topography east of Tivehvun Lake. Extremely well-sorted medium sand, several tens of feet thick, mantles the alluvial sand and gravel in the dune areas near Fort Yukon and between 12 and 30 miles southeast of Fort Yukon. The frozen dune sand probably contains relatively little ice, but ice-rich sediments may be buried beneath the dune sand.

The southern segment of the Porcupine Plateau from a point opposite Circle through the drainage basin of the Little Black River seems to be mantled with wind-blown silt to depths of several tens of feet. Deeply indented thermokarst topography indicates that the silt is rich in ground ice and that the ground ice extends to great depths. Soils along this segment of the route will be especially susceptible to liquefaction and to thaw-collapse following disturbance of the surface vegetation.

In the Ogilvie Mountains surficial deposits are probably thin on the steep slopes and summits, consisting of a few feet of silty-stony colluvium similar to that in the northern segment of the Porcupine Plateau. The minor ravines and gullies probably lack appreciable surficial deposits, but valleys of intermediate size appear to be filled to depths of several tens of feet with ice-rich mixtures of gravel, silt, and peat. The valleys of large rivers such as the Tatonduk, the Nation, and the Kandik are floored with alluvial gravel several tens of feet thick covered by a few feet of silt and peat. The terraces of the Yukon River consist of alluvial gravel several tens of feet thick resting on bedrock, but the gravel is probably covered, in turn, by ice-rich gravel, silt, and peat a few feet thick near the river edge and as much as several tens of feet thick at the inner margin.

Permafrost

Figure 8.1.1.4-16 shows the generalized distribution of permafrost in Alaska as it relates to the Fort Yukon alternative route.

North of the Brooks Range the Fort Yukon route is located in a zone of continuous permafrost previously described in Section 2.1.1.3. Through the Brooks Range, permafrost is still continuous and permafrost conditions are similar to those described for the Interior alternative route in 8.1.1.3.

As the Fort Yukon alternative pipeline passes through the Porcupine Plateau into the Yukon Flats it crosses a zone where permafrost changes from continuous to discontinuous. Approximately 295 miles are located in the continuous permafrost zone, while 200 miles are within the discontinuous zone.

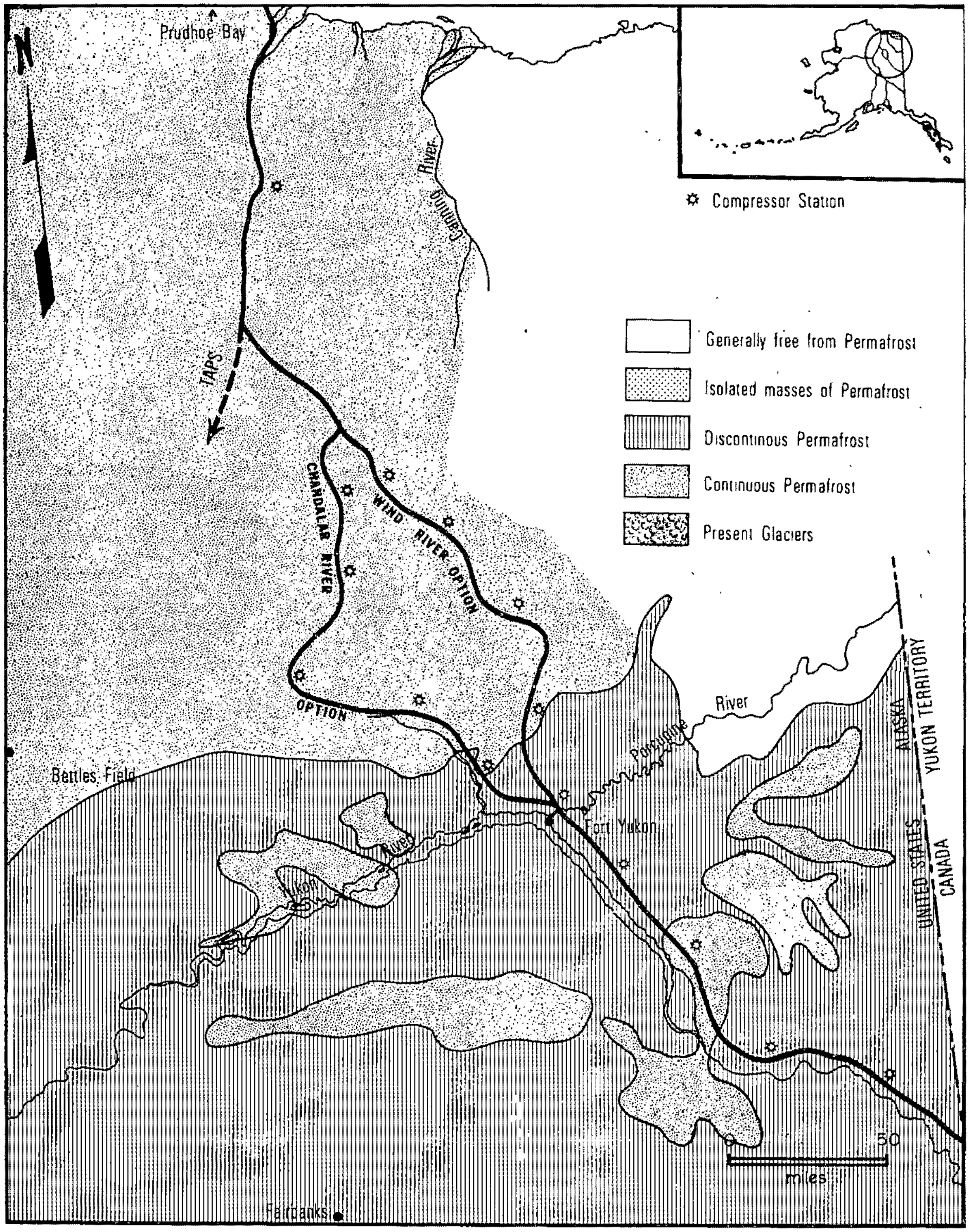


Figure 8.1.1.4-16 Permafrost zones along the Fort Yukon alternative pipeline route

The division between continuous and discontinuous zones has been chosen as the line where the mean annual ground temperature is -5° C (23° F); this criterion has been widely adopted and is used in North America.

In the continuous zone, permafrost occurs everywhere beneath the ground surface except in newly deposited materials and beneath bodies of water that do not freeze to the bottom in winter. In the discontinuous zone, there are areas of nonperennially frozen ground, as well as layers of ground within and above the frozen layers that do not freeze. This zone has a subzone, in which permafrost occurrences are limited to isolated patches ranging in size from a few square feet to thousands of acres.

In the continuous zone, the active layer is generally 1.5- to 3-feet thick.

In the discontinuous zone, the suprapermafrost layer is variable in thickness, ranging from a few feet in the northern part to several tens of feet, generally farther south.

Two boreholes near Fort Yukon indicate frozen ground at depths of 18 and 390 feet, respectively. A single hole at Eagle showed permafrost at a depth of approximately 50 feet. Fine-grained, ice-rich soils will be encountered locally in valley bottoms in the northern segment of the Porcupine Plateau.

The southeastern segment of the Porcupine Plateau from the Yukon River through the valley of the Little Black River appears to be deeply mantled with ice-rich perennially frozen silt. Small lakes and steep-sided minor valleys there seem to be the result of natural thawing; if so, they demonstrate that if the surface is disturbed and thawing occurs, the soils are subject to subsidence of as much as 100 feet.

Surficial deposits in the Ogilvie Mountains are probably frozen below depths of 5 or 10 feet, but the permafrost probably contains little or no ground ice in most places. However, ice-rich fine-grained sediments subject to liquefaction and thaw-settlement may be encountered in some valley bottoms and at the inner edge of the high terraces of the Yukon River.

Soils

Soils of the Fort Yukon alternative route are shown on Figure 8.1.1.4-17 and summarized in Table 8.1.1.4-3.

Erosion

Study of topographic maps failed to turn up any gullied badland areas of active erosion along the Fort Yukon alternative route, but a more detailed examination of air photos would be required to establish with certainty whether any active badlands naturally exist within the Alaskan segment of the route.

Mass Wasting

Landslides, rock falls, and snow avalanches occur frequently on steep valley walls in the Brooks Range. Another area subject to landslides will be encountered in the Ogilvie Mountains, where the route follows the Yukon River between the mouth of the Kandik River and the Canadian border. The landslide-susceptible areas here are the steep slopes undercut by the Yukon

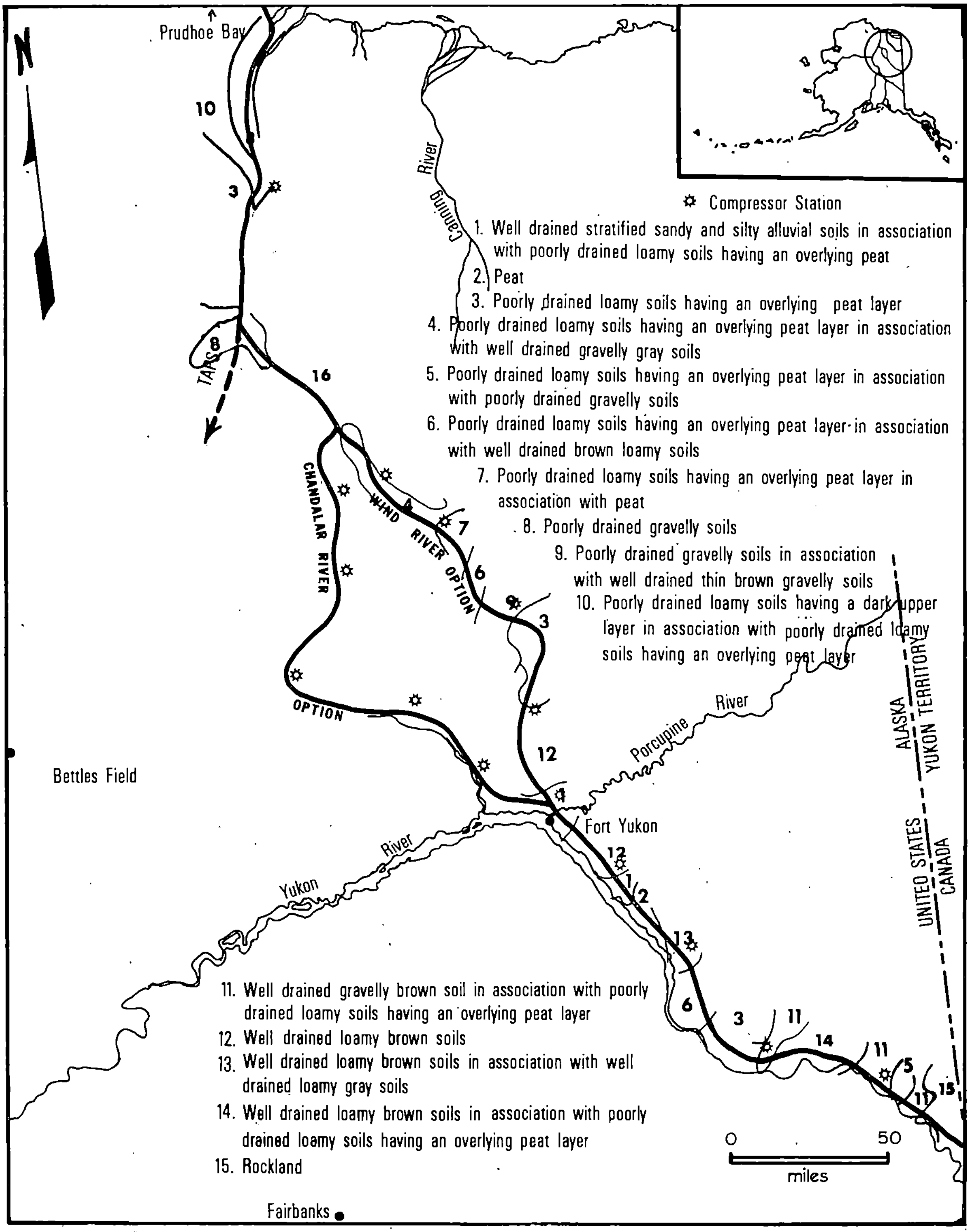


Figure 8.1.1.4-17 Soils of the Fort Yukon alternative pipeline route

Table 8.1.1.4-3 Soils of the Fort Yukon alternative pipeline route

No.	Description	Miles	% of Route	Location
1.	Well-drained stratified sandy and silty alluvial soils in association with poorly drained loamy soils having an overlying peat layer.	37.6	7.6	Yukon Flats
2.	Peat	4.8	1.0	Yukon Flats
3.	Poorly drained loamy soils having an overlying peat layer.	62.4	12.6	Arctic Foothills and Christian River area adjoining Yukon Flats
4.	Poorly drained loamy soils having an overlying peat layer in association with well-drained gravelly gray soils.	45.2	9.1	Upper East Fork of Chandalar River
5.	Poorly drained loamy soils having an overlying peat layer in association with poorly drained gravelly soils.	10.0	2.0	Yukon-Porcupine Plateau north of Eagle.
6.	Poorly drained loamy soils having an overlying peat layer in association with well drained brown loamy soils.	41.6	8.4	Slopes east of the East Fork of Chandalar River
7.	Poorly drained loamy soils having an overlying peat layer in association with peat.	16.8	3.4	Chandalar River Valley-East Fork
8.	Poorly drained gravelly soils.	34.8	7.0	Upper Coastal Plain and Upper Sagavanirktok River
9.	Poorly drained gravelly soils in association with well drained thin brown gravelly soils.	14.8	3.0	Upper Christian River area
10.	Poorly drained loamy soils having a dark upper layer in association with poorly drained loamy soils having an overlying peat layer.	61.0	12.3	Arctic Coastal Plains
11.	Well drained gravelly brown soil in association with poorly drained loamy soils having an overlying peat layer.	36.4	7.4	Upper Yukon River
12.	Well drained loamy brown soils	48.8	9.9	Uplands bordering Yukon Flats.
13.	Well drained loamy brown soils in association with well drained loamy gray soils.	18.4	3.7	Yukon - Porcupine Highlands east of Yukon Flats
14.	Well drained loamy brown soils in association with poorly drained loamy soils having an overlying peat layer.	14.8	3.0	Yukon - Tanana Highlands adjoining upper Yukon River
15.	Rockland	47.6	9.6	Brooks Range, upper Yukon area at Boundary
	TOTAL	495.0	100.0	

River on the outside of bends and meanders. No data are available on the extent of landslide-susceptible slopes and the frequency of landslides. In the Kandik River basin, however, significant land slides have occured where steep terrain was denuded of living vegetation by a recent forest fire. Landslide studies would be required if this route were to receive serious consideration.

Earthquakes

The historic record indicates that the level of earthquake activity along the Fort Yukon route is low. The closest known earthquake of potentially destructive size is a poorly located magnitude 6.0 shock in 1958 about 65 miles from the route. Since the installation of a regional seismograph network in the mid-1960's smaller shocks have been located. In the eastern Brooks Range and the western Porcupine Plateau at least eight shocks, four of which are in the magnitude 4 class, have occurred in the region bounded by the Middle and East Forks of the Chandalar River and by the Junjik River. Estimated epicenters of these shocks lie within 40 miles of the route; but uncertainties in the epicentral determinations must allow for plus or minus 25 miles margin of error. Earthquakes as large as magnitude 5.0 have occurred in the southern Porcupine Plateau within 50 miles of the route. Epicenters of numerous small earthquakes of magnitude 2.0 and greater from the interval 1968-1971 have been located within 25 km of the route between 62° N. latitude and 142° W. longitude (Gedney and others, 1972). The uncertainty in the epicentral locations is such that the location of a fault or faults can only be inferred. Refer to Figure 8.1.1.4-18.

The earthquake potential along the Alaskan portion of the route may be specified in terms of a magnitude 5.5 maximum expectable earthquake. This is consistent with the use of a magnitude 5.5 design earthquake for the northernmost (north of 67° N) segment of the trans-Alaska oil pipeline (Federal Task Force Alaskan Oil Development, (SITF 1972, p. 380; Page et al, 1972, p. 2).

Glaciers

The small glaciers near the Fort Yukon Route in the eastern Brooks Range have not been studied and nothing is known of their recent history nor of their present regime. Study of topographic maps suggests that the glaciers were larger several centuries ago but that they probably have not extended into the area of the route at any time during the last several thousand years. The glaciers are short and straight, and they are unlikely to surge. If they were to expand, several decades would probably be required before they would extend into the area in which a pipeline would be located.

Water Resources

A substantial mileage of the Fort Yukon route closely parallels rivers or streams. These include the Sagavanirktok and Ribdon Rivers on the Artic Slope and the Wind and Yukon Rivers to the south. From map inspection, it is estimated that 13 streams more than 100 feet wide and 128 streams less than 100 feet wide would be crossed. There also are a substantial number of very small creeks and intermittently flowing tributaries which also would be crossed.

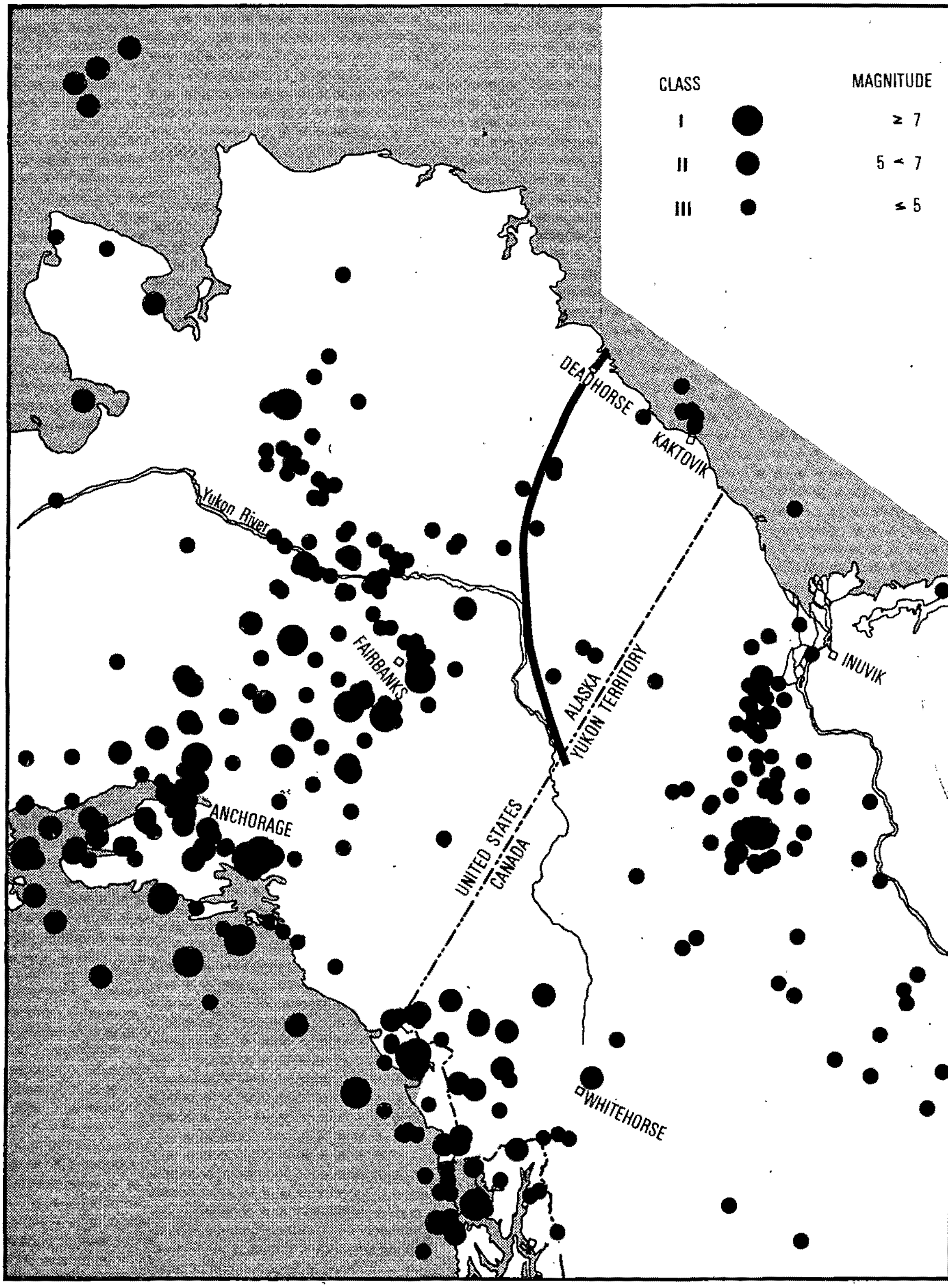


Figure 8.1.1.4-18 Earthquake epicenters of the Fort Yukon alternative pipeline route

Characteristics of water quality and occurrences described on the applied-for AAGPC route (2.1.1.5) and the Interior alternative (8.1.1.3) apply to the Fort Yukon alternative route with the following exception.

The Yukon River in Alaska is silty, reflecting the large amounts of glacial meltwater from tributaries far upstream. In summer, water temperature often runs about 50° to 60° F between mid-June and mid-August. In winter, water temperatures range from 32° to 35° F. Average date of freezeup is November 8, with average breakup taking place May 9. Because headwater streams freeze during winter, the Yukon has clear water during winter.

Data from gauging stations at Eagle and Circle indicate 80 percent of the total runoff occurs during summer. Peak discharges, which often exceed 300,000 cfs, coincide with breakup in late May or early July. Low flows range from 16,000 to 20,000 cfs and occur in late February or early March when there is as much as 6 feet of ice on the river. Annual fluctuations of the Porcupine River range from a maximum discharge of 250,000 to 740,000 cfs. Ice jams occur, with significant raising of the river level and resultant scour by high water velocities and ice cakes.

Tributary streams crossed by the Fort Yukon alternative route south of the Continental Divide, including the Porcupine, Black, Kandik, and Nation, are clear except immediately after rainstorms or spring breakup.

Water is taken from the Yukon River at Eagle for domestic purposes during winter. In summer, shallow wells supply potable water.

The Fort Yukon alternative pipeline route follows narrow stream valleys across the Brooks Range. The Yukon Flats are characterized by extensive muskeg and a maze of small lakes, ponds, and meandering streams. Lakes and ponds are recharged by annual flooding of the Yukon River and exhibit the full range of ecosystems from newly created ponds with standing water-killed trees and shrubs to peat bogs having only small areas of open water in their centers.

Flooding may be severe as a result of ice jams in the spring, but tributary streams also exhibit marked fluctuations of up to 10 feet as a result of heavy rainstorms in headwater areas. The Yukon River can fluctuate several feet in only a few days as a result of rains hundreds of miles upstream.

The alternative Fort Yukon Route involves the potential Woodchopper hydroelectric damsite. The route is located next to the Yukon River through an area where a 496-foot dam could be built to store 31 million acre-feet of water, with an estimate of firm power potential of 2.16 million kilowatts at a 75 percent annual load factor. Annual firm energy production would be 14.2 billion kilowatt hours. The Fort Yukon route also crosses an area withdrawn for the Rampart Dam (5.04 million kilowatts and firm annual production of 34.2 billion kilowatt hours).

Vegetation

Eight vegetation types are traversed by the Fort Yukon alternative route. In the following list each type is indicated and the approximate percentage of the 495-mile alternative is shown. Refer to Figure 8.1.1.4-19 and Table 8.1.1.4-4.

Wet tundra, moist tundra, and high brush vegetative communities are described in 2.1.1.6 for the applied-for AAGPC route. Alpine tundra, upland

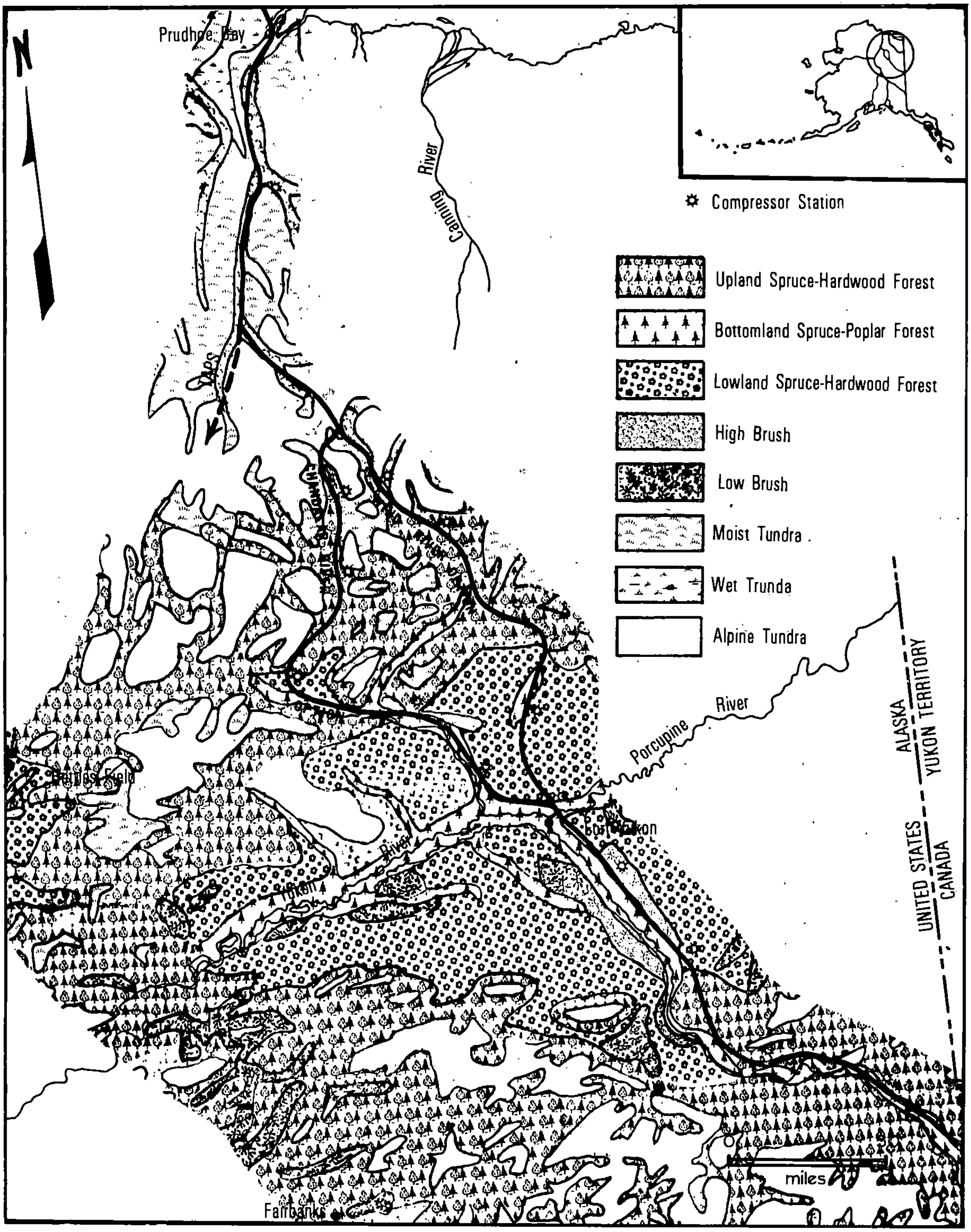


Figure 8.1.1.4-19 Vegetative types of the Fort Yukon alternative pipeline route

Table 8.1.1.4-4 Vegetation associated with the Fort Yukon Alternative route.*

Vegetation Type	Approximate Miles	Approximate Percent
Wet Tundra	15	3
Moist Tundra	53	11
High Brush	95	19
Alpine Tundra	45	9
Upland Spruce-Hardwood Forest	140	29
Low Brush, Muskeg-Bog	20	4
Bottomland Spruce-Poplar Forest	60	12
Lowland Spruce-Hardwood Forest	65	13
Total	495	100

* Wind River option. Overall the Chandalar River option would be similar except there would be more upland Spruce-Hardwood forest.

spruce-hardwood forest, low brush, muskeg-bog, and bottomland spruce-poplar forest are described in 8.1.1.3 for the Interior alternative route.

Lowland spruce-hardwood forest is a dense to open interior lowland forest of evergreen and deciduous trees, including extensive pure stands of black spruce. Black spruce are slow growing and seldom exceed 8 inches in diameter or 50 feet in height. Cones of this tree open after fire and spread abundant seed, enabling black spruce to quickly invade burned areas. The slow-growing stunted tamarack is associated with black spruce in the wet lowlands. Like black spruce it is of little commercial value, seldom reaching a diameter of more than 6 inches.

Rolling basins and knolls in the lowlands have a varied mixture of white spruce, black spruce, paper birch, aspen, and poplar. Small bogs and muskegs are found in the depressions.

Undergrowth species include willow, dwarf birch, low bush cranberry, blueberry, Labrador tea, crowberry, bearberry, cottongrass, ferns, horsetail, lichens, and a thick cover of sphagnum and other mosses. Large areas burned since 1900 are covered by willow brush and very dense black spruce sapling stands.

This system occurs in the intermontane basins and lowlands throughout interior Alaska. It is also found on shallow peat, sand dunes, glacial deposits, outwash plains, alluvial fans, and on north slopes.

Elevations vary from sea level to 1,500 feet in higher basins and lowlands and to over 2,500 feet on north slopes.

Human Influence on Existing Vegetation

Approximately the first 110 miles of this alternative route closely follow the trans-Alaska pipeline now under construction. Therefore, vegetative alteration has occurred. Provision of a new road introduces a potential for continued human influence on the vegetation.

From where the route leaves the trans-Alaska oil pipeline to the former Venetie Indian Reservation, the vegetation is basically unaltered by the influence of man. Within the former reservation, but away from village or group dwelling areas, there is no appreciable human influence on vegetation.

Along the Yukon and Porcupine Rivers during the steamboat era (1898 to 1940), wood requirements were met from locally available forest materials. Tens of thousands of cords, of wood were required to operate the boats. Conversion to oil as fuel began in the 1920's and the last wood burner reportedly was discontinued prior to World War II.

Unique, Sensitive, or Threatened Plants

There are no known or threatened plants directly associated with the Fort Yukon alternative route. However, the area along the United States-Canada border is distinctive in that it has not been glaciated. Studies of plant associations at Eagle (on the opposite side of the Yukon River from the alternative route) indicate plants in this area may not be found elsewhere in Alaska. It is also noted that the topography and geology is distinct between the north and south side of the Yukon River. The former is dominated by sedimentary rocks; the Calter metamorphics. Endemic plants to the Eagle "greenstone" area reported by Shacklette (1966) include: bellflower, (Campanula flavum), small-flowered rocket (Erysimum aurita), viscid bocoweed (Oxytropis viscida forma albida), beard tongue (Penstemon Gormani), scorpion weed (Phacelia mollis and P. sericea), cinquefoil (Potentilla pennsylvanica var. strigosa), and pink (Silene repens subspecies purpurata).

Fire Hazard

Fire hazards involve the same two zones (tundra and northern boreal forest) described in Section 8.1.1.3 for the Interior alternative zone. The major difference is that almost 60 percent of total Fort Yukon Route is within the high fire hazard boreal forest.

Wildlife

The Fort Yukon alternative route traverses the Arctic North Slope along and generally close to the oil pipeline for 110 miles. Ungulate species occurring in this area include caribou, moose, mountain sheep, and recently introduced musk oxen. Carnivores include grizzly and polar bears, the wolf, coyote, wolverine, red and arctic foxes, lynx (occasional), marten (occasional), mink, otter, and weasel. Rodents include the porcupine, marmot, ground squirrel, lemming (both brown and collared), and several species of voles. Three species of shrews occur there. Wildlife considerations are basically the same as discussed for the Interior alternative 8.1.1.3. The following discussion emphasizes wildlife relationships with regard to the Fort Yukon alternative.

Caribou

The Sagavanirktok drainage is flanked by the ranges of the Porcupine Caribou Herd on the east and the Arctic Herd to the west (Figure 8.1.1.4-20). Both caribou herds traditionally winter in the foothills and southern slopes of the Brooks Range and summer in the northern foothills and on the Arctic Coastal Plain. In section 2.1.1.7, the Porcupine Herd is discussed in detail.

These two herds intermingle in the summer in the vicinity of the Fort Yukon alternative route, but have traditional calving areas which appear to be the focal point of the range of each herd (Lent, 1966; Skoog, 1968). Calving grounds for the Arctic Herd are in the headwaters of the Utukok and Colville Rivers to the west of the route.

One additional caribou herd is of consideration along this route: according to Hemming (1971) portions of the Fortymile Herd cross the Yukon River between Circle and Eagle for a few weeks on summer range. This is not an annual occurrence and is probably related to range conditions south of the Yukon. Since the Fortymile Herd is presently at low ebb, crossing to the north side may not occur again until herd numbers build up.

AAGPC (1974a) notes that the Fort Yukon route crosses winter range between Mile Posts 170 and 240 and that northward spring migration routes involve the area in the vicinity of Buffalo Mountain and Chandalar River.

Dall Sheep

Dall sheep are associated with the Fort Yukon route at two widely spaced locations: Brooks Range and the United States-Canada border.

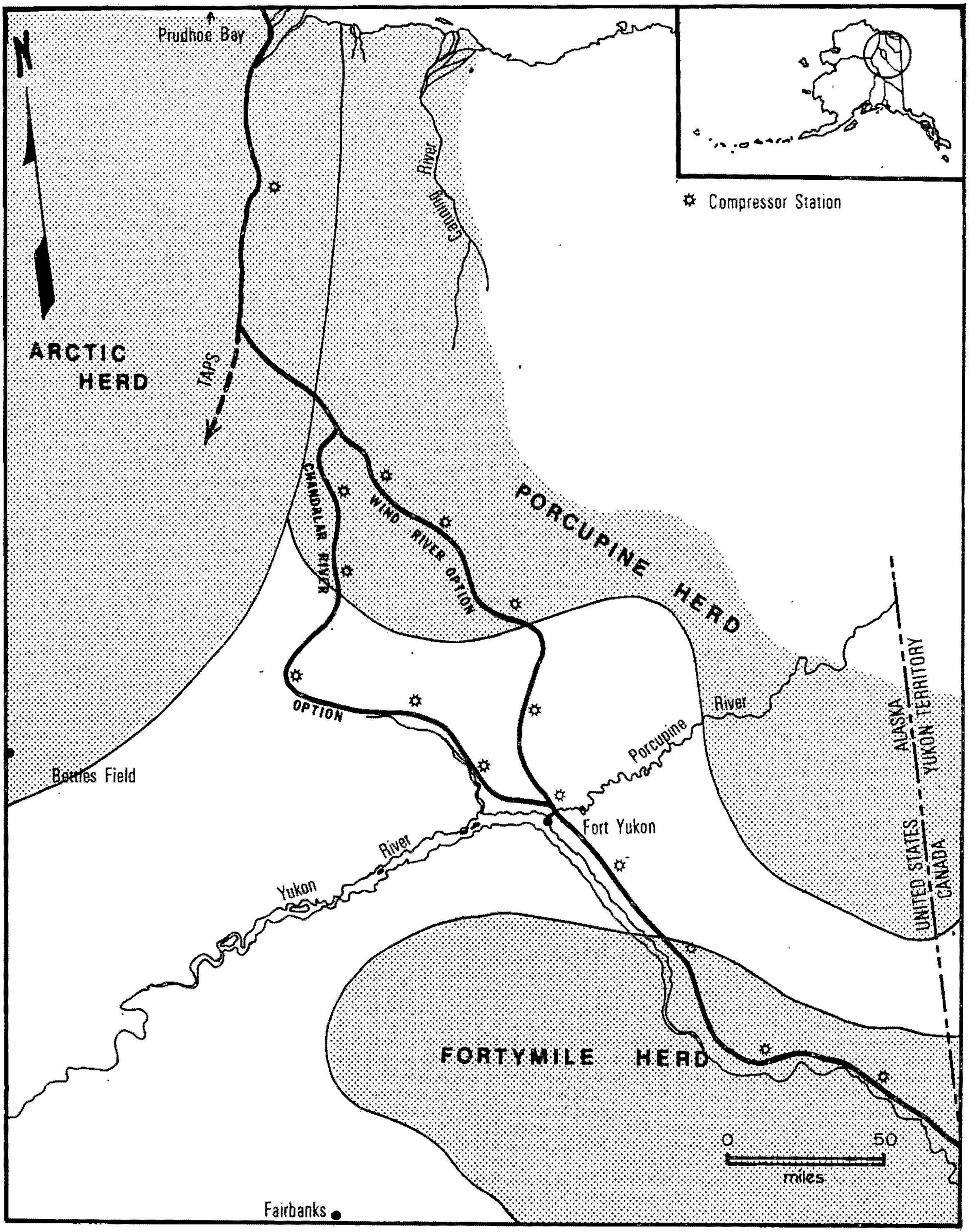


Figure 8.1.1.4-20 Main caribou herds of the Fort Yukon alternative pipeline route

The Brooks Range provides good to excellent habitat for Dall sheep along the Continental Divide. Approximately 100 miles of the Fort Yukon alternative route are located within Dall sheep habitat. Although population levels are not known, it is believed that there are fewer sheep associated with the Fort Yukon crossing of the Continental Divide than the Canning River drainage area described in 8.1.1.3.

The north side of the Yukon River near the United States-Canada border is reported to contain the partially gray Fannin color phase of Dall sheep (APG 1974a). These distinctive sheep may occur along limestone craigs adjacent to the Tatonduk River.

Moose

Moose are distributed throughout the Brooks Range. Discussions in 2.1.1.7 (applied-for AAGPC route) and 8.1.1.3 (Interior alternative route) are considered typical of moose in the Brooks Range portion of the Fort Yukon route. The AAGPC (1974a) notes that there are moose concentration areas in the Ribdon and Wind River valleys.

The Yukon Flats provide good moose range. Birch and aspen, characteristic of the secondary stage of forest following fire, and willow, a pioneer species on sandbars and other areas, are preferred foods. Numerous ponds and marshes with their abundance of aquatic plants further enhance the area as moose habitat. Wintering areas are usually adjacent to the Yukon, Chandalar, and Porcupine Rivers. On the basis of aerial surveys conducted in March 1962, the winter population of moose was estimated at approximately 5,000 animals.

Along the Yukon River moose occur in moderate numbers. The Woodchopper impoundment area associated with the Fort Yukon route is estimated to contain 1,000 moose. Carrying capacity is believed to be considerably higher.

Moose stay in the rolling areas adjoining the Yukon River during summer. Severe winter conditions force them into river bottoms, principally along the Yukon and its major tributaries.

Bear

Black bears are believed to be abundant and have fairly uniform summer distribution in forested lowland regions and are approximately two or three times as numerous as grizzlies. In alpine areas the total bear population may be lower, but grizzlies become relatively more abundant.

Bear distributions in the Brooks Range are described in 2.1.1.7 and 8.1.1.3 (applied-for and Interior alternative routes, respectively). These descriptions are considered typical of the Fort Yukon alternative route. Field studies by the Bureau of Outdoor Recreation in 1973 on the Wind River as a potential wild river disclosed above average distribution of grizzly bears along portions of the valley to be traversed by the Fort Yukon Route.

Marine Mammals

The distribution of marine mammals in the Prudhoe Bay area of the Fort Yukon route is considered the same as that described in the Interior alternative route (8.1.1.3).

Furbearers

Furbearers are distributed along the Fort Yukon Alternative route in a manner similar to that described for the Interior Alternative route in 8.1.1.3. The Yukon Flats also contain excellent habitat and populations of furbearing animals.

Wolves of the Yukon Flats depend primarily on moose for their prey, but in areas both to the north and south, they may subsist more extensively on caribou. Beaver, snowshoe hares, and even mice may be used extensively when big game is not available, particularly during the denning season when movements are restricted. Wolf populations have been relatively stable and probably number several hundred animals. Bounties, which did not affect populations significantly, were discontinued in 1968.

Birds, General

Avian species of the higher elevations of the Brooks Range and the Beaufort Sea coast have been discussed in 8.1.1.3.

Except for waterfowl and peregrine falcons, there are no detailed studies of avian populations or distribution along the Fort Yukon Alternative routing. It is believed that general distributions (except as noted in this discussion) are typical of those described for the applied-for route (2.1.1.7) and the Interior Alternative routing (8.1.1.3). For a detailed discussion of avian populations in the area south of the Brooks Range crossed by the Fort Yukon Alternative route, the reader is also referred to the Final Environmental Impact Statements for the proposed Yukon Flats National Wildlife Refuge, Porcupine National Forest, and Yukon-Charley National Rivers (APG 1974).

One hundred and thirty species of birds have been identified on the Yukon Flats. Most are migratory but 13 species remain year around. The region is particularly important for waterfowl and other birds commonly associated with aquatic habitats.

Waterfowl

The abundance of water in lakes, ponds, and stream channels of the Yukon Flats provides habitat for birds from all four flyways of the North American continent. Waterfowl, in particular, utilize this area during migration and for nesting and molting. Fall populations for the region average 2.1 million ducks which become available for harvest as they pass through Canada, the mainland United States, and Mexico.

Waterfowl use begins shortly before breakup in April or May when the first snowmelt forms small ponds. Use continues until freezeup in October. Small ponds open relatively early and some of the ducks and geese found there in the spring are members of migrant groups moving farther north and west.

The larger and more productive lakes are important molting habitat in late summer, not only for populations of ducks that nest or are raised on the Flats, but also for birds that arrive from distant areas.

Southward migrants concentrating in this fertile area comprise a significant portion of the population in the fall of the year. Both ducks and geese are found in large numbers on many lakes, and on islands and bars of the river where migrating geese graze extensively on horsetail growing on stabilized areas. Many thousands of snow geese pass through the area in spring and occasionally small flocks of black brant are also observed.

By far the greatest importance of Yukon Flats to waterfowl is for nesting and for rearing young. Production takes place even in years when drought eliminates many prairie breeding areas and scatters waterfowl which might have nested there. Some of the prairie and parkland habitat of Canada and the conterminous United States has a higher number of water areas per square mile in favorable years and is at times more heavily occupied by waterfowl. However, these highly productive areas do not have the capacity to produce consistently in times of drought. There is evidence that drought in the prairies causes a greater northward movement of ducks, many of which contribute to the Yukon Flats population during these periods. Thus, the Yukon Flats is a segment of the continental waterfowl breeding grounds almost unequalled in extent and of continuous high productivity.

The Bureau of Sport Fisheries and Wildlife (Fish and Wildlife Service) conducted studies of waterfowl on the Yukon Flats from 1953 to 1955 and from 1960 to date. In addition, breeding populations of waterfowl in the Flats have been censused annually from the air since 1953. These surveys indicate that since 1956 the breeding population has averaged more than a million ducks. Table 8.1.1.4-5 summarizes these data.

The largest and most productive duck populations are found at low elevations where ducks nest and raise their broods on the many small, shallow ponds, lakes, and potholes. Scaup are the most abundant species followed by pintail, wigeon, green-winged teal, scoter, shoveler, and canvasback.

Canada and white-fronted geese are important segments of the nesting population. Canada geese are most abundant on larger lakes or on sandbars and islands of the Yukon River whereas white-fronted geese most commonly nest on the banks of small streams.

Trumpeter swans also nest in the region but their numbers are limited.

Cranes, loons, grebes, and shorebirds are also associated with aquatic habitats and occur in large numbers. Observations of adult sandhill cranes indicate that there are about 10,000 in the breeding population with a minimum annual production of 500 to 1,000 young.

Arctic, common, and red-throated loons are found on the Yukon Flats, with arctic loons the most abundant. Studies indicate about 15,000 arctic loons are in the breeding population.

The distribution of horned and red-necked grebes is similar to that of ducks during the breeding season in that they are most abundant in shallow, fertile lakes. Inasmuch as grebes are shy and escape observation by prolonged submergence or use of emergent cover, reliable estimates of their numbers are not possible, but as they occur on nearly every lake or pond, their numbers must exceed 100,000.

Raptors

Several species of raptors have been observed in the region, but none has been studied in depth. Bald eagles are sparsely distributed throughout the area and golden eagles occur, but ospreys, red-tailed hawks, and great horned owls are considerably more abundant than other large raptors and are widely distributed throughout forested habitats. The gyrfalcon and the

Table 8.1.1.4-5 Waterfowl populations of Yukon Flats, Alaska

Species	Nesting Population Number	Nesting Population Percent
Ducks		
Mallard	63.700	6.0
Gadwall	300	t
Pintail	188,300	16.6
Green-winged teal	80,500	7.5
Blue-winged teal	t	t
Wigeon	140,800	14.0
Shoveler	53,300	5.0
Ring-necked duck	t	t
Canvasback	50,500	4.7
Lesser scaup	376,700	35.1
Goldeneye	12,100	1.1
Bufflehead	17,600	1.6
Oldsquaw	26,100	2.4
Scoter	63.700	6.0
Merganser	100	t
Total Breeding Population	1,073,700	100.0
Estimated Fall Population		
Adults plus young	2,147,000	
Geese		
Canada	8.000	61.5
White-fronted	5,000	38.5
Total Breeding Population	13,000	100.0
Estimated Fall Population		
Adults plus young	16,500	

Source APGC (1974b)

t = Less than 0.1 percent

threatened peregrine falcon nest along the rivers wherever suitable cliffs are available. Neither is common in lowlands of the Yukon Flats, but critical nesting habitat exists along the upper Yukon River through the Eagle Trough. Peregrine falcon also nest at Frankin Bluffs near the Sagavanirktok River.

Twenty species of raptors, eighteen of which are known or thought to breed in the area, occur in the upper Yukon area between Fort Yukon and Eagle. At least three pairs of bald eagles nest along or near the Yukon River and are closely associated with the lowlands. Six pairs of bald eagles were observed in 1974 along the lower 40 miles of the Charley River. Golden eagles nest on ledges and other locations associated with the tundra uplands, where they are quite common. Rough-legged hawks reportedly nest in substantial numbers in the area, principally along tributaries to the Yukon (Grundy, pers. comm.).

America's largest falcon, the gryfalcon, is known to inhabit highlands in the southern part of the area, and presumably nests there (McGowan, pers. comm.).

Among the breeding raptors the peregrine falcon is of pre-eminent importance due to its present relative abundance along the Yukon River despite its status as an endangered species. Eighteen to twenty pairs were counted along the Yukon River in the early 1950's between Eagle and Circle.

Nesting occurs on steep bluffs near water. One nest site may be used repeatedly, though it is common for a pair to utilize several sites over a period of years. Though the birds are very sensitive to human intrusion into the nesting area, it appears that existing levels of human intrusion normally do not lead to disruption of nesting activity (Grundy, pers. comm.).

Fish

The fish resources of the Yukon Flats include both anadromous and resident species. Anadromous fish are those which originate in fresh water, migrate to salt water to mature, and return again to fresh water to spawn. Refer to 2.1.1.7 and 8.1.1.3 for discussions of fish found on the Beaufort Sea Coast and Brooks Range, respectively.

Of the five species of Pacific salmon utilizing the Yukon River, only chum, coho, and chinook salmon ascend as far as the Yukon Flats to spawn. Chinook salmon of the Yukon River probably travel farther upstream to spawn than anywhere else in the world, reaching Nisutlin Lake in Canada, nearly 2,000 miles from the sea.

Although chum salmon usually spawn in the lower reaches of streams close to the coast, some ascend the Yukon to the outlet of Teslin Lake in Canada, a distance of 1,735 miles. The only other known run of chum that approaches this migration is found in the Amur River of Siberia. Because of genetic adaptation to this long spawning migration, the Yukon River race is among the finest of this species, having extremely rich, deeply orange-colored flesh.

The coho also travel great distances to spawn in the upper Yukon drainage. One verified report indicates that this species has been taken from the Porcupine River, more than 1,000 miles from the mouth of the Yukon. Other reports indicate that populations of coho travel another 200 miles up the Porcupine River tributaries to spawn.

Substantial spawning areas for salmon, particularly fall chum, are present on several streams including the Chandalar, Black, Sheenjek, and Porcupine Rivers.

Annual spawning escapement of the three species using the upper Yukon drainage in 1961 and 1962 was about 270,000 fish but numbers vary and may be lower or much higher than this figure. The returning cycle of adults represents a valuable economic resource for commercial and sport fishermen of the Yukon River from its mouth to spawning areas in Canada.

Resident fish of the Yukon Flats area include the northern pike, arctic grayling, whitefish, longnose sucker, inconnu (sheefish), burbot, lake chub, trout-perch, and sculpin. Small populations of arctic char and ninespine stickleback likely are present in the region. The northern pike is the most common and important sport fish of the area. These fish seem to prefer sluggish streams and the warm waters of shallow, weedy lakes, but are sometimes abundant in cold, clear, deep lakes, as well.

The arctic grayling is widely distributed in clear, cold streams and lakes. It is more abundant in mountain streams within the area adjoining the Yukon Flats. It also is an excellent sport fish and is valued in the creel of anglers. Grayling commonly depart from small streams in the fall and move downstream to larger rivers, but some remain over winter in the smaller tributaries where there are pools having sufficient depth or where seepage flow is present.

The sheefish or inconnu inhabits many northern lakes and rivers and has been taken at several locations in the Yukon Flats. Within the United States it is found only in Alaska.

The longnose sucker, whitefish, and ciscoes are common inhabitants of both lakes and streams. They are important forage fish for pike and sheefish and contribute substantially to the subsistence economy of the Natives.

Reptiles and Amphibians

There are no reptiles on the Yukon Flats or in other regions of northern Alaska. Amphibians are limited to one small but vociferous frog (*Rana sylvatica cantabrigenis*) that is often heard but uncommonly observed on marshes and ponds.

Threatened Species

As previously indicated, peregrine falcon nesting sites are found along cliff and canyon areas of the Yukon, Franklin Bluffs, and perhaps elsewhere. Inventories are incomplete.

From what is known of the species, any disturbance during nesting could result in nest abandonment or even cannibalism of young. Refer to Figure 8.1.1.4-21 for a display of sensitive areas associated with all species along this route.

Ecological Considerations

Discussions of ecological considerations for the applied-for route (2.1.1.8) and the Interior alternative route (8.1.1.3) are considered

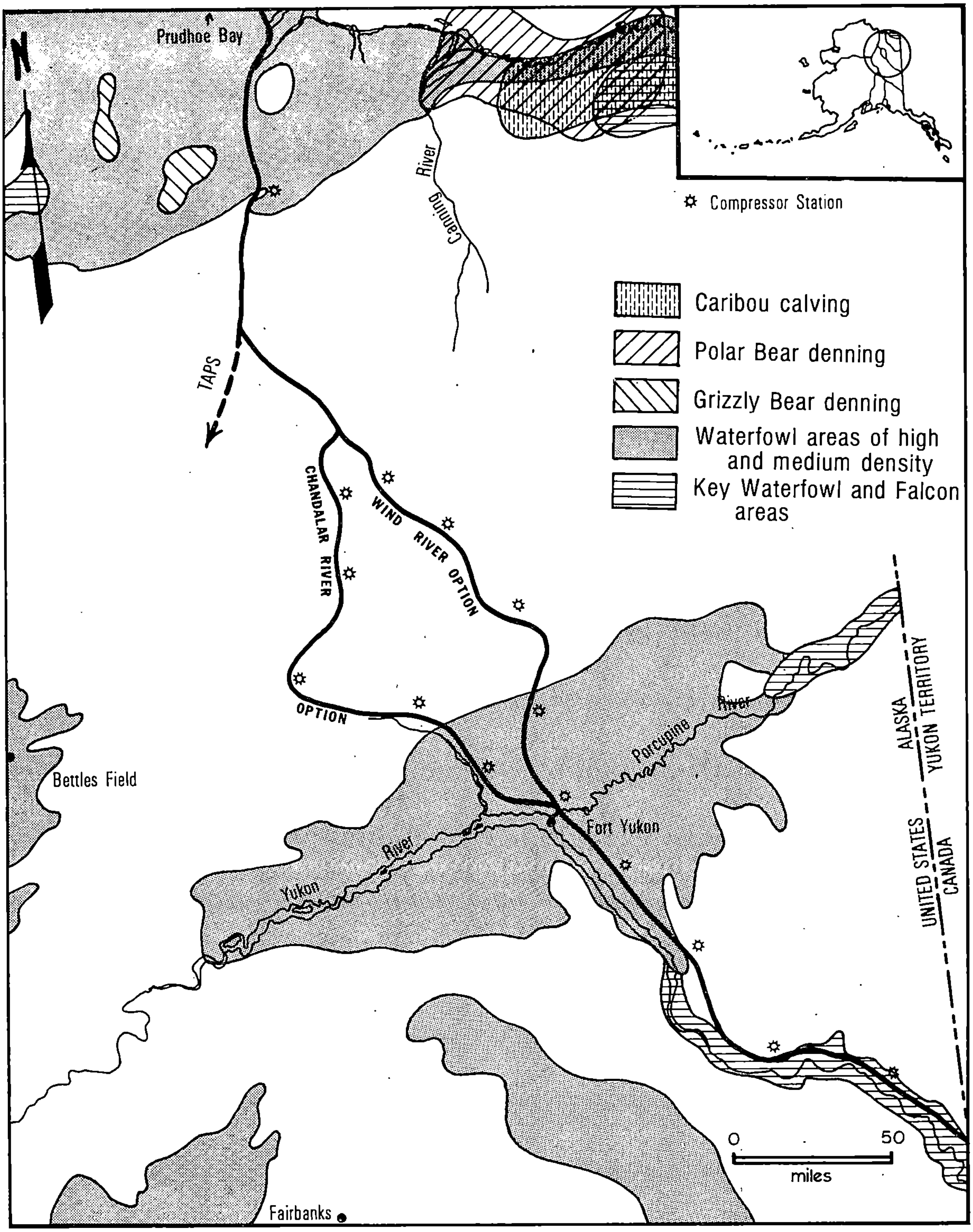


Figure 8.1.1.4-21 Sensitive wildlife habitat of the Fort Yukon alternative pipeline route

applicable to overall considerations of the Fort Yukon alternative pipeline system.

Economic Factors

Economic factors described for the applied-for AAGPC route in 2.1.1.9 and the Interior alternative pipeline system in 8.1.1.3 are considered applicable to the Fort Yukon route because of its location in remote areas of Alaska. The basic difference is that more people would be required to construct the longer system necessary in the Fort Yukon alternative. The result would be to extend the economic effects caused by the Trans-Alaska oil pipeline system until the Fort Yukon alternative system becomes operational.

Table 8.1.1.3.-7 shows the commercial facilities of the rural communities associated with the Interior alternative route. In addition to these, the communities of Venetie and Eagle are involved with the Fort Yukon alternative pipeline system. Venetie has a general store. Eagle has a general store and a lodge.

Subsistence use of fish and wildlife are shown for the route associated with the Interior alternative in Table 8.1.1.3-9.

Subsistence harvests of fish and wildlife by the residents of Venetie and Eagle are presented in Table 8.1.1.4-6.

Sociological Factors

Overall population characteristics of Alaskans directly associated with the Fort Yukon alternative are similar to those described for the Interior alternative route (8.1.1.3).

Population

In total, the Fort Yukon alternative pipeline system involves approximately 1,100 Alaskans living in rural comminities. An estimated 2,000 Alaskans are believed to be directly involved with the Fort Yukon Alternative routing. Although these people reside primarily in small communities, families are scattered throughout the general area. For example, in the summer of 1973 at least five family groups were living along the Yukon River between Circle and Eagle. Three of these families had lived there for at least 3 years and the population may be increasing. Two men live at Coal Creek to protect mining property. A number of cabins exist on the Yukon, particularly near the mouths of tributary streams. In 1974, Fort Yukon, the largest community, had more than 600 residents. The smaller communities were Venitie (pop. 108), Eagle (pop. 92), Circle (pop. 63), and Central (pop. 35).

Local Government

Central, Eagle, and Fort Yukon are second class incorporated cities while Circle and Venetie follow traditional Native governmental approaches. Except for Central which is entirely non-Native, each village also has a village corporation constituted under provisions of the Alaska Native Claims Settlement Act.

Native people throughout the area south of the Brooks Range are members of the Tanana Chiefs Conference Regional Native Association and the Doyon,

Table 8.1.1.4-6 Subsistence harvests associated with the Fort Yukon alternative pipeline route

	Yukon Flats**	Venetie+	Eagle
Big Game			
Moose	481	33	30
Caribou	1,062	200	100
Grizzly bear	32	19	1
Black bear	130	11	3
Dall sheep	59		
Furbearers			
Muskrat	43,409	4,000	6
Beaver	3,223	400	4
Otter	4	--	--
Lynx	4,981	250	120
Fox	668	160	--
Marten	3,778	211	160
Mink	1,963	219	2
Squirrel++	2,595	500	100
Weasel	1,334	150	5
Rabbit	21,912	2,200	1,500
Wolverine	204	27	13
Wolf	151	37	25
Porcupine	149	24	15
Birds			
Ducks	10,947	2,210	300
Geese	2,779	230	--
Ptarmigan	5,735	540	35
Spruce grouse	3,253	350	50
Snowy owl	5	--	--
Fish (lbs)	873,760	73,860	§
Berries (lbs)	9,357	50	1,634
Plants/roots (lbs)	186	---	--
Garden Produce (lbs)	22,385	2,000	11,500

Source: APG 1974a, 1974b, 1974c

** Composite of 7 rural communities located in the Yukon Flats area of the Yukon and Porcupine River area, Alaska, 1973

\+ Included in Yukon Flats

++ Includes tree and ground squirrels

§ Pounds not available, but includes 4,000 chinook salmon

Ltd. Regional Native Corporation, both with headquarters in Fairbanks. Doyon, Ltd, has a subregional office in Fort Yukon. The villages of the Yukon Flats have their own Native association, Gwitcha Gwitchin Ginkhye, which means "Yukon Flats People Speak."

Community Services

Public utilities, community services, and facilities are extremely limited at communities in the immediate vicinity. Both Eagle and Circle have community wells, but at Circle it is reported to be little used, as people obtain water from surface sources. Neither village has a sewage disposal or treatment system. Waste disposal is by means of indoor and outdoor privies and cesspools. At Circle there is a small community power system. People use wood or oil stoves and kerosene or gas lamps. At Eagle Village, the situation is similar. Eagle Village has applied for a community power station through the Alaskan Village Electrification Cooperative program. In the city of Eagle several homes have their own power generators. Circle has radio telephone connections with Fairbanks, but there is no telephone service at Eagle. In Eagle radio communication is available at the school and at the BLM field station. Traditional modes of transportation within the area such as hand-propelled boats, dogsleds, and snowshoes have largely given way to the powerboat, snowmobile, and airplane.

Travel by river stern-wheelers was discontinued in the mid-1950's. Today barge traffic still serves the river-accessible communities during each year's four or five ice-free months. Small riverboats and, during certain years, cruise boats run the river as well as the navigable lower portions of tributary streams, hauling machinery and materials and providing access for fishing and recreation. Residents continue to use the Yukon as a main highway, by boat in summer and sled--mainly snowmobile--in winter. In 1973 about 30 canoes traveled from Eagle to Circle.

In 1967 Terry Brady operated a small vessel with a barge on the Yukon. He found the operation sufficiently promising to carry out a feasibility study, including a proposal for passenger and car ferry service between Dawson, Eagle and Circle. He estimated that the 285-mile run could be accomplished upstream in 35 hours and downstream in 18 hours. The proposal involves a 60-foot, diesel-powered towboat hauling a 150-foot barge capable of carrying 88 overnight passengers (36 in staterooms) and 18 vehicles. Initial cost was estimated at $350,000 to $500,000 with first 5-year costs about $1.6 million, and an initial 5-year maximum gross at full capacity of $3.3 million. The State of Alaska conducted its own study and found that the ferry would be marginally feasible, given high rates and increased tourist visitation. The State study was based on larger vessels (Alaska Department of Public Works, 1973).

Air transportation is of major importance, particularly in winter when roads are not kept open. Three planes regularly operate along the Yukon between Eagle and Circle. Eagle has a 3,600-foot gravel strip that is 1.7 miles east of town and is served by commercial flights from Fairbanks as well as bush traffic. Planes also use the grass of the former Fort Egbert parade grounds. A similar strip exists at the village of Circle. A number of airstrips suitable for light and short-take off-and-landing (STOL) type aircraft exists, notably at Woodchopper and Coal Creek. If future use patterns demand, the Eagle strip could be made suitable for small jets, but Circle may require a new strip. Lakes and rivers in the area are used for float plane landings. Gravel bars are used for small air craft landings.

A summer mail trail was maintained from Eagle to Circle from 1926 to the late 1930's (Ritchie, 1972). A road was constructed up Woodchopper

Creek in 1925 which is still maintained today. It connects placer operations in Woodchopper and Coal Creeks. Another road serves gold placers 10 miles above the Yukon on Fourth of July Creek.

A State road from Fairbanks to Circle, the Steese Highway, was improved for truck traffic by 1939. Today it is a good asphalt and gravel road. The Tok to Eagle road, the Taylor Highway, was completed by 1948 and developed as a standard road in 1957. It is a good gravel road and connects the Alaska Highway with Dawson, Y.T., Canada. Road connections to Eagle and Circle are closed in winter, although portions have occasionally been kept open during the winter for access by mining companies.

Land Use

Existing

The Fort Yukon alternative pipeline system involves both developed and undeveloped areas in Alaska. The first 110 miles south of Prudhoe Bay are located close to the newly constructed road to Prudhoe Bay and the trans-Alaska oil pipeline system. Land uses in the Prudhoe Bay area are discussed in 2.1.1.11 for the applied-for AAGPC route.

The remainder of the route is located almost exclusively in an uninhabitated, undeveloped region of Alaska. Major portions of the area crossed by this route are de facto wilderness. Present land uses are limited by difficult access and therefore, the land is oriented to subsistence and sport use of fish and wildlife, local timber harvest, outdoor recreation, and limited mining.

Potential

The status of land use planning, described in Section 2.1.1.11 for the applied-for AAGPC route, is that there are no land use plans. It should be noted that the Fort Yukon alternative (Wind River Option) crosses the Venetie Indian Reservation which is in the process of being transferred to the private ownership of the Venetie Village Corporation under the provisions of the Alaska Native Claims Settlement Act. The Chandalar River option avoids the Venetie Reservation.

Mineral, timber, and agricultural resources described in Section 8.1.1.3 for the Interior alternative route are also involved with the Fort Yukon alternative route.

AAGPC (1974a) estimates 180 miles of commercial forests will be crossed by the Fort Yukon alternative route.

Wilderness

The Fort Yukon alternative route crosses several areas where the Secretary of the Interior has recommended special management and proposed inclusion in national conservation systems. These include for the Wind River Option: the southwestern extension of the Arctic National Wildlife Refuge, the Wind National Wild River, the Yukon Flats National Wildlife Refuge, the Porcupine National Forest, and the Yukon-Charley National Rivers.

The Chandalar River Option avoids the proposed Wind National Wild River. The Fort Yukon alternative route crosses the Porcupine River downstream from the lower boundary of the proposed Porcupine National Scenic River. These areas have also been recommended for study to determine if all or portions should be included in the National Wilderness Preservation System. None of these proposals has been considered by the Congress, which must approve them before the areas can be placed into one of the recommended conservation systems. Approximately 40 percent of the total mileage (195 of 495) crosses areas where there may be potential for inclusion in the National Wilderness System. The proposed Wind River Option would eliminate the 65-mile long segment of the Wind River from designation as a wild river and would significantly alter existing public historic and natural values in the proposed Yukon-Charley National Rivers. At least 100 miles (20 percent) of the route crosses areas identified by the Joint Federal-State Land Use Planning Commission for Alaska as having high existing public value for wilderness.

Recreation

The potential for growth of a local tourist and recreation industry is considered excellent along portions of the Fort Yukon route. The existing levels of recreational use and the number of tourists are significant, especially in the Fort Yukon, Circle, and Eagle areas.

Both Eagle and Circle are well situated for tourist access. Eagle is the terminus of the Taylor Highway, about 50 miles north of the junction of the road from Dawson, Y.T., the small BLM campground at Eagle provided 4,000 visitor days of use in 1972, a 212 percent increase over 1968. Fifty percent of recorded visitors were from outside Alaska. Circle, located on the Yukon River, has a boat launching ramp and campground and is the terminus of the Steese Highway, some 165 miles from Fairbanks.

Along the highways and at Eagle and Circle, a few commercial enterprises which are mostly family-owned and operated, cater to the tourist needs for accommodations, meals, gasoline, and automobile services. Historical interpretive services are presently provided at Eagle by the local historical society. Air charters serving the area derive some income from tourist passengers.

Land Status and Ownership

The Fort Yukon alternative route transects a multitude of withdrawal areas. Overall Federal ownership for the Wind River Option is approximately 301 miles (61 percent); Natives may own up to 160 miles (32 percent); and the remaining 34 miles (7 percent) is on State and Federal lands within State ownership. Approximately 110 miles (22 percent) is in the existing corridor occupied by the trans-Alaska oil pipeline. Of the Federal ownership almost 40 percent is located within areas proposed for addition to the national park, forest, wildlife refuge, or wild river systems.

The land ownerships associated with the Chandalar River Option is similar to that of the Wind River Option except that the percentage of State ownership is increased from approximately 7 percent to slightly less than 20 percent with a corresponding decrease in Native ownership.

Figure 8.1.1.4-22 and Table 8.1.1.4-7 display general land ownership patterns.

Pending issuance of patent or interim conveyance from the Federal Government to private Native ownership and Congressional action on the

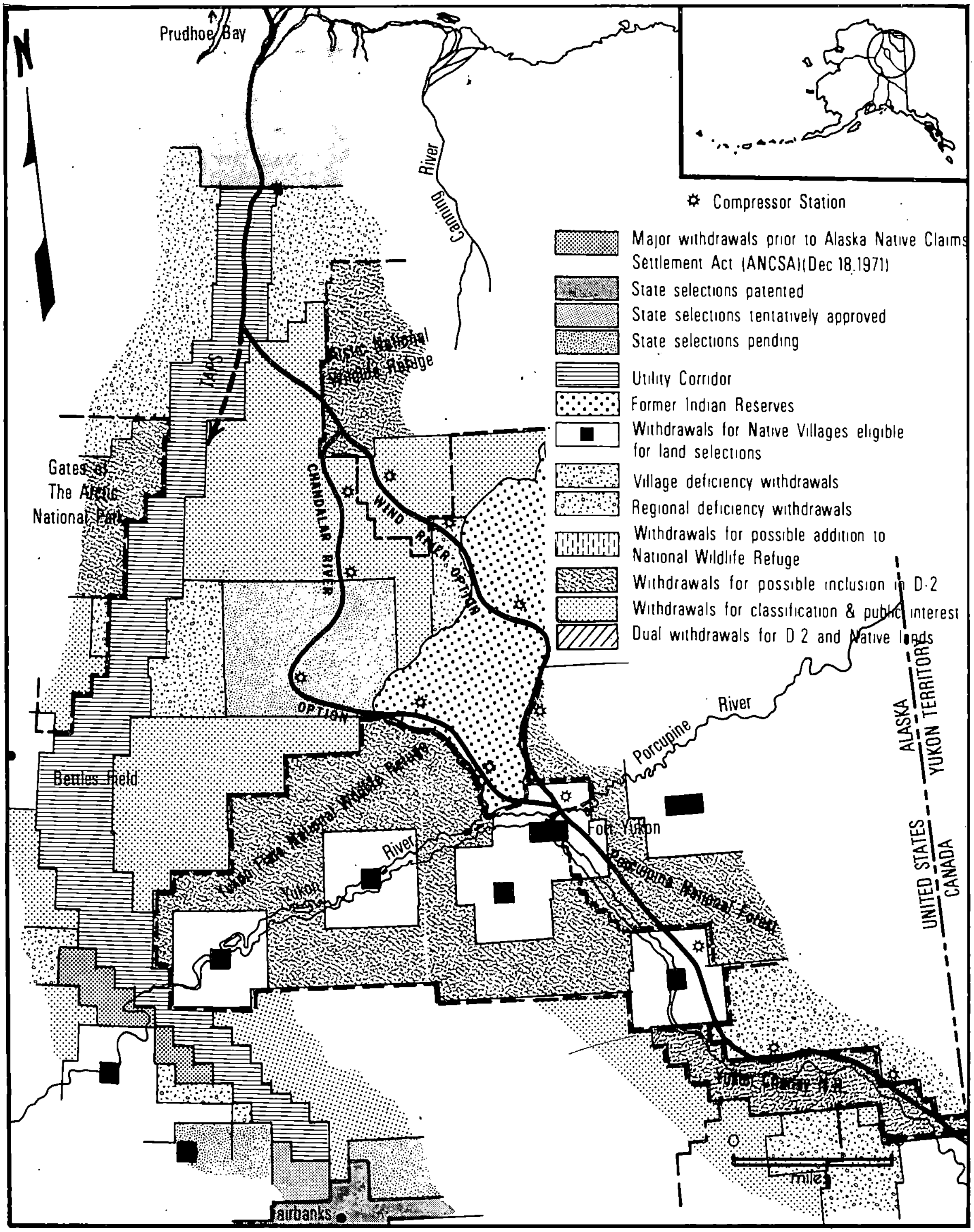


Figure 8.1.1.4-22 Land ownership and administration of the Fort Yukon alternative pipeline route

Table 8.1.1.4-7 Land status and ownership associated with the Fort Yukon alternative pipeline route

Status	Miles*
State Transportation Corridor**	34
Federal Transportation Corridor**	66
Federal National Interest (D-1)	40
Federal National Conservation Systems (D-2)	195
Arctic National Wildlife Refuge (proposed)	(45)
Yukon National Forest (proposed)	(60)
Yukon-Charley National Rivers (proposed)	(90)
Wind National Wild River	(65)***
Native (potential)	(160)
Venetie	(75)
Fort Yukon	(40)
Circle	(35)
Eagle	(10)

* All Mileage is approximate.

** Trans Alaska oil pipeline.

*** River miles within ANWR.

proposed Alaska Conservation Act of 1974 (17(d)(2)), all areas associated with the Fort Yukon Alternative, except small acreages, remain under BLM management.

Historic, Archeological and Unique Values Area

Historic Summary

The one recorded site of historic interest is Prudhoe Bay. This traditionally Eskimo coastal settlement is known to have been occupied intermittently since Sir John Franklin named that bay on August 16, 1826. Franklin's explorations of the coast and subsequent expeditions, including those to recover traces of his lost party, are discussed with other coastal history in the Offshore Route.

Two sites of historic interest are also included in this area. Fort Yukon has been the upper Yukon's center for trade and exploration since the early 19th century. The other site, Fort Yukon Roadhouse, is of 20th century importance.

The 27 sites listed by name and AHRS designation are within Eagle township. They are, therefore, not discussed individually but as a group. The few individual sites and the two complexes, Jack Wade and Chicken, are included for their contribution to the purview of the region, despite their location outside the 10-mile corridor.

The Hudson's Bay Company, a British fur-trading company, can be credited with most of the original mapping of the Fort Yukon area and the establishment of a settlement at that site.

In 1846, Robert Bell, a Hudson's Bay Company voyager and trader, was led by Indian guides to the junction of the Porcupine with the Yukon. He came by way of the Porcupine River from Fort McPherson on the Mackenzie River in Canada. The next year Alexander H. Murray, Bell's assistant, followed the same route and established the Hudson's Bay Company trading post which he named Fort Yukon, the westernmost post of the company.

Robert Campbell, another company voyager and trader, in 1848 descended the Yukon by Indian canoe to the newly established trading post, thus connecting his discoveries with those of Bell and various exploring fur-traders.

In the mid-1860's the Russians and the English did cooperate with the American Western Union Telegraph Company's exploration efforts in the area for the purpose of establishing an intercontinental telegraph line. It was to extend from the United States through Canada and what was then Russian-America to Asia and Europe. The project was abandoned in 1866 when the Atlantic cable was laid. These explorations, however, marked American exploration of the Yukon.

Robert Kennicott, in charge of the scientific part of locating the Yukon division of the overland line, spent a season in 1863 studying the ethnology of the vicinity and examining the river and surrounding country. In 1866 Kennicott died in Alaska while preparing to further explore the upper Yukon. Frank Ketchum and Mike Lebarge continued the explorations begun by Kennicott. In 1867 they explored the upper Yukon and its headwaters in Canada and the United States. William H. Dall, a Smithsonian scientist for whom Dall sheep and Dall Mountain are named, in 1867 reached Fort Yukon on the same mission. He was accompanied by Frederick Whymper, the artist and author. All four men spent a season at Fort Yukon exploring the immediate area.

Accompanying the purchase of Alaska in 1867 were explorations and surveys by the United States Army. In 1869 Captain C.W. Raymond accurately determined that Fort Yukon was west of the 141st meridian and thus in the United States. He ordered the Hudson's Bay Company to vacate the post.

Historic Evaluation

The route, as it follows the valley of the Sagavanirktok River, has not been environmentally conducive to historic Eskimo, Indian, or white settlement. Only in the coastal area and immediate inland river valley was there early motivation for exploration and settlement. Eskimo hunting and fishing sites are known to have existed at various times and locations throughout the Prudhoe Bay area from at least the early 19th century. They were noted by explorers, both Russian and British, at first in search of the Northwest Passage and later in search of furs, whales, and wealth. The seasonal Native campsites established themselves on a more permanent, year-round basis as the fur trade and whaling increased. White exploration of inland areas occurred only when an occasional trader or whaler ventured inland for game or new sources of trading goods. These ventures did not prove to be worthwhile; thus no inland trading settlements were established. Mapping of anything but the coastline was left for U.S.G.S. survey teams in the 20th century.

The corridor over the Philip Smith Mountains of the Brooks Range has been, historically, of subdued interest to white settlers and explorers. Any importance of the area in general must result from its contribution to the fur trade conducted at nearby Fort Yukon, the depository for furs collected by both Indians and white men throughout the latter half of the 19th century.

Missionaries, first of the Church of England and then succeeded by the Episcopalian Church, traveled to Native villages and camping sites throughout the area on an intermittent basis from the arrival of Rev. William Kirby in 1861 through the first quarter of this century.

Beginning in the 1860's, missionaries from Fort Yukon visited Native villages and communities along the southern portion of the route. The missionaries did not establish white settlements or church structures, preferring to travel among the tribes and villages.

At the same time, and earlier, regional Natives brought furs to white Yukon traders, first of the Russian American Company and later the Hudson Bay Company and the Alaska Commercial Company. As the fur traffic declined and followed that of prospecting, the population and traffic along the corridor also declined.

The historic character of the Fort Yukon region is the cumulative result of voyagers and fur traders of the British Hudson's Bay Company, exploratory and mapping efforts by the Western Union Telegraph Company, United States government-sponsored explorations, the Alaska Commercial Company, and the intermittent visitations and records of missionaries to the area.

Numerous sites and structures of historic interest lie along the Yukon between Eagle and Circle. One of the best of the old woodcutting camps is Miller's Camp on the north bank of the Yukon River (now privately owned). One building burned recently, another was destroyed, and a third was damaged by ice flows, but the other structures are in good condition. Also privately owned is the Adolph Biederman "estate" where there is an old fish factory with five or six cabin-size structures and numerous smaller buildings, all in an excellent state of preservation. At Slaven's Cabin, a mining camp of the period of 1890 to 1930, there are several buildings in good condition. A road runs from there to Coal Creek gold placer mines (still active). Only 2 cabins remain at Nation in addition to 13 ruins. Across the Yukon River from Nation at least four cabins are in good to excellent condition.

Archeological

The prehistory of the area north of the Brooks Range is described in 2.1.1.12 for the applied-for AAGPC route and 8.1.1.3 for the alternative route. The following description applies to the Fort Yukon route south of the Continental Divide in Brooks Range.

Paleoenvironmental Settings

From Prudhoe Bay to Oksrukuyik, the route follows the valley of the Sagavanirktok River, a major stream draining the north slope of the central portion of the Brooks Range. Approximately half of this segment corridor in the Brooks Range Paleoenvironmental Zone was affected by the Wisconsin Glaciation. However, the unglaciated portion of the corridor in the Arctic Coastal Plain Zone was at the same time contiguous with a now submerged portion of the Arctic Coastal Plain. Thus the unglaciated land area during the Wisconsin Glaciation maximum was actually a wider ice-free corridor than indicated by the modern coastline.

During the time span considered, the climate has always been arctic throughout the corridor, with short periods slightly warmer and much longer periods colder than today. Archeologically the paleoenvironments of pre- and mid-Wisconsin Glaciation for the Arctic Coastal Plain Zone are very important, as the coastal plain is one of the theoretical migration routes for the Paleoindian and the early Eskimo. Although theoretically possible for earlier periods (pre-Wisconsin), all known archeological sites in the corridor date from the recession of the most recent glaciation, a period of warming climate.

About 45 percent of the Wind River Option is in the Brooks Range Paleoenvironmental Zone and 55 percent in the Intermontane Zone. High passes of the Philip Smith Mountains of the Brooks Range contain remnants of Wisconsin glaciers on both sides of the Continental Divide. Except for the time span since recession of glaciers, paleoenvironmental settings indicate low probability of archeological sites but high probability for sites since the contact period occurring in the northern portion of the corridor where considerable archeological surveys have been conducted for Alyeska.

The unglaciated, or only partially glaciated, portion of the corridor has had arctic, subarctic and continental climates that were also, at times, wetter and drier than at present. Most significant in this unglaciated portion has been the cyclical advance and retreat of the boreal forest that, during the height of the Wisconsin Glaciation, retreated to a small area along the Yukon and Porcupine Rivers. During the glacial maximum the periglacial area likely had a dry, cold steppe ecosystem with vegetation more sparse than modern tundra.

The Chandalar Option in the Brooks Range mountains and foothills is in the southern half of the Brooks Range Paleoenvironmental Zone, where past climates have ranged from arctic to subarctic and continental. In this corridor ecosystem changes were marked during Pleistocene and recent epochs by retreats and advances of the Central Alaska boreal forest. The present partially forested condition represents the most recent re-advance of forests from a residual area that survived the Wisconsin Glaciation maximum in the lowlands along the Yukon River to the south.

Archeological sites of pre-Wisconsin Glaciation are possible, but their evidence is likely to have been obliterated by glacial action. Thus archeological sites not more than 10,000 years old and representing interior hunting and fishing cultures are those most likely to be found in this corridor.

From the southern boundary of the Brooks Range Paleoenvironmental Zone, the route crosses approximately the northern third of the Intermontane Zone. Except for isolated patches on higher elevations, this corridor was not glaciated by the Illinoian or Wisconsin Glaciation. At the height of the Wisconsin Glaciation the northern portion of the corridor would have had an arctic climate and a tundra or dry steppe ecosystem similar to modern tundra but generally drier.

There is paleobotanical evidence of the Wisconsin age of a residual area of forest along the Yukon River and approximately the southeast one-third of this segment corridor.

This residual forest, though slightly more sparse than the present forest around Fort Yukon, spread northward and southward during the last 10,000 years to again occupy the former tundra on portions of the south slopes of the Brooks Range, which had been covered with glacier ice.

On a paleoenvironmental basis, archeological sites dating from the first arrival of early man in Interior Alaska could occur in this corridor.

A short segment crosses the modern Yukon Flats and the Porcupine River a few miles upstream from Fort Yukon. This area in the Intermontane Paleoenvironmental Zone has remained unglaciated at least since before the Illinoian Glaciation more than 100,000 years ago, although much of the recent alluvial deposits now occupying the area consist of materials originally produced by glacial action, some at great distances from the area.

Paleobotanical records show that the boreal forest, which had during the Sangamon Interglacial interval occupied larger areas of interior and northern Alaska, retreated to a refugium in this locality at the height of the Wisconsin Glaciation about 20,000 years ago. This area, therefore, has remained forested for all of the 40,000 year period considered, even though the regional climate has varied from slightly warmer to colder than at present. There is considerable contact period and Early Man potential here.

The remainder of this route closely parallels the right bank of the present Yukon River. This segment in the Intermontane Paleoenvironmental Zone has been glaciated on isolated higher elevations and during the Wisconsin Glaciation would have been more than 100 miles from the edges of major ice covered areas to the north, east, and south.

At the height of the Wisconsin Glaciation the climate here was likely drier and colder than at present, as the major areas of heavy precipitation would then, as now, have been in the Alaska Range and coast mountains. The geographical distribution of vegetative ecosystems at the height of the Wisconsin Glaciation indicates a refugium of sparse forest along the Yukon River throughout the length of this segment corridor. This area has been forested for the last 40,000 years but at times has been near areas of tundra and dry, cold steppe.

Archeological sites in this corridor could date from the first arrival of Early Man in interior Alaska, although earlier sites near the Yukon have a high probability of having been obliterated by recent and extensive alluvial sediment.

Archeological Summary

Although caribou hunting stations and habitation sites by pre- and post-contact Eskimo use appear to reveal little new data for compartive analysis of hunting practices, SAG R-5 on a naturally protected knoll at Franklin Bluffs has yielded a large collection of specimens that appear to be of Eskimo workmanship, as well as microtools suggestive of Arctic small tool technologies.

Chert flakes, large notched points and biface fragments of Tuktu-Palisades II type recovered from four localities near the confluence of the Sagavanirktok and Ribdon Rivers (PSM 060) provide the only evidence at present for prehistoric occupation of this region. Radio carbon analysis has placed the age of similar specimens from the Tuktu complex of Anaktuvuk Pass at about 6,000 B.P. (Campbell, 1962). A number of localities containing tent rings and caribou fences of the type utilized prior to the introduction of rifles appears to pertain to early historic and recent periods.

Four Eskimo summer camps in the Sagavanirktok River and Galbraith Lake regions are seasonal stations for exploiting riverine faunal resources. PSM 004 and PSM 009 are of recent origin; PSM 068 and PSM 003 are approximately 200 years old. Two additional sites are nondiagnostic.

Two sites lie in the vicinity of Big Lake. One site, at the east end of Big Lake, has been tested. It appears that the cultural material may be stratified. A second site near Linda Creek contained nondiagnostic chert flakes.

Archeological Evaluation

The proximity of this route to Fort Yukon increases its potential for recovery of new archeological data that may contribute to our understanding of the kinds of influences which have shaped the Athapascan ways of life. Discovery of sites of prehistoric age could provide essential time depth for ethnoarcheological research incorporating both early historic and recent studies of Alaskan Indian culture. In this regard, the enthographic reports of Robert Kennicott and other explorers from the mid-19th century (discussed in Historic Evaluation) affect the essential historical perspective of the immediate contact period on which comparative analysis depends.

On the basis of recorded data, this corridor is one of the most critical for retrieval of potentially valuable information regarding Paleoindian manifestations and changing adaptive patterns from the earliest interior Eskimo peoples to the present. It is assumed, however, that current investigations in some areas are complete depending on the proximity of the gas route to the crude oil route. Areas of greatest concentration of known sites lie in the Atigun River and Galbraith Lake regions and the bluffs and terraces of the Sagavanirktok River about 10 kilometers southwest of Oksrukuyu.

The presence of specimens relating to the Notched Point Tradition provides significant time depth in this virtually unknown archeological zone. Additional sites reflecting temporal sequencia would be invaluable for clarification of the origin and distribution of this early Arctic hunting tradition and could yield information regarding subsequent development of Athapascan cultural patterns.

It is quite possible that discovery of additional sites of pre- and post-contact Eskimo use could reveal important information on North Alaskan Eskimo origins. The presence of microlithic tools in the Franklin Bluffs area suggests that survey should be carefully conducted for further evidence of early occupation.

Unique Areas

There are no areas nominated for special management as Science Research and Natural areas along the Fort Yukon alternative route south of the Brooks Range. The Prudhoe Bay and Sagavanirktok River areas are discussed in 2.1.1.12 for the applied-for AAGPC route.

There are, however, three distinctive areas associated with the Fort Yukon alternative between Circle and Eagle: peregrine falcon traditional nesting sites, geological exposures, and the Greenstone plant association.

The bluffs overlooking the Yukon River in this area are traditional nesting sites for the peregrine falcon, a threatened bird species. In 1970, 12 pairs were known to nest in this area. The Fort Yukon alternative route passes directly beneath a large proportion of this traditional nesting habitat.

The Yukon River has downcut through a series of sedimentary, often colorful, rocks. The deposits vary in age from Upper Precambrian to Upper Tertiary (APG, 1974a). The oldest of this series, the Tinder Group, is found along the lower Tatonduk and National Rivers, and provides an unusually complete and intact record of geologic events during a 600-million-year span at the close of the Precambrian era. The oldest brown microfossils from northwestern North America recently were discovered at the mouth of the Nation River in the vicinity of the Fort Yukon alternative route. It is very possible that traces of more complex life forms will be found.

No apparent interruption is evident in the sequence of sedimentary rocks of the Tinder Group and younger deposits. The Upper Yukon River area is, therefore, one of only four areas in North America where it is possible to investigate the complete transitional sequences between Precambrian and Paleozoic eras (Cloud, 1972).

The sequence of sedimentary rocks continues through young rocks with only minor interruption along the bluffs of the Yukon River downstream from Nation River. These younger exposures contain numerous fossil-rich strata having an outstanding record of marine faunal evolution through a span of approximately 300 million years (Cambrian through Mississipian).

As indicated in the discussion of vegetation (8.1.1.4), the Fort Yukon alternative route traverses an area which has not been glaciated. At Eagle (on the south bank of the Yukon River across from the Fort Yukon route) studies by Shacklette (1966) disclosed an endemic "Greenstone" plant community. It is possible and highly probable that similar endemic plant communities are associated directly with the Fort Yukon alternative since it involves an unglaciated area. It should also be noted that geologic conditions on the north bank of the Yukon sometimes have marked differences because of the Tintina fault.

Air Quality

There are few recorded data on air quality along the Fort Yukon alternative route. Except where altered by man's influence around villages, air quality can be assumed to be high.

In years of high wildfire occurrence, temporary smoke curtains prevail throughout large portions of interior Alaska. Distribution of smoke is a function of wind and there is no record of summer wind direction norms.

Environmental Noise

The Fort Yukon alternative route traverses an uninhabited, undeveloped area of Alaska for most of its length. Therefore, noise is associated only with natural events such as wind or rapids or with occasional airplanes or motorboats.

Environmental Impacts Caused by the Fort Yukon Alternative Pipeline System

Major engineering, location, and construction uncertainties are associated with the Fort Yukon alternative route in Alaska. The following analysis of anticipated environmental impacts reflects these uncertainties. Experience in arctic construction is adequate to predict the probable degree of expected change to the existing environment; and where available data are not adequate, the impact analysis so indicates.

The Fort Yukon Alternative gas pipeline route would create impacts in Alaska similar tc those discussed for the applied-for AAGPC route in the Prudhoe Bay area and the Interior Alternative through the Brooks Range (Sections 3.1.1.1 through 16 and 8.1.1.3, respectively). There are, however, significant differences in matters of intensity, duration, or location of a particular effect as well as impacts specific to the Fort Yukon Alternative.

Major impacts expected if the Fort Yukon alternative route is selected for construction of a gas transmission system are summarized below.

Permafrost--Impacts are similar to those discussed for the applied-for route except that more than 200 miles of the Fort Yukon alternative cross discontinuous permafrost. Frost heave forces associated with frost bulb formation around the pipe in such regions are increased over those expected in regions of continuous permafrost and the proposed mitigating measure (surcharge) has yet to be demonstrated. Unchecked frost heave forces increase the possibility of differential pipe loading and threaten pipeline integrity.

Duration of Impacts--Construction activities will span 2 years, including both summer and winter. The possibility of berm erosion is increased, which can compromise the effectiveness of surcharge as a mitigating measure for frost heave and buoyant forces which in turn threaten pipeline integrity. The impacts described for the applied-for route will be similar but last longer.

Fire--About 85 percent of the Fort Yukon alternative passes through fire-susceptible area. Because no roads exist or are planned there, fire control will be difficult and large forest areas could be lost.

Wildlife--The route passes close to peregrine falcon nesting areas for about 70 miles. Under worst case conditions, up to 75 percent of the traditional nesting sites of the endangered peregrine falcon in the Upper Yukon could be lost due to human and industrial type disturbances. Approximately 85 miles of this route intersects areas identified as having high-value, critical waterfowl habitats in the Yukon Flats. Impacts resulting from disturbances, habitat loss, pollution, and direct mortality would cause waterfowl population losses of an unknown amount. Loss of limited winter habitat in the Brooks Range will create severe impacts on moose.

Subsistence--Wildlife for harvest will be less available to area residents if the Fort Yukon alternative is selected because of heavier competition made possible by increased access.

Historic Values--Both Circle and Eagle played roles in gold rush history. As more people move into the communities because of pipeline activities and easier access, historic values may be lost.

Many of these impacts can be fully or partially mitigated. Refer to 4.1.1.1 for a discussion regarding mitigation which applies to some of these impacts.

Impact of the Fort Yukon Alternative Route on Climate

Impacts on climate caused by the Fort Yukon Alternative gas pipeline are similar to those discussed for the applied-for AAGPC route and the Interior Alternative (3.1.1.1 and 8.1.1.3, respectively).

Impact of Climate on the Fort Yukon Alternative Route

Adverse winter conditions will restrict construction, operation, and repair conditions in a manner similar to those described for the applied-for AAGPC route (3.1.1.1) and the Interior Alternative (8.1.1.3).

Impacts of the Fort Yukon Alternative Route on Topography/Landscape

Facilities constructed north of the Brooks Range will have impacts similar to those described in the applied-for AAGPC route (3.1.1.2) in that manmade structures will create topographic relief in an area where nature provides a flat to moderately rolling terrain. Since the area north of the Brooks Range is either within the rapidly developing Prudhoe Bay oil and gas field or the corridor traversed by a new two-lane gravel road and the soon-to-be-completed oil pipeline between Valdez and Prudhoe, additional topographic/landscape modifications for this section are considered of no major consequence.

Facilities constructed within the Brooks Range as part of either the Chandalar or Wind River Option will have varying impacts depending upon the specific location. For example, the portions of the system constructed in the undeveloped Ribdon River valley will be similar to those described for the Interior alternative up the Canning River, e.g., there is no way to build a pipeline system through alpine tundra without leaving scars on the landscape or without facilities such as compressor stations and their attendant exhaust plumes and physical size offsetting the natural scene.

Through the lower Wind and Chandalar River Valleys and the Porcupine Plateau and the Yukon Flats the Provinces (Figure 8.1.1.4-23) the forest cover will screen both compressor stations and the pipeline from observation at ground level. From the air, facilities and the pipeline alignment will be very pronounced and have an adverse effect on the visual landscape.

Where the Fort Yukon alternative route enters the Eagle Trough, substantial impacts on topography and landscape are expected. In this portion of the alternative route (especially from the Kandik River to the United States-Canada border) the route will follow the north bank of the Yukon River. To reach a throughput of 4.5 bcf/d, two compressor stations will be required in this segment (Mount Kathul and Calico Bluff). It is probable that gravel needed to construct the pipeline system will be taken from terraces well above the present river level. Construction of the pipeline and its related facilities also may create impacts on the natural landscape by scarring the bases of bluffs and from removal of timber and borrow materials.

Impact of the Fort Yukon Alternative Route on Geology

Mineral Resources

According to the Bureau of Mines (1975), the construction and operation of a gas pipeline will have little impact on the development of hard rock minerals and energy producing minerals except for oil, gas, sand, and gravel. It is conceivable that mining in the Chandalar District will be stimulated with the Chandalar River Option if access is improved and available for public mining uses. Only when a permanent access road connects this segment to the present road system will the pipeline have a real impact on other mineral and energy producing resources. If gas were discovered along the route (e.g., Yukon-Kandik Oil and Gas Provinces), it might be transported through this Fort Yukon Alternative gas pipeline.

The highways and oil pipeline have put heavy demands on gravel. The gas pipeline would require approximately 14.4 million cubic yards of backfill gravel. In many areas old and new riverbeds are the only gravel sources. Consequently, as gravel extraction increases within the corridor, secondary impacts will be made on stream hydrology and water quality.

Permafrost

One of the most critical factors to be considered is the thawing of perennially frozen ground. Thawing the permafrost and a variety of related effects, such as the behavior of frozen soil when thawed, are highly relevant to the selection of a gas pipeline within Alaska. Some 295 miles of the Fort Yukon alternate route are located within zones of continuous permafrost. The remaining 200 miles cross the zone of discontinuous permafrost.

Permafrost with little or no ice generally does not cause serious engineering or environmental problems, but permafrost that is ice-rich can cause extremely serious engineering and environmental problems if allowed to thaw. Ice-rich, fine-grained permafrost soils, when thawed, undergo a change in volume and a loss of strength. In order to preserve the permafrost and obviate these problems, the Applicant has proposed burying the pipeline and refrigerating the gas in Alaska to a temperature below 32° F.

In addition to the difficulties that normally confront major construction projects in permafrost areas, a buried chilled pipeline would pose special problems; for example, heaving caused by the freezing of unfrozen water commonly present in fine-grained permafrost soils. Even though the ground temperature is below freezing, significant quantities of unfrozen water can be present in fine-grained soils. If the ground temperature were lowered by the chilled gas, part of this water would freeze and expand, causing the ground to heave.

Overall problems caused by continuous permafrost are similar to those discussed for the applied-for AAGPC route (Section 3.1.1.3). There are significant differences, however, in the effects of permafrost in the transition areas between the continuous and the discontinuous zones crossed by the Fort Yukon alternative route (Figure 8.1.1.4-16). As with other elements of the Fort Yukon route, the problems of discontinuous permafrost are not new to the total pipeline system from Prudhoe Bay to the lower 48 states but represent a transfer of a project-related aspect from Canada to Alaska. Impacts described for the discontinuous permafrost zone in Canada (Part III, Canada, Permafrost) are similar to those expected along the lower 200 miles (40 percent) of the Fort Yukon route within Alaska.

Ice-rich, fine-grained soils may prove to be widespread in the lower 45 miles of the Wind River Valley and on down the East Fork of the Chandalar River. Excavation for a pipeline or construction of inadequately designed access roads and foundation pads might lead to thermokarst subsidence and liquefaction of fine-grained soils in this part of the route. Inadvertent disruption of the permafrost regime here could lead to the development of large, new thermokarst lakes. Construction on slopes or summits would be likely to have little impact on the permafrost regime.

Fine-grained peat, silt, and sandy silt lie at the surface over pemafrost along much of the Yukon Flats Province crossed by the Fort Yukon route. Ice-rich soil may also be present beneath the dunes in the portion of the route extending southeastward from Fort Yukon. Construction in these areas might lead to thermokarst subsidence and liquefaction of the soil.

That portion of the route passing through the southeastern segment of the Porcupine Plateau is probably the most fragile and difficult stretch within the Alaskan part of the Fort Yukon alternative route. Ice-rich, perennially frozen silt and peat, tens of feet thick and only a few degrees below freezing, appear to mantle the landscape throughout nearly all of this stretch of the route. Trenching in this area would result in considerable quantities of excess spoil consisting of black peat and peaty silt; this material would have to be disposed of with great care lest its lower albedo result in accelerated thawing and subsidence of the substrata. Coarse-grained materials would be needed in quantity for backfill, airstrips, and compressor pads, but borrow material is extremely scarce and possibly unavailable. The inevitable disturbance of the surface due to trenching and movement of heavy equipment would be likely to result in extensive, irreversible, and long-term persistent thermokarst subsidence and drainage modification.

Permafrost problems are minimal in the Ogilvie Mountains. Much of the route is underlain by bedrock and colluvial mantle with only a low ice content where frozen. Small areas of ice-rich peat, silt, and muck might be encountered in the bottoms of the minor valleys.

As indicated, there are areas of discontinuous permafrost. Areas without permafrost and areas where it has been deeply thawed may be found, particularly under or near bodies of water. Therefore, because of changing conditions the Fort Yukon alternative route will cross from solid zones of permafrost-free areas innumerable times. (See permafrost Figure 8.1.1.4-16.)

Even in the coldest part of Alaska, a thin layer of ground, the "active layer" thaws every summer, and separates the permafrost from the ground surface. The thickness of this layer varies and can change dramatically when the surface is disturbed. (See section 3.1.1.3 for a detailed discussion of impact on permafrost.)

All disturbances in permafrost areas will have long-term effects on the permafrost regime. Short-term effects result when ice-rich soils become exposed to direct radiation of the sun and/or new sources of water. Modification of the heat balance will cause degradation of the permafrost layer. If a high-ice content area is involved, subsidence, slumping, gullying, and establishment of new drainage patterns may occur. Once initiated, permafrost degradation is difficult to arrest until a new heat balance is achieved. Disturbance, mixing of soil etc., will slow revegetation. Continuing erosion also adversely affects natural revegetation. These conditions are concentrated in the first 200 miles of the Fort Yukon Alternative but will occur throughout the route.

Frost Heave

Potential for frost heaving appears most likely at or near streams, thaw lakes, beaded drainages, and wherever unfrozen soil is encountered. Frost heaving will cause the pipeline to be displaced upward thereby greatly increasing stresses on the pipeline system with increased risk to pipeline safety in the proposed high-pressure system. This becomes a serious engineering problem in the 200 miles of the Fort Yukon alternative route crossing the discontinuous permafrost zone (see Canada, Permafrost, for a detailed discussion of impacts which are similar to those expected to occur in the Alaskan discontinuous permafrost zone).

Slope Stability

The Fort Yukon alternative route crosses the Brooks Range through an area where side and valley slopes are very steep. Thus, construction of a pipeline might lead to oversteepening of valley slopes that presently lie at the angle of repose and close to avalanches and rock falls. Vibrations due to winter construction, especially blasting, could result in devastating and dangerous snow avalanches.

Slopes decrease in the southern foothills of the Brooks Range and are generally stable on the Porcupine Plateau. Construction of a pipeline would not likely reduce slope stability to a significant extent.

Slopes are low and consequently, mass wasting processes are insignificant in the Yukon Flats and that portion between Prudhoe Bay and the foothills of the Brooks Range. Gullying might be a problem along the route where it crosses the bluff separating the Christian River flood plain from the high terrace to the northwest. Exposure of the windblown sand by trenching for a pipeline or vegetative disturbance might result in renewal of wind erosion and re-activation of the dunes in the sections of the route extending southeastward from Fort Yukon.

Mass movement of soils on slopes is considered minimal for the southeastern segment of the Porcupine Plateau and would not likely be affected by pipeline construction. Accelerated erosion could develop in the fine-grained soils, however, if they were allowed to thaw.

The Ogilvie Mountain segment crosses rugged terrain. This and the Yukon River segment have steep slopes. Landslide-prone areas would probably be aggravated by construction activities and could threaten the integrity of a pipeline. Kathul Mountain, Montauk Bluff, and a steep bluff west of the mouth of the Nation River appear to be particularly hazardous areas.

The impact of this alternative pipeline route on slope stability would be similar to those described on the applied-for AAGPC route (3.1.1.3) and Interior Alternative (8.1.1.3). Although impacts would be local, their proximity to water courses (where the terrain is steepest) can cause major secondary impacts on water quality through increased siltation. A tertiary effect resulting from slope instability would be to upset the heat balance controlling the underlying permafrost. (See discussions under Permafrost and Drainage.)

Earthquakes

It is concluded that the alternative Fort Yukon pipeline system will traverse areas of seismic activity similar to those encountered by the northern half of the trans-Alaska oil pipeline. No active faults are noted. However, earthquakes in excess of 5.5 (Richter scale) have been recorded to the south of the route in the vicinity of Fairbanks. Based upon decisions and general engineering criteria established for the oil pipeline in similar conditions, it is believed that earthquakes pose no special threat to the Fort Yukon alternative route in Alaska.

Impact of the Fort Yukon Alternative Route on Soils

Indications are that as much as 14.1 million yards of borrow material will be used for construction. Some would be used for gravel pads, some to replace ice-rich soils that cannot be returned to the ditch, and some used for pipe bedding. Commitment of a nonrenewable resource (gravel) is considered significant when the total available resource quantities have not been inventoried and are unknown.

Tentative plans are to dispose of excess spoil in the borrow sites from which new backfill material was removed. Transporting ice-rich soil materials to new locations could have major local impacts if these ice-rich materials thawed and reached rivers, streams, or lakes as mud or provided a source of dust.

Overall impacts on soils resulting from the construction, operation, and repair of a gas pipeline along the Fort Yukon Alternative are expected to be similar to those discussed on the applied-for AAGPC route (3.1.1.4) and the Interior Alternative (8.1.1.3).

The Fort Yukon alternative route passes through a region (near Fort Yukon) where soils and climatic conditions are considered favorable for agricultural uses (Figure 8.1.1.4-23). Because of the linear nature of the

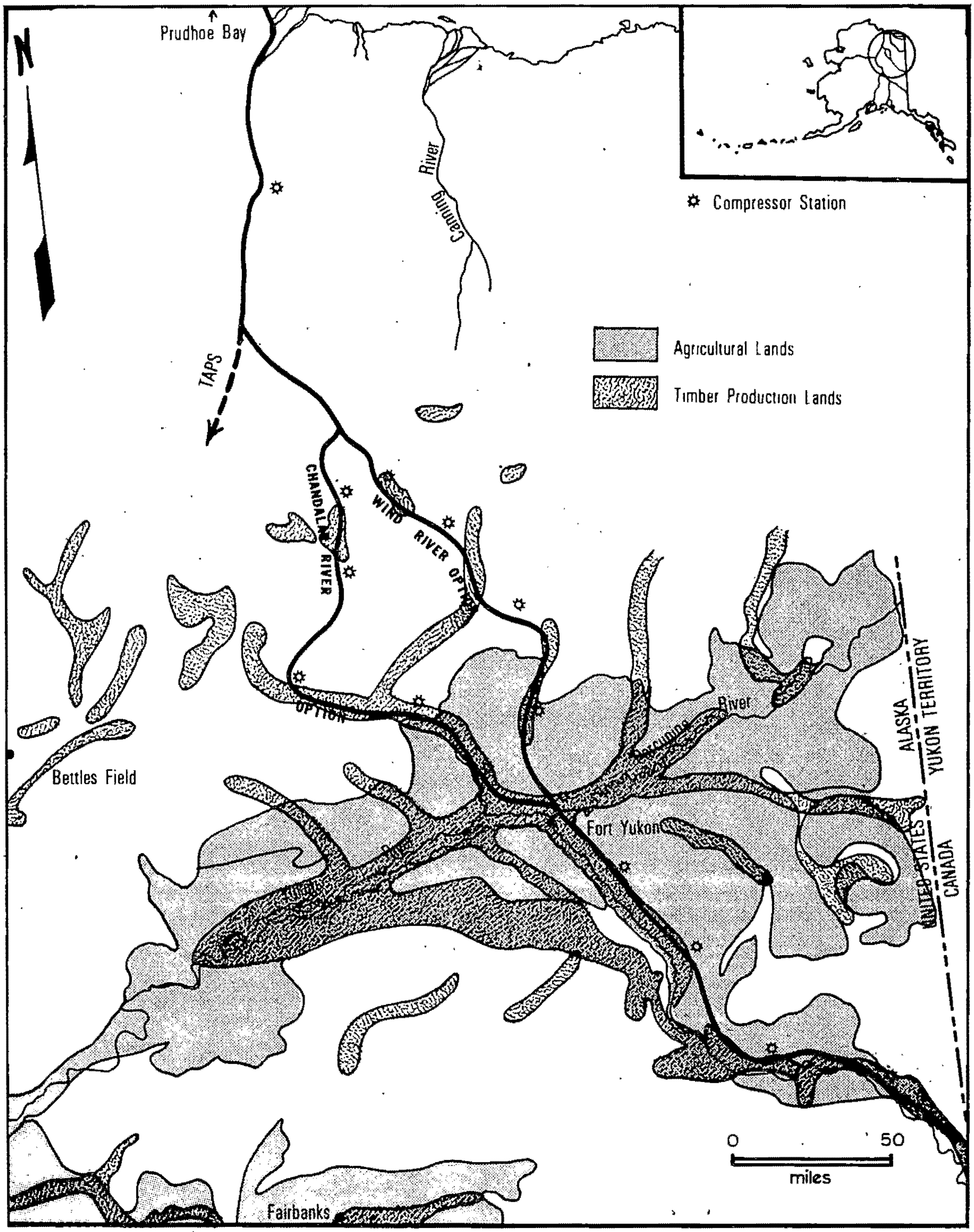


Figure 8.1.1.4-23 Agriculture and timber lands of the Fort Yukon alternative pipeline route

pipeline system, and the present undeveloped character of these agricultural lands, soil mixing or creation of a frost bulb around the buried, chilled pipeline are not expected to have a substantial impact on agricultural soils.

Impact of the Fort Yukon Alternative Route on Water Resources

Surface Water

Construction of the pipeline along the Fort Yukon route will result in substantial site specific surface alteration for the entire 495 miles in Alaska.

Within the 120-foot (36.6 m) right-of-way width, a ditch will be excavated, spoil stored, and a snow/ice working pad and road constructed. Each action has significant potential to expose soil to erosion by water which in turn can result in a lowering of water quality by addition of silt. This will be minimized by use of mechanical erosion control measures until the revegetation program is successful, permafrost stabilizes, and the frost bulb stabilizes so that long-term surface and subsurface drainage patterns and slope stability can become re-established. Accordingly, the construction of the pipeline will produce significant impact on water quality through increased siltation. Increased siltation could pose serious secondary impacts on aquatic life through smothering or destruction of habitat.

Accidental spills of fuel, hydraulic fluid, and lubricant will take place along the entire pipeline route. Most spills would be small and minor, associated with routine fueling and maintenance of construction equipment. Major spills might originate from storage areas for fuels, lubricants, methanol, and other toxic fluids would be necessary.

Ground Water

Ground-water conditions along this route are highly variable and depend largely on localized permafrost conditions.

Ground-water movement in continuous permafrost is limited except for possibly very deep movement beneath the permafrost or adjacent to the larger streams. In discontinuous permafrost, ground-water movements are similar to those in temperate climates.

Ground-water quality is generally good except in water trapped beneath permafrost, where it usually tends to have a high mineral content.

In summary, the impacts described in section 3.1.1.5 that are caused by heavy equipment, operation of a chilled, buried pipeline which will create a frost bulb, and maintenance repair activities are concluded to be significant on ground water, particularly in the discontinuous areas.

River and Stream Hydrology

The Fort Yukon alternative route crosses 13 rivers and streams wider than 100 feet and 128 rivers and streams less than 100 feet in width. In addition to river and stream crossings, the Fort Yukon route parallels closely 110 miles of the Sagavanirktok, about 65 miles of the Wind River, and 70 miles of the Yukon River in Alaska. A major crossing of the

Porcupine River approximately 10 miles above its confluence with the Yukon River would be required.

In general, the stream crossings are assumed to be made at a depth which would avoid bottom scour. The crossing of the Porcupine River involves a 10-mile wide area of braided, interlaced river channels and oxbow lakes which are annually resculptured by ice-charged spring runoff. This crossing will pose special engineering problems to assure the gas pipeline is not damaged.

Detailed engineering data such as depth of scour will not be available unless the Fort Yukon alternative is selected for the gas pipeline.

There is a prospective need for 14.1 million cubic yards of borrow materials to construct future compressor stations pads, airfields, and related ancillary facilities for the alternative pipeline system and for selective backfill of the pipeline ditch where ice-rich materials are excavated. Borrow areas will be from active and fossil flood plains, sidehills, on level areas, and from exposed bedrock quarries.

The impact of excavation of gravel on stream and river hydrology will be locally significant. These impacts are similar to those discussed for the applied-for AAGPC route (3.1.1.5) and the Interior Alternative (8.1.1.3).

The impact of the chilled gas pipeline buried in river and streambeds could have significant adverse impacts on water distribution and erosion of the streambeds and banks. Excavation of borrow will cause local environmental impacts on stream and river hydrology and could threaten pipeline integrity.

Surface Drainage Other Than Rivers and Streams

Construction and operation of the Fort Yukon alternative pipeline system will provide countless opportunities for cross drainages to be diverted parallel to the pipeline. Principal project features affecting surface drainage patterns include the pipeline ditch, ditch mound, frost bulb around the chilled pipeline, and snow/ice roads.

The pipeline ditch, ditch mound, frost bulb, ice roads, and spoil piles will affect surface drainage patterns. Impacts associated with the pipeline ditch, frost bulb, and ditch mound will be long term and will result in wet conditions on upslope sites and dry conditions on downslope sides. Impacts from ice roads will be temporary but can pose serious threats to pipeline safety whenever surface drainage is concentrated at the newly excavated ditch. Airfields, future compressor stations, ports, and repeater communications are thought to have no significant impact on surface drainage patterns.

Impact of the Fort Yukon Alternative Route on Vegetation

Vegetation type and plant community studies are few and rather generalized. Some small areas have received detailed study.

Approximately 9,700 acres of existing tundra brush and forest will be destroyed by the construction of permanent spur roads, airfields, compressor stations, communication towers, borrow pits, and other structures. Additional but unknown acreage will be disturbed during construction by the use of temporary work pad, snow and ice roads, and temporary winter trails. Approximately 180 miles of the route involve trees considered to have potential for commercial development.

Secondary impacts resulting from construction and operation of the proposed pipeline will affect an additional, but undetermined, area through changes in various physical conditions of the plants' environment. These secondary impacts which modify habitats will result in greater long-term changes in plant communities and the functioning of the various ecosystems, than the seemingly severer short-term construction impacts.

A closed forest canopy does not exist and timber stands of merchantable quality and quantity are widely scattered. The amount of timber to be removed within the immediate impact zone would be insignificant. This timber, although economically marginal, should be salvaged where possible. Since only a small timber area would be affected and possibly salvaged, the impact on commercial forest is considered insignificant.

The clearing of the right-of-way will leave a rather straight line clearing across the landscape. (See Esthetics for this impact evaluation.)

Major secondary impact on the forest production could come as a result of insect epidemics which could be associated with slash piles and scattered piles of logs. Dendroctonus, the white spruce bark beetle endemic to the area, could threaten forests if vegetative materials are not disposed of properly.

If disposal were not accomplished and bark beetles did become established, all of the white spruce along the gas pipeline route could be threatened. An example of this in Alaska exists on the west side of Cook Inlet near Tyonek. Because of seismic trail clearing, trees were pushed down and slash left. A whole forest was destroyed as a result of insect infestation.

The pipeline right-of-way would be revegetated with a mixture of exotic grasses the first spring after construction. Seeding and growing of grasses on disturbed sites, particularly in the Arctic, are now in an experimental stage, and little experience is available from which to predict proper methods or their likelihood of success.

The evidence to date indicates that certain exotic varieties of agronomic grasses can be expected to germinate and grow more successfully than the native grasses tested, at least during the first few years. The native grasses will gradually dominate the site as the percentage of plant cover increases, but plant succession proceeds very slowly and it may be 30 to 50 years before the vegetation on the pipeline mound resembles that in the adjacent undisturbed communities. Therefore, the pipeline will be a discordant element in the vegetation for many years and will show up as a long, straight line with a color and texture different from the surrounding landscape (see Esthetics). Trees would not be allowed to reestablish over the pipeline.

Applications of grass seed and fertilizer at various places along the pipeline probably will be necessary each year until the backfilled ditch slumps, settles, consolidates, erodes, and eventually stabilizes.

Wetland plant communities downslope from the line which are deprived of their normal water supply will gradually be replaced, as plant species better adapted to drier sites become established. The downslope changes may be slower than the upslope changes, but the ultimate results will be the same, i.e., replacement of the present natural vegetation by a new mosaic of communities.

Lower soil moisture in the pipeline berm, reduced soil temperatures over the chilled pipe, and increased micro-relief will create another set of conditions alien to the present plant communities and will probably result in at least two new sets of communities growing along the crest and side slope of the pipeline mound. These changes in plant species occurrence and communities will radically modify the landscape through which the pipe passes and make its location easily visible to the knowledgeable observer.

There may be some potential impacts from accidental spills of petroleum products and other chemicals during construction and operation of the pipeline, but their effects should be local and insignificant with respect to both terrestrial and aquatic vegetation. Fertilizers applied as aids in revegetating disturbed terrestrial areas, however, may become pollutants if introduced in sufficient quantities into watercourses.

Although all vegetation zones crossed by the proposed pipeline route are subject to fire, they differ in their ability to carry a fire, once it has begun. (See Vegetation Figure 8.1.1.4-19.) Table 8.1.1.4-8 summarizes the amounts of vegetation types encountered along the Fort Yukon alternative route and their fire characteristics.

Wildfire

With the introduction of additional ignition sources along the alternative route, the number of fires will increase as well as acreage burned. It is important to note that 58 percent of the total route in Alaska (285 miles) is through vegetation having medium to high rates of fire spread and predominately high incidence to control.

In Alaska, eight "bad" fire years--when more than 1,400,000 acres burned-- occurred from 1940 to 1973. On the basis of these data, conditions for extensive fires could be expected in about 1 in 5 years.

Impact of the Fort Yukon Alternative Route on Wildlife

The construction, operation, and maintenance of Fort Yukon alternative pipeline system would reduce wildlife populations of local and regional significance by directly or indirectly destroying their habitats. See sensitive wildlife habitat Figure 8.1.1.4-16.

The reduction may be caused by direct and indirect harassment from project-caused disturbance during critical periods of an animals' life cycles. Reduction also will result from increased harassment, and/or destruction of wildlife because of better access to the area, the introduction of pollutants to the ecosystem, and the inability of certain species of wildlife to adapt to human presence.

All the larger mammals react in various ways to aircraft, which will be present during construction and operation phases of the alternative route.

The impact of physiological stress on animals such as caribou and sheep running from helicopters or other aircraft has been calculated (Geist 1971). In the warm summer months, moose and bear being hazed by aircraft, whether intentional or not, could easily run until exhausted, making them susceptible to accidents and predation.

Table 8.1.1.4-8 Vegetation associated with the Fort Yukon alternative route and the relationship to wildfire

Vegetation Type	Percent by Type	Rate of Spread	Resistance to Control
Upland Spruce & Hardwood	29	High	Medium
Lowland Spruce & Hardwood	13	High	High
High Brush	19	Low	High
Low Brush & Muskeg-Bog	4	Medium	High
Bottomland Spruce & Poplar	12	Medium	High
Wet Tundra	3	Low	Low
Moist Tundra	11	Medium	Medium
Alpine Tundra	9	High	Low

Disturbance during and immediately following birth can result in substantial decrease in survival of the newborn young in moose (LeResche 1966) and mountain sheep (Pitzman, 1970).

Long-term pollution from accidental spills of oil and other lubricants, methanol, and other lethal substances used during the operation and maintenance of the proposed project can adversely affect areas of wildlife habitat.

Caribou

Three caribou herds utilize portions of the Fort Yukon route. The Arctic and Porcupine herds overlap in the area north of the Brooks Range between the Sagavanirktok and Canning Rivers. The Porcupine Herd winters in and around the southern Brooks Range portion of the route and the Fortymile Herd in some years drifts from farther south and crosses the Yukon River between Circle and Eagle to summer in the area. Critical habitat areas (Figure 8.1.1.4-21) for these three herds are not involved with this route.

The severest primary impacts of the alternative pipeline route will be those affecting caribou behavior and population dynamics rather than habitat.

Winter construction activities would have a direct effect on individual caribou. The Porcupine Herd would be affected in a manner similar to that described for the Interior route (8.1.1.3). Pipeline structures built during the winter will remain to influence animal behavior at other times of the year, and, indirectly, the herds' population.

Aircraft disturbance would be experienced year-round and would be concentrated at the airstrips and helicopter landing pads. Disturbance during the summer by low flying aircraft could have minor effects, but harassment of the caribou in winter can have severe direct impacts on individual animals. In midwinter, when the daily energy balance of a caribou is low, harassment by aircraft, snowmachine, or other project-associated vehicles can cause an animal to expend more energy than it can acquire from the available forage, thus placing the animal in a negative energy balance. Repeated harassment will lead to death of the animal.

Increased access to a herd has led to increased hunting, which has had adverse impacts on caribou herds. There is no reason to expect the improved access to areas associated with this alternative pipeline will produce other effects.

In summary, the Fort Yukon alternative pipeline route intersects important winter range of two caribou herds in Alaska, but avoids traditional calving areas. Physical changes in the total habitat available for caribou use will not be reduced appreciably. However, intrusions into caribou ranges of operating facilities, such as airfields and compressor stations, and the human activities required to operate and repair these facilities will cause significant changes in the behavior patterns of caribou and, in turn, will cause a reduction of the number of caribou or a shift of animals to less preferable habitat.

Dall Sheep

Dall sheep do not occur in high densities along the Fort Yukon alternative but are found in areas where the route passes through the Brooks Range and down the Wind River. Near the U.S.-Canada border, the alternative route intersects a portion of sheep range that may be used by Fannin sheep although occurrence of the sheep in this area is questionable.

Impact on Dall sheep would be those resulting from disturbance discussed in section 8.1.1.3 and more fully in section 3.1.1.7.

Moose

The Fort Yukon alternative route will create severe impacts on moose in the Brooks Range because the number and condition of moose are limited by the small amount of winter range (primarily in river valleys like the Ribdon, Chandalar, or Wind Rivers). The construction of the system will destroy valuable habitat while operation of compressor stations may cause the behavior patterns of moose to change enough so that moose shift to less desirable range. Through the Yukon Flats no serious impacts on moose are expected as a result of the Fort Yukon alternative because of the abundance of moose winter range and general wide distribution of moose. Large numbers of moose are reported to winter along the upper Yukon river in bad winters. Construction of the pipeline and operation of compressor stations may displace some of these moose, but because of the width of the Yukon River Valley, impacts will not be as severe as in narrow valleys through the Brooks Range. These impacts are similar to those discussed for the Interior Alternative route (8.1.1.3).

Wolf

The primary impact of construction activities on wolf habitat will be the loss of some choice den sites in areas also chosen as upland borrow sites for road, airfield, and other embankment materials.

Because digging in permafrost soils is difficult, wolf dens may be used year after year. Any construction or operation activity within sight or hearing of these established dens would cause their residents to abandon and avoid the sites as long as the human presence persists.

Increased access to the area and increased human presence will intensify hunting pressure including illegal killing of wolves. Since wolves generally do not migrate out of an area or hibernate during the winter, they are exposed to harassment and hunting all year around and will probably suffer their greatest losses during the winter seasons in which the pipeline and ancillary facilities are to be built and subsequently around areas where human activities are concentrated on a regular basis (such as compressor stations). The overall result of the Fort Yukon alternative pipeline system on wolves will be a decrease in the number of wolves. The extent of loss of wolf populations is not known.

Bear

Polar bears inhabit only that portion of the Arctic Slope nearest the Beaufort Sea. Because of existing development in the Prudhoe Bay area polar bears may no longer use the area associated with this gas transmission system (see 3.1.1.7). Adverse impacts of pipeline activities on grizzly bear densities and behavior as described in section 3.1.1.7 apply to this alternative.

The number of grizzly bears affected by the construction, operation, and repair of this route is unknown. Adverse impacts of pipeline activities on grizzly bear densities and behavior as described in Section 3.1.1.7 apply to this alternative.

While black bears are somewhat more tolerant of human activities than grizzly bears, they also are more likely to become nuisances. Because of this and their trophy value, black bear numbers will be adversely affected by construction and operation of this alternative pipeline.

Birds

Probably the most significant wildlife species in the Yukon Flats area, through which part of this alternative route will run, are migratory water fowl. Approximately 85 miles of this route intersects areas identified as having high value, critical waterfowl habitat (Figure 8.1.1.4-21).

Because of the wide range of habitats that the construction, operation, and repair of the Fort Yukon alternative pipeline system will pass through, a larger percentage of these species will be affected than along some other routes in Alaska.

Potential conflicts between the pipeline construction and operation and bird populations can occur from disturbance, habitat destruction, pollution, and direct mortality. While some of these impacts are unavoidable, others depend on the location of various facilities, construction practices, and scheduling of activities. Among the major potential impacts which could be avoided are those caused by aircraft and human presence at certain critical times.

The construction phase of this alternative gas pipleine system would not be devastating to bird resources in general, but it would contribute to an ever-increasing attrition of bird populations through exploitation and deprivation of habitat.

The number of birds that would be displaced by this loss of habitat is not known. Birds displaced by habitat modification, although not killed outright, are removed from the breeding population and thus contribute no further offspring during their lives. This occurs because they can seldom find suitable substitute breeding habitat which is not already occupied by others of their species. Thus, when habitat is lost, the population eventually stabilizes at a lower level. Since important bird habitat is associated with this alternative routing through the Yukon Flats, the impacts caused by the pipeline will be significant.

Oil and other accidental pollutant spills on land or water because of construction or maintenance procedures are detrimental to birds and their habitat. This threat to the bird resources cannot be evaluated, because the effect of spills would be related to the location, volume, and the season of the year.

Disturbance could increase stress and alter normal behavior patterns during critical life history phases such as spring migration, nesting, molting, or fall migration staging; decrease reproductive success; or cause the birds to desert traditional areas such as molting areas or nesting sites for which there may be no alternative. The impact of disturbance on a particular species is a function of the type and intensity of the disturbance, the time of year, the location, the mobility of the disturbance source, the distribution pattern of the bird, and the species' sensitivity to disturbance. The major sources of disturbances associated with construction and operation of the alternative pipeline are aircraft traffic, construction activities, human presence, permanent facilities, and water traffic.

These disturbances to waterfowl are expected to cause loss of bird habitat similar to that described for the applied-for AAGPC route (3.1.1.7) and the Interior alternative (8.1.1.3).

There are significant numbers of raptors in the area. The major impact on these species would be from the destruction of traditional critical nesting areas as well as potential reduction of food supplies. The latter is not considered to be of major consequence, while the former most definitely is.

Endangered Species

The peregrine falcon, an endangered species, nests in the steep valley of the Yukon River near the Canadian border and also at Franklin Bluffs. Falcons hunt along the river flood plain and uplands during the summer. See section 3.1.1.7 for impacts on endangered species.

Fish

The primary impacts of the proposed construction and operation of the gas pipeline on fish life will be adverse and can be broadly categorized as arising from increases in suspended particles, reduction in dissolved oxygen, and introduction of pollutants. 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 severer short-term environmental degradation.

Impacts on affected populations could be extensive, causing elimination or reduction of fish populations from segments of streams crossed by the Fort Yukon alternative pipeline system. Refer to discussion in sections 3.1.1.7 and 8.1.1.3 for impacts that apply to this route.

Impacts of the Fort Yukon Alternative Route on Ecological Considerations

This alternative system influences three major ecological systems. As discussed here, the tundra and taiga (forest) are separate systems, with the freshwater overlapping the tundra and taiga.

Much of the discussion of impacts of the project on ecosystems is contained in separate discussions on vegetation, permafrost, fishing resources, etc. Because there is no precedent for a project of this kind and magnitude and especially because its effects will be superimposed upon those from the Alyeska hot oil pipeline construction, analysis of impacts on ecosystems can be made only in the broadest terms.

Tundra Ecosystem

The tundra ecosystem has been extensively discussed in Sections 2 and 3 of the applied-for route analysis (3.1.1.8). Potential impacts on this type of ecosystem include the introduction of weed or other exotic vegetative species to the detriment of the native vegetation; pollutant damage to vegetation (pollutants include liquid, airborne, and soil wastes); change of ground thermal regime resulting in degradation of permafrost, erosion, and loss of vegetative cover; and actual loss of primary productivity through loss of habitat because of covering or clearing areas used for roads, borrow pits, etc. These impacts will apply for all ground areas affected by the proposed pipeline.

Taiga Ecosystems

The impacts listed under tundra ecosystems also apply to taiga. In addition, if material cleared from the right-of-way is not mulched or burned immediately, insect populations may build up and have the potential for killing trees over large areas adjacent to the pipeline route.

The possibility of wildfire is much greater in this than in the other land-related ecosystems. A discussion of wildfire-related problems is presented in Section 3 of the applied-for AAGPC route (3.1.1.7) and in 8.1.1.4 of the alternative Fort Yukon route.

Freshwater Aquatic Ecosystems

Impacts on the fish, aquatic mammals, bird, and insect life also affect this ecosystem, as discussed in AAGPC proposed route (Section 3.1.1.7).

Other potential effects of the construction and operation of this alternative system include: (1) disruption of habitat through excavation, fill, and gravel borrow, (2) hydrologic disruption through channel modification, (3) habitat modification through increased siltation, decreased available oxygen, change in stream thermal regime, (4) eutrophication through possible input of sewage effluents and terrestrially derived nutrients such as fertilizer used in revegetation processes, (5) addition of toxins from such sources as sewage effluent, machinery, fuel spills, and pipeline testing, and (6) withdrawal of water for camp use, pipeline testing, and firefighting.

Economic Impacts Caused by the Fort Yukon Alternative Route

The economic impacts of the Fort Yukon alternative route as developed by the University of Alaska econometric model (Scott, 1975) described in section 8.1.1.1 include: a property tax of $28.0 million, construction employment of 4,107, a capital value (pipe and compressors) of $1.4 billion, an increase in gross State product of $179.4 million, a total State employment effect of 16,500, an increase in real wages and salaries of $139.1 million, population growth of 23,100, an addition to personal income statewide of $399.2 million with an increase in per capita income of $335, and a total addition to State revenues of $136.9 million. All figures are for 1980.

Employment

Numbers of workers employed during peak construction periods or the duration of construction in Alaska are not known. As with the Interior alternative, the number of workers needed to construct the Fort Yukon alternative represents a transfer of work from Canada to Alaska (see 8.1.1.4). Because of the longer length of pipeline in Alaska, it is estimated that the peak employment requirements will be from 7,000 to 8,000 workers. This represents a work force approximately 33 to 38 percent as large as that required during the peak construction of the trans-Alaska oil pipeline system (21,000 direct employment).

The Fort Yukon alternative system is located north of Fairbanks; whereas, the oil pipeline system is located both north and south of Fairbanks. Although specifics of the work force required to construct this alternative pipeline system are not known, it is reasonable to assume that economic impacts now being caused by the influx of oil pipeline construction workers will be extended through the completion of the Fort Yukon alternative for the Fairbanks area (see 2.1.1.9, 8.1.1.3 and 8.1.1.4). Because of its key location as distribution and supply center, Fairbanks will experience impacts similar in intensity to those caused by the oil pipeline. Circle will be affected much as described for the Interior alternative as it will serve as a major distribution point for the Fort Yukon alternative. Similar impacts will result at Eagle, as it is assumed that its road access will also make it a major supply depot on the Fort Yukon alternative. Because of the small size of both communities, it is expected that impacts will be similar to those now taking place in Valdez as a result of the construction of the trans-Alaska oil pipeline.

Permanent employment opportunities produced by the Fort Yukon alternative are not expected to be substantially different from those described for the Interior alternative. There will be slightly more permanent jobs in Alaska, but these reflect the longer length in Alaska. As such, this is a transfer of work from Canada. Employment in Fort Yukon, Circle, and Eagle would be slightly enhanced because of their proximity to the alternative route and to operating compressor stations.

Potential Development of Associated Resources

The Fort Yukon alternative, like the Interior alternative, is associated with three significant resources on the south side of the Brooks Range: Yukon-Kandik oil and gas province, minerals, and timber-agriculture. These resources are now undeveloped, presumably because of their remote location. The first drilling exploration program for oil and gas in the Yukon-Kandik is scheduled to commence in early 1976. There are plans to drill at least four exploratory wells in an initial effort to discover petroleum reserves in the geologic basin.

<u>Oil and Gas</u>--The Fort Yukon alternative serves the same Alaskan Arctic Slope oil and gas areas described in 8.1.1.3 for the Interior alternative. The Fort Yukon alternative also would serve the Yukon-Kandik area in a similar manner except that the Interior alternative goes to the north, while the Fort Yukon alternative passes through the center and southern portions. Accordingly, the Fort Yukon alternative is more favorable to oil and gas exploration development activities in the Yukon-Kandik province because it is closer.

<u>Minerals</u>--The Fort Yukon alternative will stimulate to development of mineral deposits along the side of the Brooks Range much as would the Interior route (8.1.1.3). The only difference is that the more westerly crossing of the Brooks Range by the Fort Yukon alternative favors mineral development in the Chandalar Mining District.

The Fort Yukon alternative will have little, if any, impact on phosphate, subbituminous coal, or oil shale deposits along the Eagle Trough because of their relatively small size and overall costs for development and transportation to markets.

Forestry and Agriculture--The Fort Yukon alternative will have the same impacts on potential forestry and agriculture uses in the Yukon Flats area as those described for the Interior alternative (8.1.1.3). The only difference is that rather than a temporary access road between Circle and the Interior route, the Fort Yukon alternative will provide a series of permanent airstrips and cleared rights-of-way. Some commercial timber production potential would be lost. Because of the linear nature of the right-of-way, no significant loss of potential forestry or agricultural uses is envisioned.

State and Local Revenue

Income to the State of Alaska and to the North Slope Borough from the Fort Yukon alternative route will be slightly higher than from the applied-for AAGPC route because it will bring taxable improvements into the State and larger numbers of construction workers for a longer time. It would involve a construction impact about 3 times that of the proposed route and yield about 3 times more property tax (Scott, 1975). At the same time, costs will be greater (more schools, roads, police, etc.) as more people move to remote areas. A prime example will be the necessity to maintain roads to Eagle and Circle on a year-round basis. (These two roads are now closed during the winter.)

Alaskan Native-Owned Resources

Impacts on Alaskan Native-owned resources will be similar to those described for the Interior Route.

Impacts Caused by the Fort Yukon Alternative
Route on Sociological Factors

The Fort Yukon alternative pipeline system is located in the North Slope Borough on the north of the Continental Divide and an unorganized borough to the south. It is recognized that the overall cultural values of the Eskimo north of the Divide and Athabascan Indian to the south are different. But both place heavy importance on natural values.

Because the area south of the Brooks Range to Fort Yukon is remote, the sociological factors discussed in 3.1.1.9 and 10 for the North Slope Borough are considered typical. That portion of the Fort Yukon alternative route east of Fort Yukon is different as Fort Yukon is a major regional distribution and population center, whereas, both Circle and Eagle are connected directly to the Alaska Highway System.

Impacts expected on populations in Anchorage and Prudhoe Bay will be similar to those described in 3.1.1.10 for the applied-for AAGPC pipeline route. Kaktovik will not be affected by the Fort Yukon alternative route, but villages south of the Brooks Range probably will notice some changes in their populations in direct proportion to how close they are to permanent facilities required to operate and maintain the pipeline system. These include Venetie, Fort Yukon, Circle, and Eagle. Fairbanks will also experience a permanent population increase because of its position as a regional supply and transportation point.

Communities like Venetie most likely will suffer temporary (less than 5 years) sociological problems, while Fort Yukon, Eagle, and Fairbanks will have long-term population increases. These will be similar to those discussed for the Interior alternative (8.1.1.3). Because of the larger numbers of workers required to build the longer segments of the total pipeline system required in Alaska by the Fort Yukon alternative, the population shifts will be larger. It is expected that overall shifts will be comparable to those caused by the trans-Alaska oil pipeline system as it is probable that peak construction activities for the gas pipeline will follow the completion of the oil pipeline by several years. Because of the increased access to small interior communities, Kruse et al (1975) consider this alternative as having a more highly disruptive social impact.

Subsistence

The 1,100 Alaskans living at the Chalkyitsik, Venetie, Fort Yukon, Eagle, Central and Circle areas will be affected by the Fort Yukon alternative gas pipeline route in a manner similar to that described for the Interior route (8.1.1.3).

Impacts include substantial, but unknown, reductions in the annual subsistence harvest of 33 moose at Venetie and 30 at Eagle; 200 and 100 caribou, respectively; 19 and 1 grizzly bear, respectively; 11 and 3 black bear, respectively; 2,210 and 300 ducks, respectively; and 230 geese at Venetie.

Subsistence harvests at Fort Yukon are described in 8.1.1.3 (Interior route). Annual harvests by people living at Fort Yukon will be adversely affected by the Fort Yukon alternative system as the Fort Yukon system will bring permanent facilities and concentrate human activities in areas also valuable for subsistence uses. The extent of this effect is not known as there are no firm plans which can be evaluated in terms of the systems location, construction schedule, or operating characteristics.

The Fort Yukon alternative pipeline system will have substantial and profound impacts on the existing way of life of Alaskans residing in rural areas such as Venetie, Circle, and Eagle. Similar changes will take place at Fort Yukon, but because of its larger size and more diversified social structure, impacts on subsistence may be less intense.

Local Government and Community Services

Local governments at Circle (pop. 63) and Eagle (pop. 92) will be affected substantially as highways to neither community are kept open during the winter and visitors are few.

Cost of Transportation

Transportation facilities to Eagle and Circle will be improved as it is expected roads will be kept open on a year-round basis after the 2 or more year construction period. Transportation facilities will not be improved to Fort Yukon, but the frequency of flights to that community is expected to increase. Both will have the long-term effect of lowering transportation costs, as now it is necessary to plan bulk movements during the few months the highway is open or the Yukon River is navigable.

As with any pipeline system, competition for available space and transportation equipment will be severe during the construction period. This competition is expected to cause delays and increase the overall cost of transporting goods throughout rural Alaska as the network developed for the trans-Alaska oil pipeline construction will have been largely dismantled due to the interval of several years between peak construction needs of the oil pipeline and gas pipeline.

Impacts of the Fort Yukon Alternative Route on Land Use

The Fort Yukon pipeline system in Alaska lies in an area which is largely unoccupied and undisturbed. The Prudhoe Bay area and the State patented lands are currently being developed for oil and gas production.

All route options involve construction, operation, and repairs taking place in undeveloped and remote areas. Virtually nothing has been done in terms of statewide or regional land-use planning. This lack of planning and anticipated impacts are similar to those discussed in the AAGPC applied-for route 3.1.1.11.

Land ownership along this route is changing rapidly. Where it was mostly Federal, areas are now being transferred to the State of Alaska and to Native-owned corporations. The route also crosses two areas which are being considered for inclusion in one of the four conservation systems. One is the proposed Porcupine National Forest and the other is the proposed Yukon-Charley National Rivers.

In all locations along this route, gas pipeline construction and operation would have significant impacts on present land use. Those lands are now in an undisturbed or wilderness condition and used largely for the production of wildlife species which depend on extensive areas free from disturbance by man for their well-being. The wildlife, in turn, provides the base for a subsistence hunting and trapping economy and lifestyle unique to rural Alaska. Sport hunting for Dall sheep, grizzly bear, caribou, and waterfowl is also popular there, but would be reduced following pipeline installation (See 8.1.1.4).

The Chandalar option passes through an area known as the Chandalar Mining District, which has high potential for copper, lead, and zinc production. The development of access would produce the primary impact. The use of the natural gas in the mining or processing would be unlikely.

High potential oil and gas provinces are crossed by this route between the East Fork of the Chandalar River and the Alaska-Canada border. Access to these provinces created by a pipeline could encourage the development of oil and gas reserves.

The impact on the forestry resource would result from increased access and relatively minor reduction of acreage availability. The increased access impact would depend on the number of permanent roads constructed in conjunction with the pipeline. It should be noted that even a wintertime road along the gas line would increase access to the forest stands adjacent to the pipeline.

Land with agricultural potential in the Fort Yukon area would be affected if the gas pipeline spurred development of the Yukon-Kandik oil and gas province. An expanded oil and gas production industry within the Yukon Flats area could significantly affect the development of agriculture there. Active exploration is underway during the winter of 1975-76. Therefore, secondary impacts of oil and gas development of fields other than Prudhoe are not necessarily dependent upon selection of the Fort Yukon alternative route.

As the alternative Fort Yukon route does not cross lands now used for industrial purposes, the impact would be on lands with industrial potential, just as with agricultural lands.

The Fort Yukon area is a shipping center for the region. It is located on the junction of two navigable rivers (the Yukon and the Porcupine) and the development of an oil and gas industry would greatly enhance the development of the commercial and light industrial capabilities of the Fort Yukon area.

In summary, State, Federal, or local land use plans have not been completed. The construction, operation, and repair of the Fort Yukon alternative pipeline system will cause a commitment of land uses prior to the establishment of a comprehensive statewide land use plan or policy for the Arctic as recommended by the Joint Federal-State Land Use Planning Commission for Alaska.

Impacts Caused by the Fort Yukon Alternative Route on Historic, Archeological, and Unique Area Values

The Eagle site has well-preserved structures, which mark military and civic history as well. The influx of additional workers and others will no doubt increase vandalism and artifact hunting in the old trading and mining areas. This would cause a significant impact if old buildings or artifacts are destroyed or removed.

Some archeological sites have been identified near the alternative route. In general, however, the archeological and paleontological resources along the route are not known and the impacts from the route construction and maintenance cannot be assessed until a right-of-way survey is completed.

Potential impacts of the alternative system on prospectively valuable archeological areas include: destruction of sites without scientific investigation; destruction with partially completed scientific investigation; vandalism of unexcavated, partially excavated, or accidentally opened sites; and removal of artifacts (surface finds are often of great significance in the Arctic).

Construction of additional roads and airstrips will make the area more accessible. Unauthorized disturbances of antiquities and vandalism of archeological sites throughout the region are expected to increase. This secondary impact of improved accessibility on regional archeological values is considered significant and adverse.

Archeological values may have an adverse impact on the completion of the proposed system. Provisions of the National Historic Preservation Act of 1966, Executive Order 11593, and the Archeological and Historic Preservation Act (P.L. 93-291) require archeological values to be identified and protected. Thus, it is possible that a critical element of the construction schedule could be delayed.

Impacts of the Fort Yukon Alternative Route on Recreation and Esthetic Resources

Recreation

Only light recreational use has been made along this route. As soon as access is improved, either by better airports or roads, use is expected to increase sharply.

The area between Oksrukuyik and the Alaska-Canada border is largely undisturbed by man. The main access has been either by airplane or riverboat. Because this area is relatively undisturbed, the clearing of tundra brush and trees and construction of a pipeline would have a significant and irreversible impact on natural values.

With increased awareness of recreational opportunities created by pipeline-related activity, recreational use and demand for recreational facilities will increase. New recreational resources will be discovered with resulting demands for their exploitation and/or preservation.

A more direct impact of the construction of an alternative pipeline on the recreational resource would be the scars resulting from the buried pipeline or the visual impact where the facilities are above ground.

Nearly all the line south of the Brooks Range will require the clearing of brush and forest cover. This will significantly alter the natural environment and will degrade the route's recreational value, particularly where clearings are straight. Impacts identified in section 3.1.1.13 also apply to this route.

Esthetics

Many of the esthetic impacts have already been discussed under recreation. The major impacts to many people will be those that catch the eye from roads, trails, or from boats in the river. These will be the long straight forest clearing along the right-of-way, the compressor stations that are visible, special stream crossings, and the borrow areas that are not hidden from view.

For those people who appreciate esthetic qualities related to beauty, pure feelings or sensations, or to an individual's sense of "correctness" of the environment, the proposed project will have a significant adverse effect on the resource. Impacts are expected to be similar to those identified in sections 3.1.1.13 and 8.1.1.3.

Impacts of the Fort Yukon Alternative Route on Air Quality

Air quality along this alternative route is all very high. Construction and operation of the system would change this to some degree. Impacts on air quality are similar to those described in sections 3.1.1.14 and 8.1.1.3.

Compressor Stations

There is only one proposed station which might have a significant impact. This is the one with an indicated location 10 miles north and upriver from Eagle, Alaska. Winds frequently blow downriver and would carry emissions and water vapors into the Eagle area.

Construction Camps

Construction along this route would require camps, the location and number of which are unknown. Indications from the AAGPC route proposal are that each compressor site would have 500 to 800 persons. The impact of these and possibly other construction camps on existing air quality is expected to be small and localized, though temporarily adverse. (See discussion in section 3.1.1.14.)

Vehicle and Construction Equipment Exhaust

The Fort Yukon alternative pipeline would use many bulldozers, pipelayers, various excavation equipment, compressor drills, pipe benders, crushing units, tractor-trucks, and trucks in the 1/2-to 16-ton class. There is no estimate as to how many pieces of equipment or the amount of fuels or lubricants would be used for surface and air transportation. See discussion in sections 3.1.1.14 and 8.1.1.3 for similar impacts.

In summary, the impact of exhaust emissions from construction and initial operation on existing air quality is considered local and short term. Impacts on air quality along the route also would be local and short term but because air quality in such areas is now natural, additions of exhaust emissions may be significant.

The major long-term impact of exhaust emissions on air quality may be associated with the compressor stations in Alaska. These impacts are considered significant because of ice fog originating from water vapor plumes.

There may be secondary impacts on human safety as a result of increased ice fog (see Environmental Hazards)

Exhaust emissions are considered to pose no unusual health hazards for workers except in the formation of ice fog.

Prevailing strong winds in August and September pick up and carry substantial amounts of fine dusts from lake shores and streambeds (See section 2.1.1.14 for details). In addition to smothering, wind-driven particles have an abrasive effect upon plants, killing tender growth back to older more protected parts.

The anticipated impact of dust resulting from the proposed pipeline construction activities is considered to be local and minor. In addition to wind-carried dust, operation of fixed-wing aircraft and helicopters from sand and gravel airfields and pads will produce unknown but long-term additions of dust to the environment. It is expected that some borrow areas will be required for long-term maintenance of the alternative project. Such sites would provide a long-term incremental addition of unknown amounts of dust to the environment.

The existing trans-Alaska oil pipeline haul road would be used for transportation of construction materials. Addition of dust to the environment by vehicles using the gravel road would be incremental and local. There is no basis to estimate how much dust might be created, but it is considered that it would be of slight consequence.

Data supplied to the Canadian government (CAGPL, 1974) indicate routine maintenance procedures at compressor stations will result in the release of some natural gas. During station startup, the main gas and propane compression turbines will expel approximately 150 Mcf (thousand cubic feet) of unburned natural gas. Assuming that there are 15 miles between automatic block valves, pipeline failure or emergency shutdown would result in up to approximately 3,750 Mcf of natural gas discharged into the atmosphere. The natural gas will be odorless.

For the CAGPL proposed route in Canada it is stated that: The low density of natural gas causes it to rise rapidly, thereby making the effects of mainline breaks on ground-level air quality extremely temporary.

However, it is not known what would happen if large volumes of natural gas were released into ice fog. According to the Aerospace Corporation (1975), there may be a highly explosive condition in a microsecond period of time and therefore, the potential for fire or explosion cannot be discounted. The possibility of fire or explosions will be of particular concern at all the towns or settlements along the route beyond the Alaskan border.

Impacts of the Fort Yukon Alternative Route Caused by Noise from Construction Equipment

This area is primarily undisturbed wildland, and noise levels are low.

The system will add to the existing level of noise all along the route. Noise associated with construction (trucks, trenching equipment, pipelayers, etc.) will be at a location for only a short period (several days to a week or more) and, therefore, will be transitory.

Operation of mechanized equipment for the extraction of sand and gravel will cause noise that will affect wildlife (see section 3.1.1.15, Environmental Noise). Most of the construction equipment will be diesel-engine powered. Typical noise levels of construction equipment in dBA at 50 feet are given in Figure 3.1.1.15-1. These levels are found while the equipment is operating and are similar to noise levels expected during pipeline construction. Excavation is estimated to produce a sound equivalent level of 84 dB measured at 50 feet.

Aircraft will be used as the primary means of transportation except that ships will bring initial construction supplies. Aircraft will be used year around to monitor the system and to transport workers.

Noise caused by low-flying aircraft and helicopters may have an adverse impact on wildlife. The distances at which wildlife react to aircraft noise is presented in Table 3.1.1.15-4. The extent of noise impacts on wilderness will depend upon (1) type of aircraft, (2) frequency of exposure, (3) altitude of aircraft, (4) time of year, (5) amount of suitable alternative habitat, (6) present extent of habitat utilization, and (7) the carrying capacity of the available habitat areas (see sections 3.1.1.15, Environmental Noise, and 8.1.1.4, Wildlife).

This impact statement is prepared with the assumption that 16 compressor stations will be built in Alaska. The estimated distances at which residences will be affected by a day-night sound level of 55 is 7,800 feet. The distances at which wildlife react to station noise is presented in Table 3.1.1.15-2. Refer to section 8.1.1.4 for description of wildlife locations along the route. This route travels through a major nesting area (about one nest per 10 miles) of the peregrine falcon, along the Yukon River from about 12 miles downstream of Circle, Alaska, to the Alaska-Canada border (AAGPC, 1975). The Applicant estimates that a minimum of 25 pairs may be disturbed (AAGPC, 1975). They further estimate that this is "at least one-half of the known viable interior Alaska nesting habitat" for peregrine falcons (AAGPC, 1975).

Explosives would be used to dig certain areas of the alternative pipeline route in Alaska. There is no indication of where blasting will be done or the size of the explosive charge since the technique for explosive excavation of a pipeline trench in permafrost has not been developed. Most of the excavation of the pipeline trench would be done during the winter, when most wildlife species are absent from the area. The impact on resident moose of the noise from blasting the pipeline ditch is unknown. Repeated disturbances, such as blasting, however, may cause animals to move to new areas. The effect that relocation may have on the animals' survival will depend on the amount of alternative habitat, the extent of utilization, and the carrying capacity of all the available habitat areas.

Impact of Wintertime Repair of the Fort Yukon Alternative Pipeline System

Initial construction is planned to be conducted from snow/ice roads prepared in advance. Wintertime repairs of the system will create impacts similar to those described for the applied-for route with one major exception. Emergency repairs will not allow time for construction of snow/ice roads and will involve movement of heavy equipment across the frozen country.

The AAGPC proposed route discussion gives an example of a "worst case" nonwinter repair. It sets forth details on the type of equipment to be used and its effects.

In summary, on the Fort Yukon alternative route, under the "worst case" conditions both as to site of repair work and the time of the year the repair work would be undertaken, there will be substantial local adverse impacts on vegetation, soil, permafrost, water quality, and wildlife resulting from nonwinter emergency repair of the proposed system. Nonwinter repair will be much more destructive than winter repair.

8.1.1.5 Fairbanks Alternative Pipeline System

Description of the Fairbanks Alternative Pipeline System

The Fairbanks alternative pipeline system follows an alignment considered for transporting oil from Prudhoe Bay in 1972. That alternative involved following the alignment of the route actually selected for the oil pipeline 450 miles southward from Prudhoe to Fairbanks and then southeasterly along the Alaska Highway to Delta Junction, and the United States-Canada border. The 1972 final impact statement for the trans-Alaska oil pipeline system noted that the presence of the Alaska Highway would facilitate construction of the oil pipeline; that large quantities of gravel were accessible; and that no unbroken wilderness habitats would be involved. The initial 545 miles (74 percent) of the Fairbanks alternative route in Alaska (from Prudhoe Bay to Delta Junction) follows the route selected for construction of the trans-Alaska oil pipeline. The remaining 190 miles (26 percent) follows the existing Alaska Highway to the United States-Canada border while the trans-Alaska oil pipeline route swings southward to port facilities at Valdez.

In addition to the Alaska Highway southeasterly from Fairbanks, an 8-inch military fuel pipeline connects bases near Fairbanks to a marine terminal at Haines, Alaska. The area is also one where potential construction of a railroad link from Alaska to the lower 48 states has been given serious consideration. Recently, interest has been revived in the railroad extension into Canada, although there are no firm plans to proceed at this time.

In its application to the Department of the Interior and the Federal Power Commission, the AAGPC also considered the potential of constructing a chilled, buried pipeline on an alternative routing identified as the "Fairbanks Corridor." In its application to the Federal Power Commission, the EPAC (El Paso Alaska Company) also considered an LNG pipeline routing from Prudhoe Bay to Fairbanks and then along the Alaska Highway to Delta Junction, thence southward generally along the alignment of the trans-Alaska oil pipeline to the vicinity of Valdez, and thence to a proposed new port facility at Gravina Point. An alternative routing for the pipeline-LNG system would be to proceed to Canada via the Alaska Highway and then to a proposed new LNG terminal facility in the vicinity of Haines, Alaska. (See Alternatives for a discussion of the pipeline-LNG alternatives.)

In discussing the "Fairbanks Corridor" AAGPC (1974a) stated, "The substantial diversity of potential gas supplies which might be tapped by the Fairbanks Corridor and the proposed route (applied-for) suggests that the two routes are not really alternatives, but that instead, a route in Alaska from the Kandik Basin, past Fairbanks, is an independent route...."

There are no proposals to construct a buried, large diameter, chilled gas pipeline along the Fairbanks alternative route pending before the Department of the Interior or the Federal Power Commission and that detailed engineering or site locational studies have not been initiated by the El Paso Alaska Company for a pipeline-LNG system.

The following description of the Fairbanks alternative gas pipeline alignment is based upon locational data provided by the applicant. Data relating to environmental, social, and economic factors are extracted from recent information assembled by the Joint Federal-State Land Use Planning Commission for Alaska, construction data for the oil pipeline, and the final environmental impact statement prepared by the Department of the Interior in 1972 for the trans-Alaska oil pipeline to Valdez. The last source of data appears to be the primary source of information used to promote the pipeline-LNG alternative system.

Although detailed, site-specific data are lacking for the Fairbanks alternative gas pipeline system, there are sufficient similarities between environmental, social and economic factors described for the route applied for by AAGPC, the Interior gas pipeline alternative, and the trans-Alaska oil pipeline. Thus, overall impacting mechanisms can be assessed in a manner to permit comparison of the Fairbanks route with the applied for and other alternative routings.

Location

The Fairbanks alternative routing considered by AAGPC would involve construction of approximately 735 miles of pipeline in Alaska. The first 345 miles go south from Prudhoe Bay on the same alignment as the trans-Alaska oil pipeline system and the new gravel highway system to the Yukon River. From there the route generally follows the existing State highway and oil pipeline 105 miles to Fairbanks. Passing to the north and east of the City of Fairbanks, the routing proceeds southeasterly along the Alaska Highway and oil pipeline 200 miles to Delta Junction. The remaining 190 miles follow the Alaska Highway to the Canadian border.

It should be noted that the Applicant presents a minor option as the routing approaches the Canadian border. From M.P. 660, the routing could follow along the proposed railroad route up the Ladue River for the last 60 miles to reach Canada instead of the final 75 miles along the Alaska

Highway. Following the Ladue River at this juncture would shorten the route in Alaska by approximately 15 miles.

Figures 8.1.1.5-1 through 7 show the route and location of compressor stations as developed by AAGPC. The Ladue River option is shown on Figure 8.1.1.5-8, which would replace Figure 8.1.1.5-7 in the series just given.

Facilities

For purposes of evaluating the Fairbanks alternative route, it is assumed that the same size and quality of pipe will be utilized as that described in sections 1.1.1.1 through 9 for the applied-for AAGPC route.

It is further assumed that the Fairbanks alternative pipeline system will be designed to deliver a maximum throughput of 2.25 bcf/d (billion cubic feet per day) initially. The ultimate design, with 16 compressor stations operational (15 with the Ladue River option) will have a capacity of 4.5 bcf/d. Based upon the requirements for compressor stations for 2.25 bcf/d capacity on the Interior alternative system (one at Mile Post 118) it is assumed that at least two stations would be required for the Fairbanks alternative: one on the north side of the Brooks Range, site 3 at Mile Post 126, and one south of the Brooks Range, site 8 at Mile Post 365. Table 8.1.1.5-1 shows the locations of compressor station sites along the Fairbanks route.

It is also assumed that the Fairbanks alternative pipeline system will require construction of airfields and communication sites similar to that described for the Interior alternative pipeline system (Table 8.1.1.3-1). However, since this route also is close to previously established airfields and roads, the number of airfields and their sizes should be reduced considerably.

Construction, Operation, and Repair Procedures

Equipment and supplies for the Fairbanks alternative will be assembled and distributed along existing roads to Prudhoe Bay from Fairbanks and the Alaska Highway from Fairbanks to the Canadian border. It is assumed that existing port facilities on the south Alaska coast will be utilized (Anchorage, Valdez, Skagway, and Seward) for receiving equipment and supplies. Only moderate use of the port site at Prudhoe Bay should be required for the northernmost section of this alternative gas pipeline system. Fairbanks can be expected to be a primary receiving and storage area. Additionally, the towns of Delta Junction and Tok Junction can be expected to become major supply depots because of highway access to south Alaska ports. North of Fairbanks it is assumed that the existing camps of the trans-Alaska oil pipeline system will play an important role in the construction, operation, and repair of the Fairbanks alternative gas pipeline system.

An estimated 5.9 million cubic yards of gravel will be required.

Construction Schedule

It is assumed that construction activities would be conducted on a year around basis. Peak construction in Alaska would extend through 2 and possibly 3 years.

Table 8.1.1.5-1 Location of compressor station complexes

Without Ladue River Option (735 miles)*		With Ladue River Option (720 miles)*	
Compressor Station		Compressor Station	
Site No.	Mile Post	Site No.	Mile Post
1+	44	1+	44
2+	88	2+	88
3+	126	3+	126
4+	172	4+	172
5+	227	5+	227
6+	274	6+	274
7+	321	7+	321
8+	365	8+	365
9+	410	9+	410
10+	456	10+	456
11+	503	11+	503
12+	548	12+	548
13+	588	13+	588
14+	635	14+	635
15	682	15	682
16	728		

*Distance from Prudhoe Bay to United States - Canada Border.
+Common compressor station sites.
Site No. 15 is not common, although mile post mileage is the same.

Table 8.1.1.5-2 compares the seasonal mileages and construction spread requirements to complete the entire 3,549-mile-long Fairbanks alternative with the 2,629-mile-long route applied for by AAGPC in Alaska and Canada.

Work Force

Based upon the estimated work force of 5,000 direct jobs required to construct the 298-mile-long Interior alternative pipeline system in Alaska (see 8.1.1.3), it appears that between 12,000 and 13,000 construction jobs in Alaska will be required to build the 735-mile-long Fairbanks alternative. The final decision as to number of workers and number of spreads for any given time period to achieve planned results has not been given by the Applicant. It is expected that a substantial amount of secondary and indirect employment will result in Alaska. Nevertheless, it is not possible to estimate secondary or indirect employment without knowing where and when construction will be under way.

Direct permanent operation and maintenance employment in Alaska is estimated to require between 55 and 60 jobs at 2.25 bcf/d throughput and two operating compressor stations in Alaska. Direct total employment would be increased at least twofold with a throughput of 4.5 bcf/d and 15 or 16 operating compressor stations in Alaska.

Costs

The AAGPC (1974a) states that, at full capacity, the <u>total</u> Fairbanks alternative gas pipeline system will cost $2.2 billion (approximately $1,700,000 more than the applied-for AAGPC route). Costs are greater because more difficult terrain is encountered in crossing the Brooks Mountain Range and the Fairbanks alternative pipeline system is 920 miles longer.

Total operating and maintenance costs are expected to be $50.2 million more annually on the Fairbanks route in Alaska and Canada than the total applied-for AAGPC route because of the longer distance and need for more facilities.

<u>Description of the Environment of the Fairbanks Alternative Route</u>

Climate

The route is entirely within the Arctic and Continental climatic zones of Alaska previously described in 2.1.1.1 and 8.1.1.4. Figures 8.1.1.5-9 A and B show relationship of this alternative to Alaska climatic zones.

Figures 8.1.1.5-10 A and B and 8.1.1.5-11 A and B display mean January minimum and July maximum temperatures along the Fairbanks route. In general, the portion of the Fairbanks alternative south of the Brooks Range is characterized by summer temperatures ranging from 50° to 70° F with extremes of 80° and 100° F. Winter temperatures commonly range from 0° to -20° F, with lows of -60° to -70° F.

Average precipitation in the Continental climatic zone ranges from 8 to 28 inches. Fairbanks, for instance, has a mean annual rate of 11.26 inches. Refer to Figures 8.1.1.5-12 A and B for graphic display of mean annual precipitation along the Fairbanks alternative route. Precipitation is

Table 8.1.1.5-2 Comparison of seasonal mileages and construction spreads

Construction Period	Applied-for Route		Fairbanks Alternative Route	
	Spreads	Miles	Spreads	Miles
1st winter	9	700†	9	735††
1st summer	5	737†	9	952††
2nd winter	9	700†	9	595††
2nd summer	-	-	9	857††
3rd winter	8	492†††	6	410††
TOTAL	31	2629	42	3549

Source AAGPC (1974a)
†Construction in Canada
††Construction location unknown
†††Includes 195 miles AAGPC construction in Alaska (see 1.1.1.1 through .9)

rather evenly distributed throughout the year, with maximums occurring in the summer.

Except for occasional localized conditions, often topographically influenced, winds seldom exceed 10 mph south of the Brooks Range. Winds normally range from 3 to 7 mph along the route with speeds in excess of 45 mph generally considered maximum. During winter, winds are frequently absent for extended periods.

Ice fog, as discussed in 2.1.1.1, is particularly severe in the Fairbanks vicinity. Therefore, it is probable that any village or camp along the Fairbanks alternative route could generate locally severe ice fog conditions during the winter. For a detailed discussion see 8.1.1.5, Air Quality.

Topography

The 735-mile long Alaskan portion of the Fairbanks alternative route crosses eight physiographic provinces from Prudhoe Bay to the United States-Canada border (Figures 8.1.1.5-13 A and B).

Arctic Coastal Plain

The first 60 miles (Prudhoe Bay south to the confluence of the Ivishak River with the Sagavanirktok River) are located in the Arctic Coastal Plain. (See 2.1.1.2.)

Arctic Foothills

The Arctic Foothills also are described in the applied-for AAGPC route (2.1.1.2) from sources in the Brooks Range.

This segment of the Fairbanks alternative route begins a few miles north of Sagwon near the confluence of the Sagavanirktok and Ivishak Rivers and ends about 75 miles to the south at the confluence of the Sagavanirktok and Atigun Rivers. The generally unvegetated, active flood plain is underlain by sand and gravel, and the bordering, vegetated low terraces are underlain by similar materials, but in addition are mantled by a few feet of silt and sand, which in many places is ice-rich.

Brooks Range

The Fairbanks alternative route enters the Brooks Range (section 8.1.1.3, Interior Alternative) south of Galbraith Lake in the Atigun River Valley. Some of the unconsolidated deposits are ice-rich, especially south of Galbraith Lake. Locally, the route skirts talus and landslide debris. The Continental Divide is underlain by talus and rubble mantling bedrock. Once through the divide, the route follows the upper reaches of the westernmost fork of the Chandalar River and is underlain by a veneer of generally frozen glacial silt, sand, and gravel over bedrock. Locally, those surficial deposits are ice-rich. The route leaves the Chandalar River Valley about 10 miles south of the divide and enters the Dietrich River drainage and then the Middle Fork of the Koyukuk River drainage. It leaves the Brooks Range at Coldfoot.

Near the Fairbanks alternative route bedrock is chiefly Paleozoic limestone, shale, quartzite, slate, and schist. Northeast of the

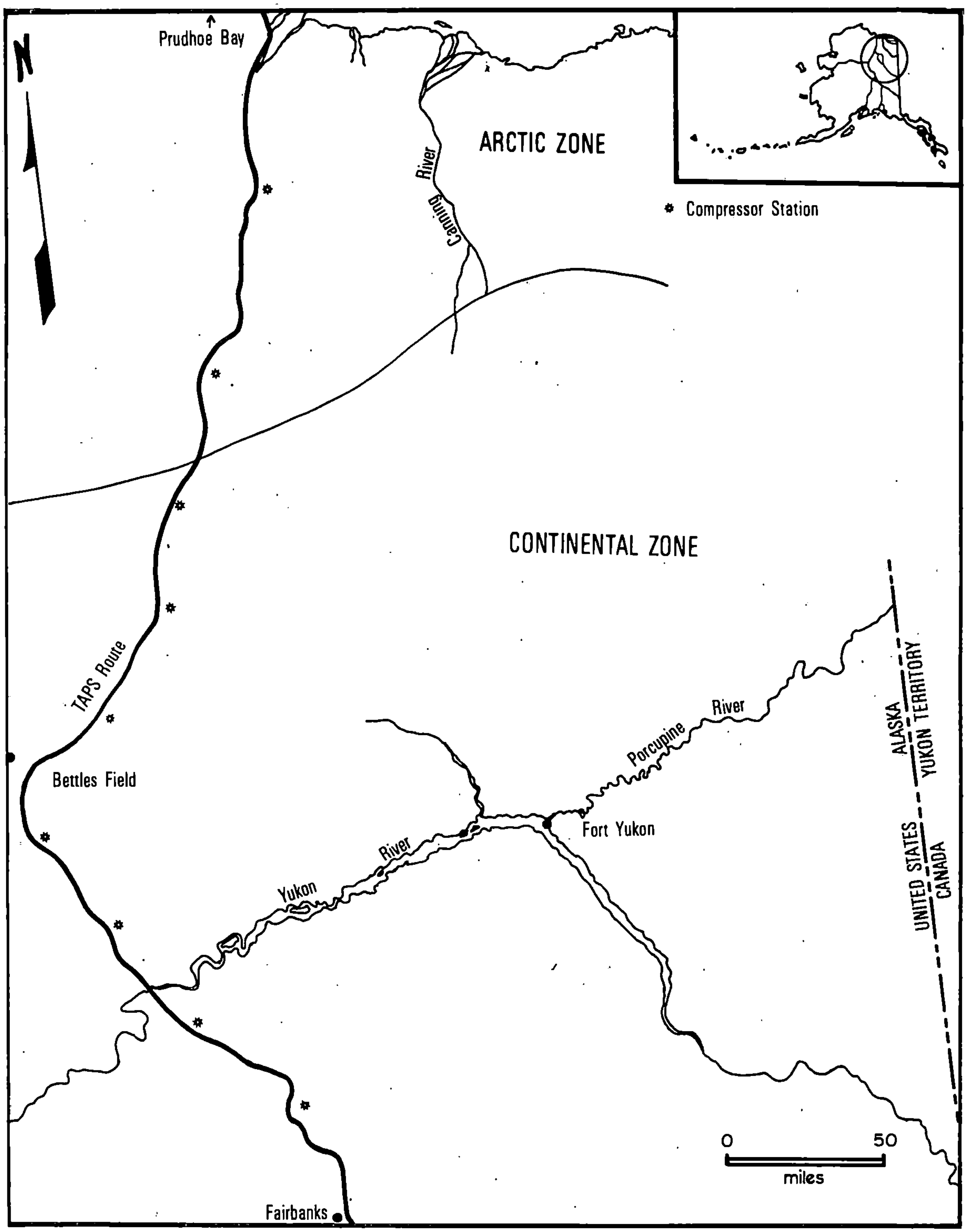


Figure 8.1.1.5-9A Climatic zones associated with the Fairbanks alternative route

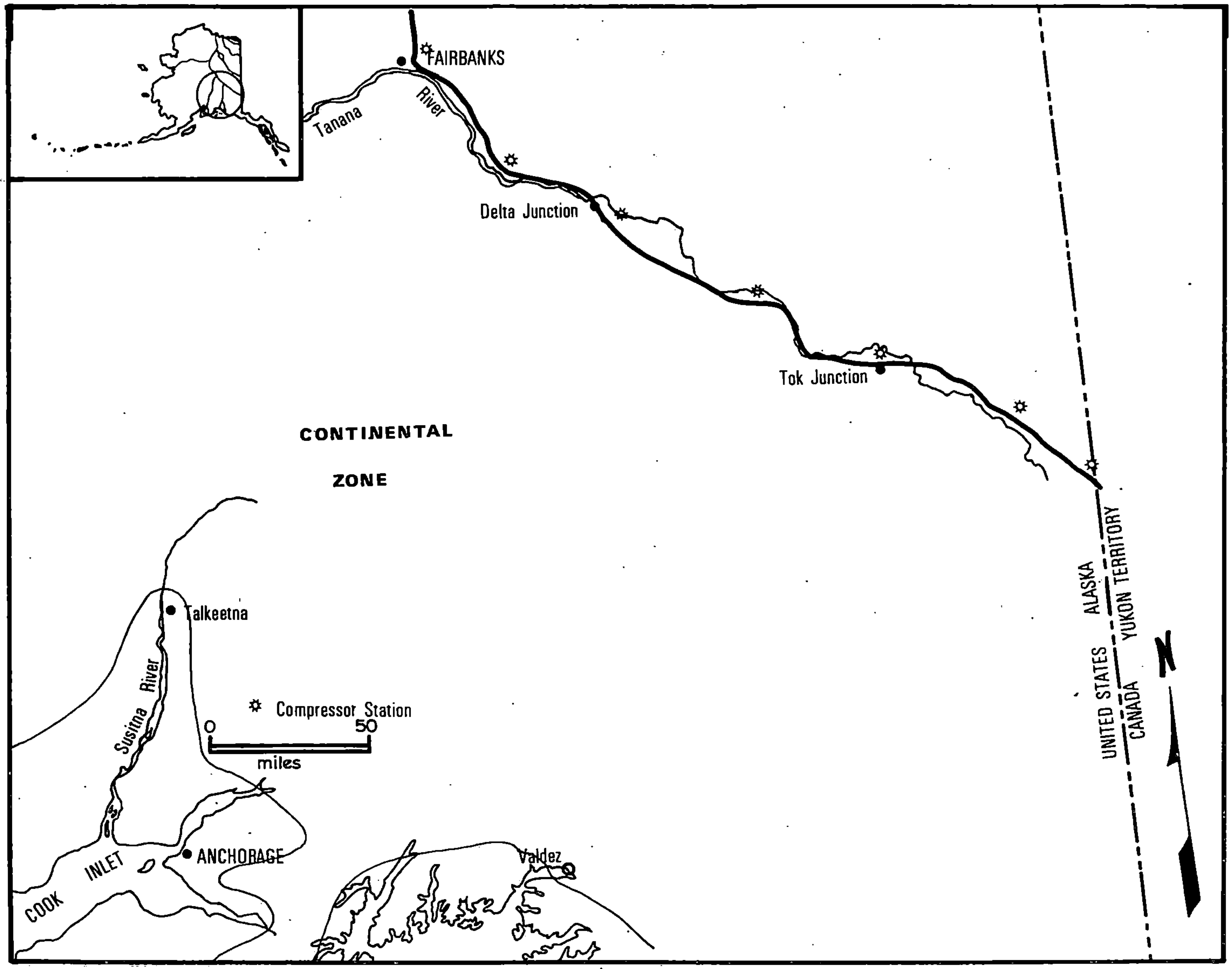


Figure 8.1.1.5-9B Climatic zones associated with the Fairbanks alternative route

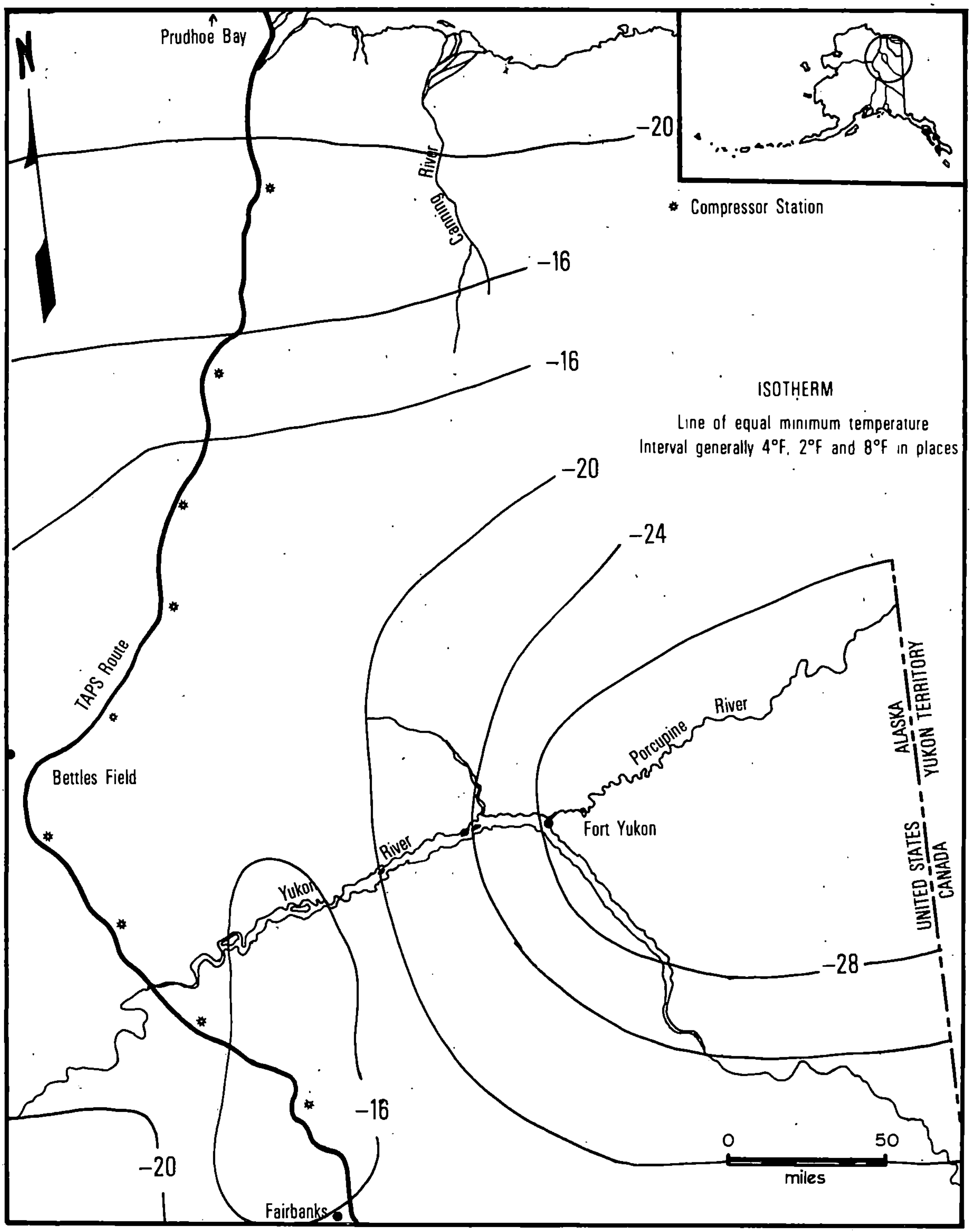


Figure 8.1.1.5-10A Climatic mean January minimum temperatures in °F along the Fairbanks alternative route

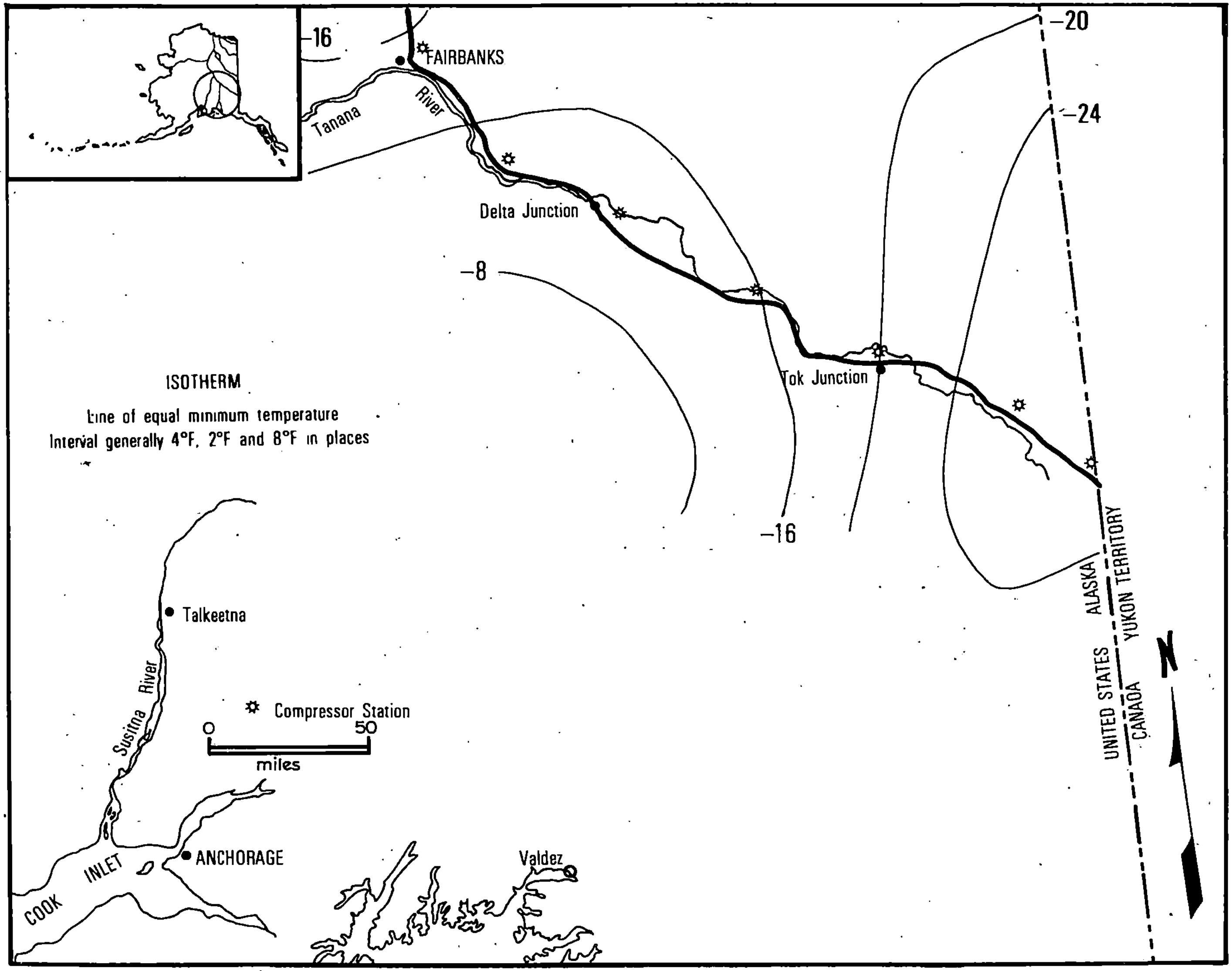


Figure 8.1.1.5-10B Climatic mean January minimum temperatures in °F along the Fairbanks alternative route

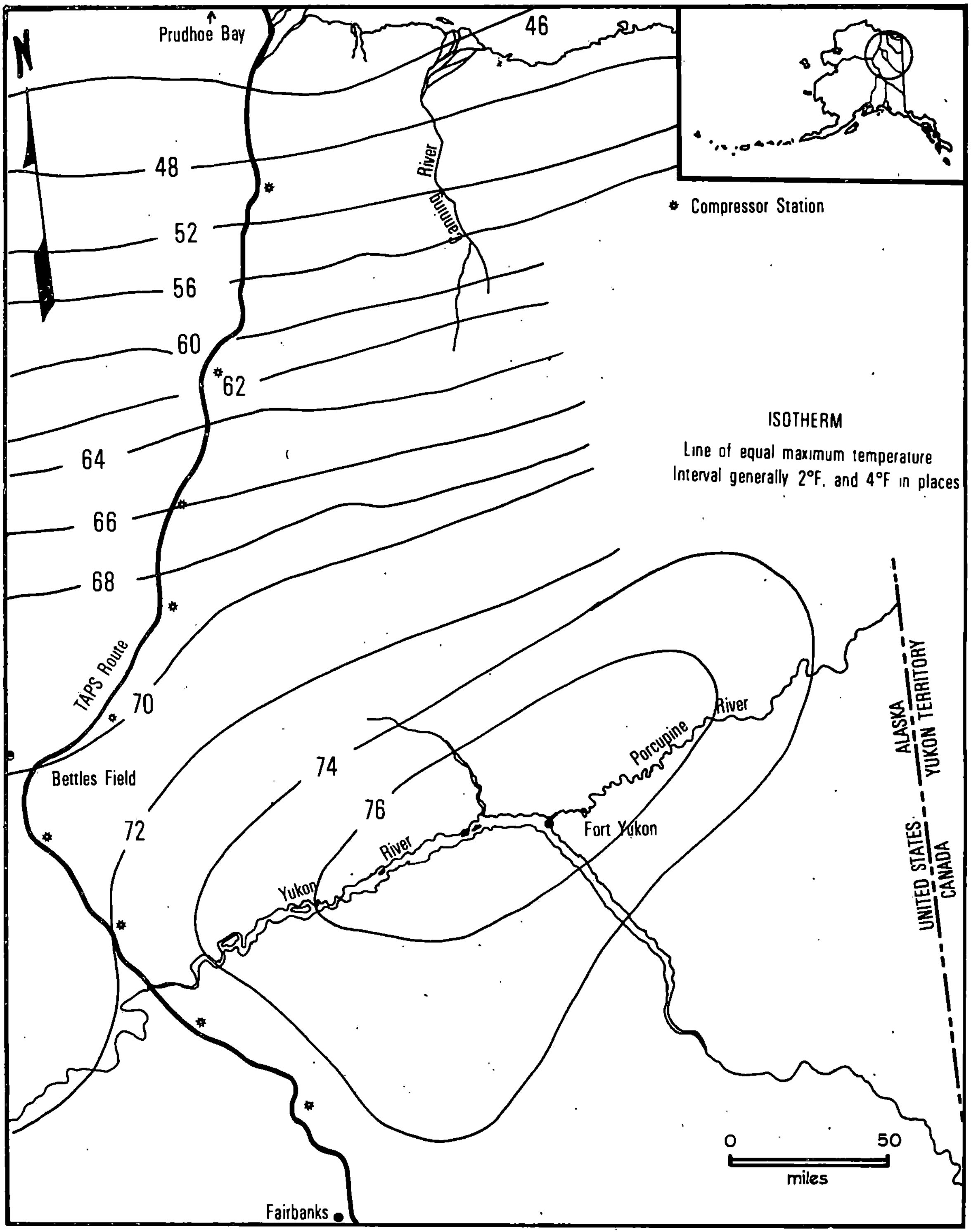


Figure 8.1.1.5-11A Climatic mean July maximum temperatures in °F along the Fairbanks alternative route

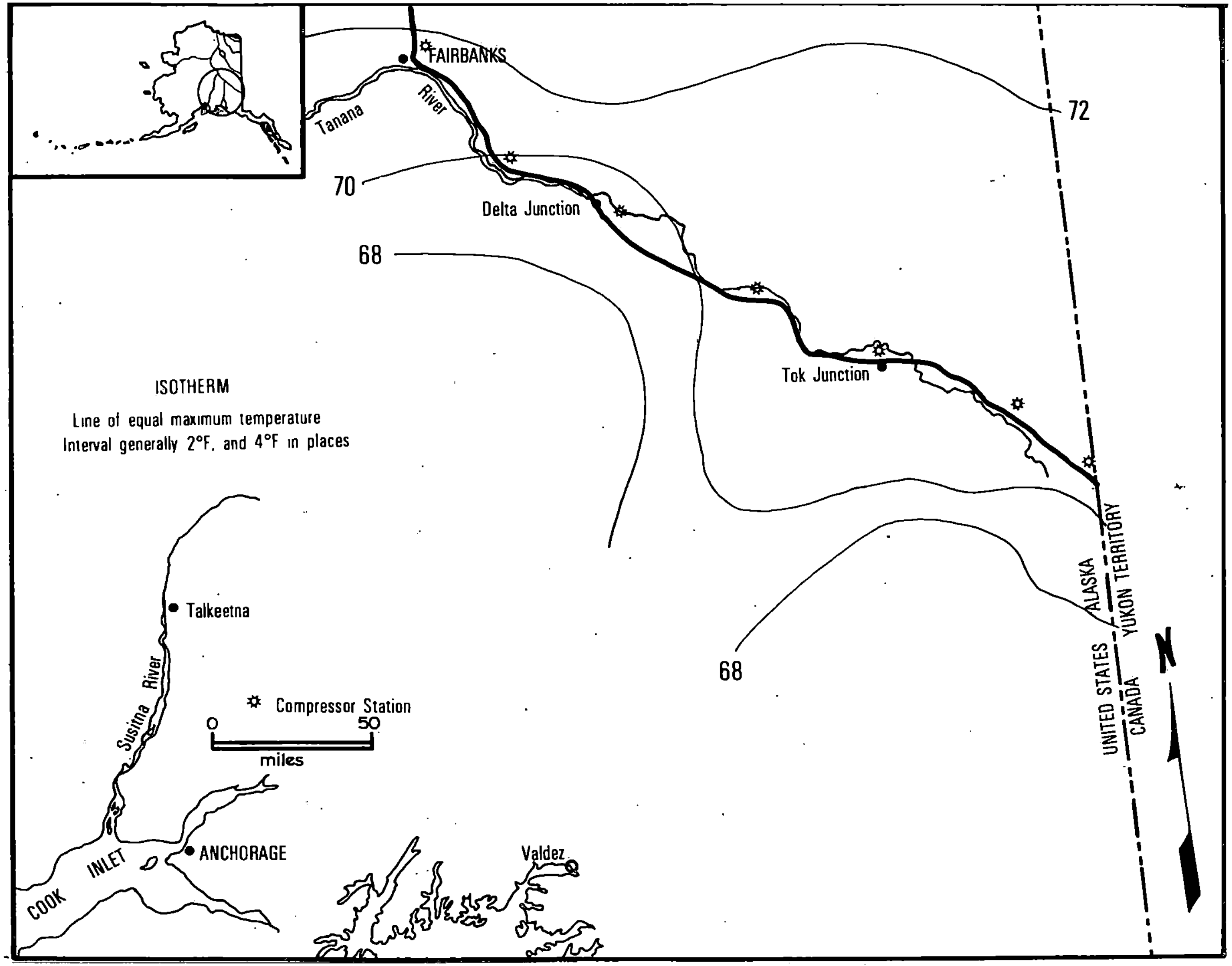


Figure 8.1.1.5-11B Climatic mean July maximum temperatures in °F along the Fairbanks alternative route.

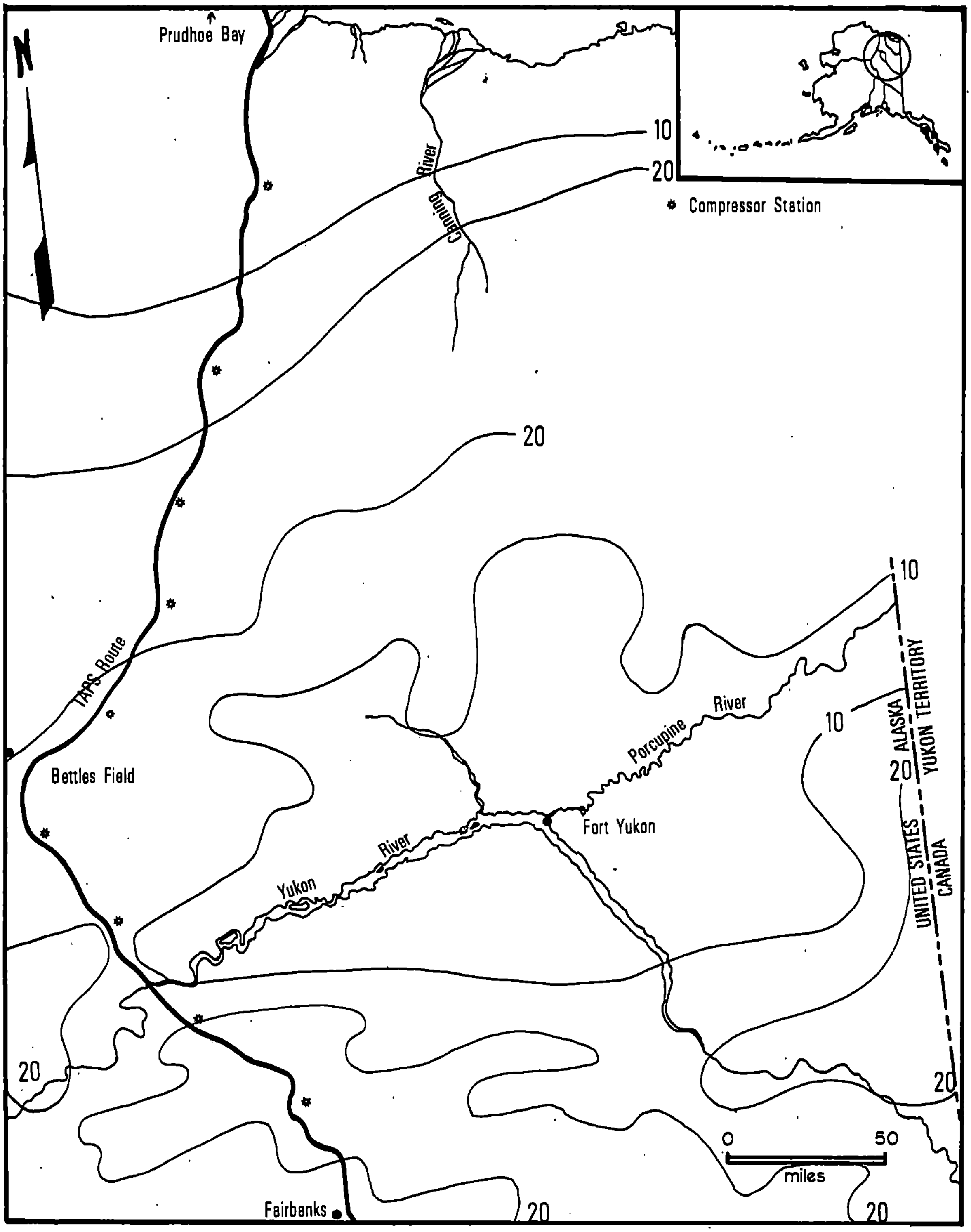


Figure 8.1.1.5-12A Climatic mean annual precipitation zones associated with the Fairbanks alternative route

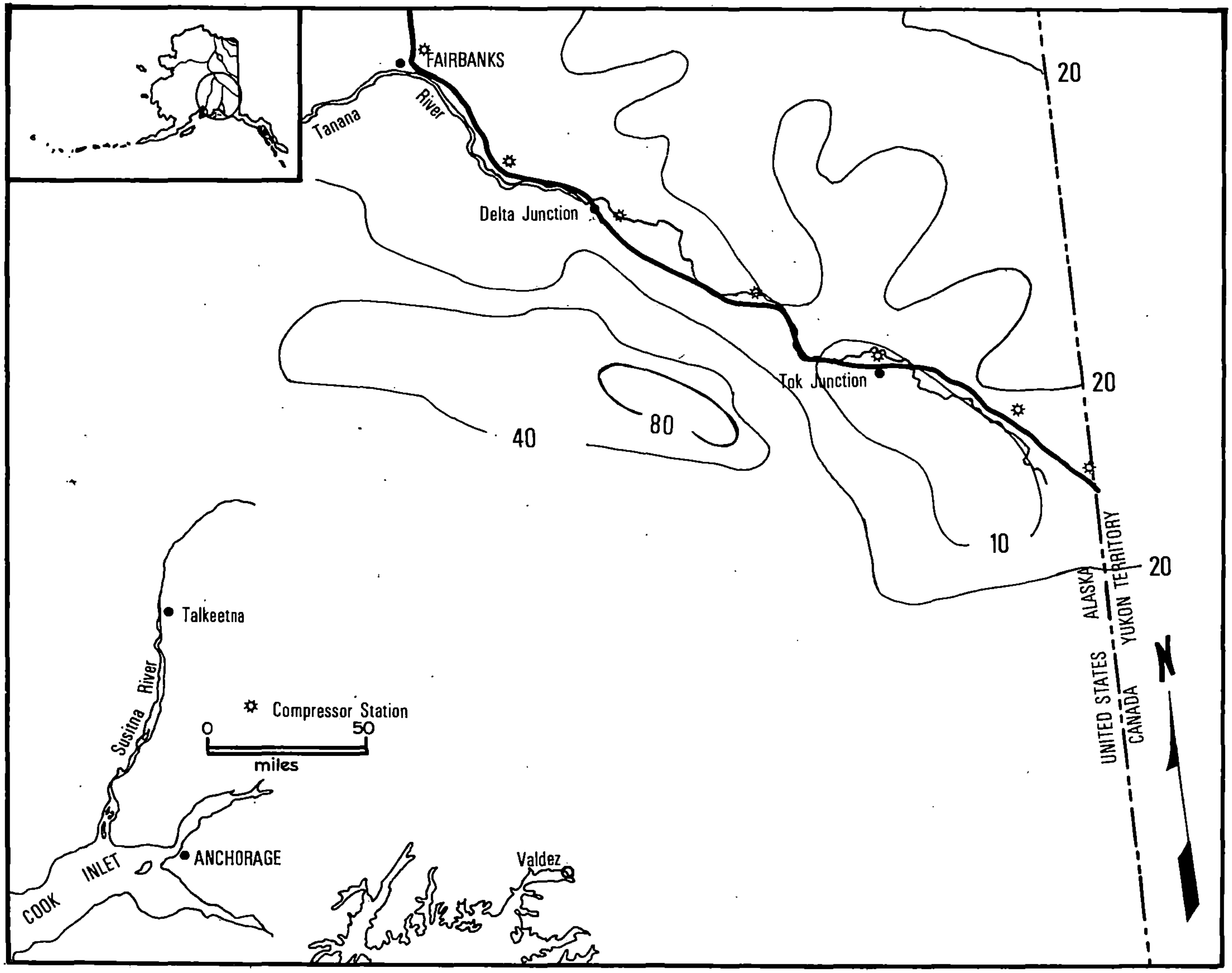


Figure 8.1.1.5-12B Climatic mean annual precipitation zones associated with the Fairbanks alternative route

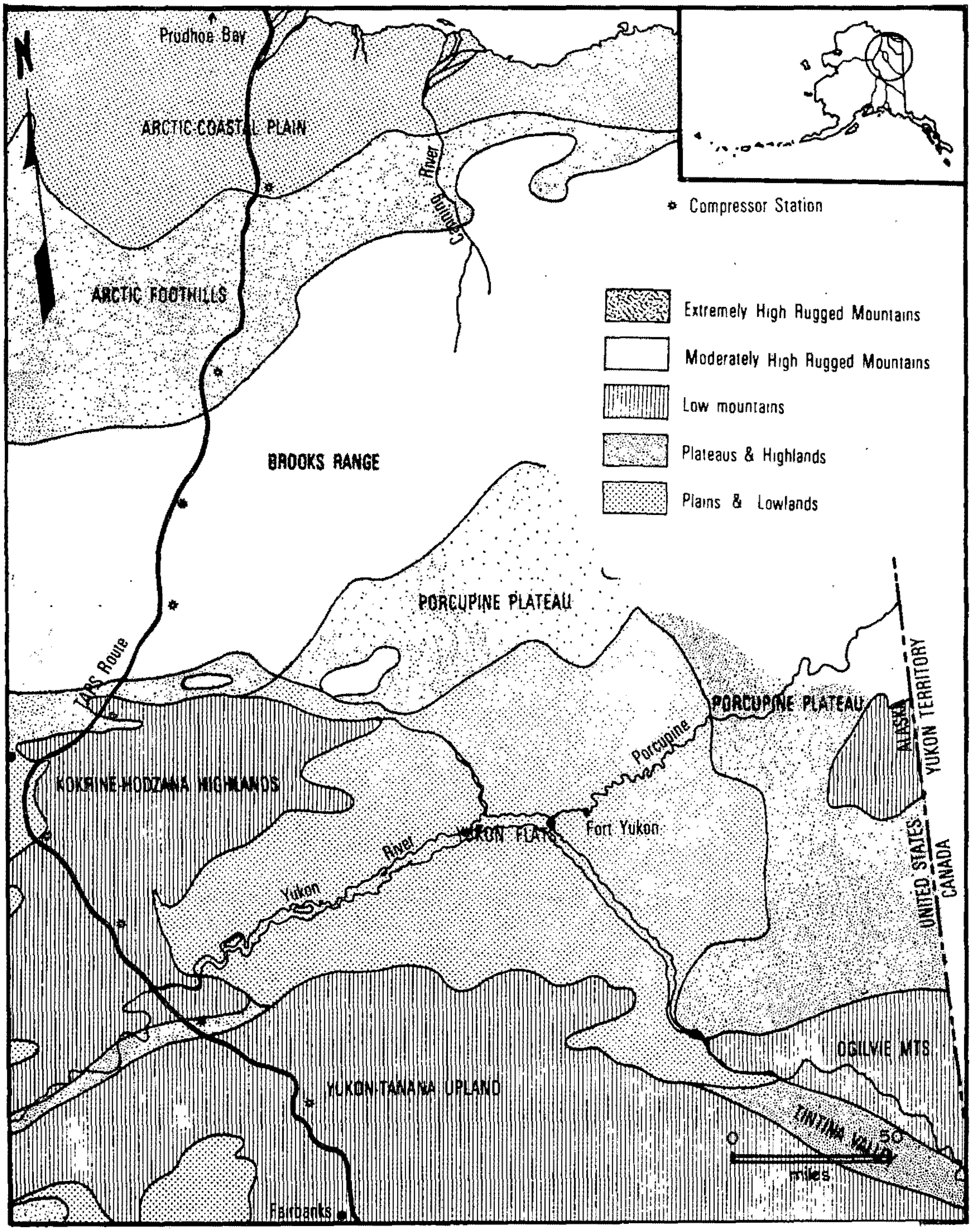


Figure 8.1.1.5-13A Physiography of the Fairbanks alternative pipeline route

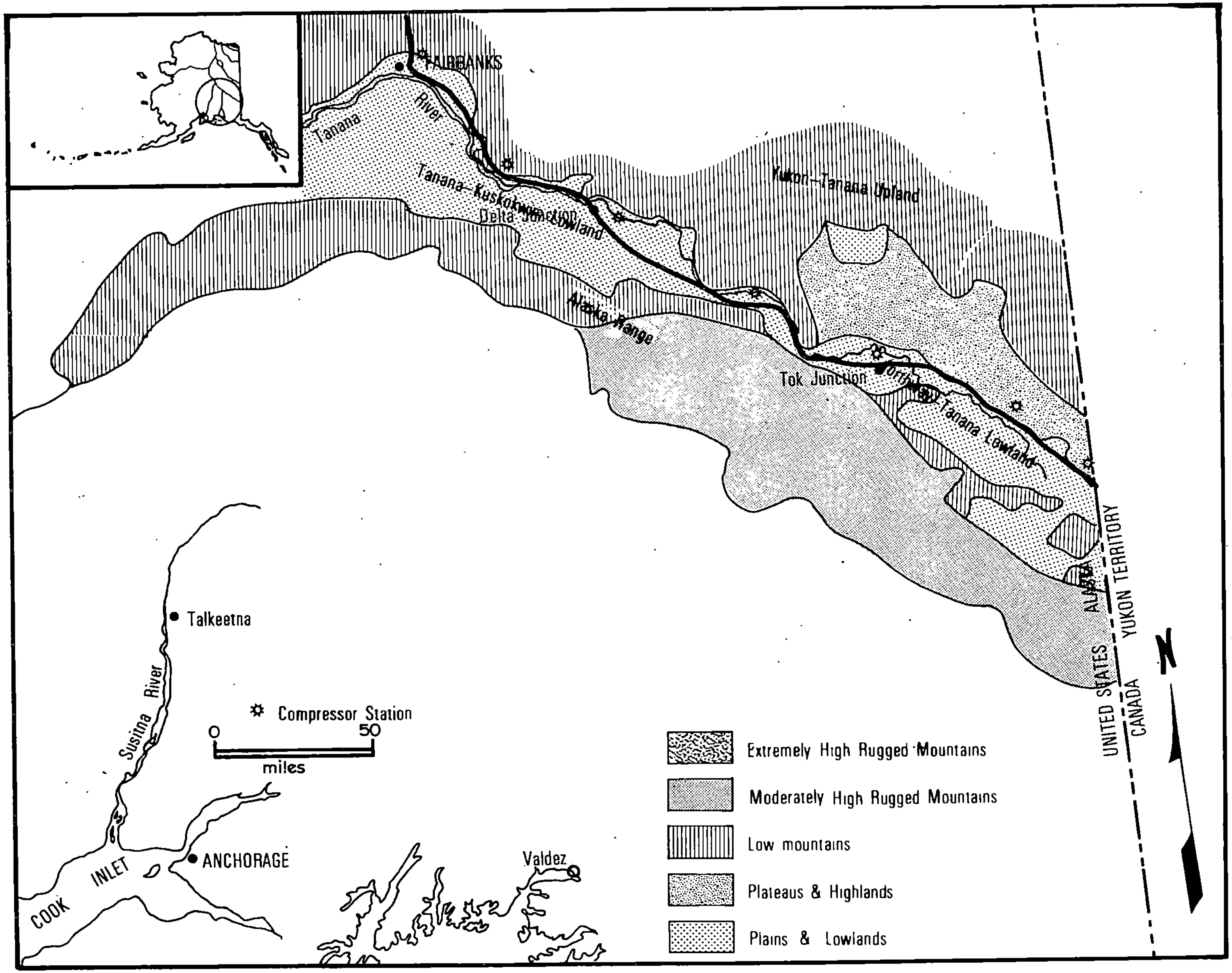


Figure 8.1.1.5-13B Physiography of the Fairbanks alternative pipeline route

Sagavanirktok River the Paleozoic rocks are in faulted folds overturned to the north. Elsewhere, they are in giant plates or nappes thrust to the north. The deformation is of late Mesozoic-early Tertiary age. The north front of the range is made of light-colored cliff-forming Mississippian limestone. Rocks south of lat. 68° N. are metamorphosed and generally equivalent in age to those farther north.

Ambler-Chandalar Ridge and Lowland

The Fairbanks alternative route enters the Ambler-Chandalar Ridge and Lowland at Coldfoot and leaves it at the South Fork of the Koyukuk River. This province consists of one or two east-trending series of lowlands and low passes 3 to 10 miles wide and 200 to 2,000 feet above sea level bordered on the north by the abrupt front of the Brooks Range. Along the south side is a discontinuous line of rolling to rugged ridges, 25 to 75 miles long and 5 to 10 miles wide, rising to 3,000 to 4,500 feet in altitude. Some of these ridges were intensely glaciated. Within the lowlands are east-trending ridges 5 to 10 miles long.

The western part of the section is drained by tributaries of the Kobuk River; the central part, by the Koyukuk River and its tributaries; and the eastern part, near the route, by the Chandalar River. The drainage was probably superposed but may have been disoriented later by glaciers. The flood plains of the major streams have thaw lakes and oxbow lakes.

The ridges are composed in part of resistant massive greenstone (metamorphosed basalt) of Mesozoic age. The lowlands are underlain largely by Cretaceous sedimentary rocks, folded into anticlines and synclines. Pleistocene glaciers from the Brooks Range extended across the lowland and through passes in the line of ridges.

Kokrine-Hodzana Highlands

The Kokrine-Hodzana Highlands consist of even-topped rounded ridges rising to 2,000 to 4,000 feet in altitude surmounted by isolated areas of more rugged mountains. Valleys have alluviated floors to within a few miles of their heads.

The irregular drainage divide between the Yukon River and its large tributary, the Koyukuk River, passes through these highlands.

The highlands are underlain chiefly by Paleozoic and Precambrian schist and gneiss having a northeast-trending structural grain, cut by several granitic intrusions, the largest of which is the granite batholith that upholds the Ray Mountains.

This segment of the Fairbanks alternative routing begins at the South Fork of the Koyukuk River and ends north of Hess Creek. The Yukon River, the largest stream crossed by the route, is the Kokrine-Hodzana Highlands physiographic unit.

Rampart Trough

The Rampart Trough is a structurally controlled depression having gently rolling topography 500 to 1,500 feet in altitude; it is incised 500 to 2,500 feet below highlands on either side.

The Yukon River enters the northeastern part of the trough through a narrow rocky gorge and swings in broad bends from one side of the trough to the other within a narrow flood plain. The Yukon and its tributaries appear to have been superposed from a surface at least 1,500 feet in altitude. Scattered thaw lakes lie on the Yukon flood plain and elsewhere in the trough. The Rampart Trough was eroded along a tightly folded belt of soft continental coal-bearing rocks of Tertiary age. Hard-rock hills and the surrounding uplands are partly metamorphosed sedimentary and volcanic rocks of Mississippian age that strike about N. 60° E. and are cut by granitic intrusions.

The Fairbanks Route enters the Rampart Trough unit north of Hess Creek, crosses the creek north of its confluence with Erickson Creek, and leaves Rampart Trough unit a few miles south of Hess Creek.

Yukon-Tanana Upland

The route enters the Yukon-Tanana Uplands south of Hess Creek and leaves it at Shaw Creek Flats.

The Yukon-Tanana Upland is the Alaskan equivalent of the Klondike Plateau in Yukon Territory. Along with the Rampart Trough and the Kokrine-Hodzana Highlands, it belongs to the Northern Plateaus physiographic province of the Intermontane Plateaus system. Rounded even-topped ridges with gentle side slopes characterize this region of broad undulating divides and flat-topped spurs. In the western part, near the route, these rounded ridges trend northeast to east; they have ridge-crest altitudes of 1,500 to 3,000 feet and rise 500 to 1,500 feet above adjacent valley floors. The ridges are surmounted by compact rugged mountains 4,000 to 5,000 feet in altitude. Valleys in the western part are generally flat, alluvium floored, and 1/4 to 1/2 mile wide to within a few miles of headwaters.

The entire section is in the Yukon drainage basin. Streams flow south to the Tanana River and north to the Yukon River. Most streams in the western part follow courses parallel to the structural trends of bedrock, and several streams have sharp bends involving reversal of direction around the ends of ridges of hard rock. Drainage divides are very irregular. Small streams tend to migrate laterally southward. The few lakes in this section are mainly thaw lakes in valley floors and low passes.

A belt of highly deformed Paleozoic sedimentary and volcanic rocks containing conspicuous limestone units, overthrust and overturned to the north, extends along the north side of the upland. The rest of the upland is chiefly Precambrian schist and gneiss but has scattered small elliptical granitic intrusions in the northwestern part; large irregular batholiths make up much of the southeastern part. In the western part a thick mantle of windborne silt lies on the lower slopes of hills, and thick accumulations of muck (frozen fine-grained sediments with a high organic content) overlie deep stream gravels in the valleys. Pingos are common in valleys and on lower hill slopes.

Tanana-Kuskokwim Lowland

The Tanana-Kuskokwim Lowland is a broad depression bordering the Alaska Range on the north; its surfaces are of diversified origin. Coalescing outwash fans from the Alaska Range slope 20 to 50 feet per mile northward to flood plains along the axial streams of the lowland. Rivers from the range flow for a few miles at the heads of the fans in broad terraced valleys 50 to 200 feet deep. Semicircular belts of morainal topography lie on the upper ends of some fans. Thaw lakes abound in areas of fine alluvium, and thaw sinks are abundant in areas of thick loess cover.

The outwash fans grade from coarse gravel near the Alaska Range to sand and silt along the axial streams. Areas north of the axial streams are underlain by thick deposits of "muck," a mixture of frozen organic matter and silt. Parts of the southwestern part of the lowland have thick loess cover, but the central and eastern parts are free of loess south of the Tanana River. Scattered low hills of granite, ultramafic rocks, and Precambrian schist rise above the outwash. Tertiary conglomerate in the foothills of the Alaska Range plunges beneath the lowland in a monocline, and the heads of the outwash fans may rest on a pediment cut across the conglomerate. The base of the alluvial fill near Fairbanks is at or below sea level.

This segment of the Fairbanks alternative route begins at Shaw Creek and ends south of Fort Greely. Geologic units to be traversed include frozen ice-rich silts over alluvial gravels from Shaw Creek across the Shaw Creek Flats, frozen silt (loess) over bedrock (schist) from the southern end of Shaw Creek Flats to the Tanana River, and generally thawed gravels and sands of alluvial origin from the Tanana River to south of Fort Greely.

From Fairbanks eastward to Tetlin Junction, the route follows the floor of the Tanana River Valley. It rises gradually in altitude from about 430 feet above sea level at Fairbanks to 1,680 feet farther upvalley near Tetlin Junction. Its width, about 25 miles near Delta Junction, decreases to 1 mile near Cathedral Bluffs and then increases again to 14 miles near the confluence of the Tok River. This section of the Fairbanks route is flanked to the south by the steep, glaciated ridges and plateaus of the Alaska Range, which rise to altitudes of 5,000 to 7,000 feet. It is flanked to the north by the Tanana River, which flows along the edge of the Yukon-Tanana Upland. Through this section, the route crosses a series of broad outwash fans derived from the Pleistocene glaciation of the Alaska Range. Across the initial 45 miles from Delta Junction to George Lake Lodge, the terrain is nearly flat and relatively well drained, with local relief of 100 feet or less. The route here lies almost entirely upon outwash aprons, which now stand well above modern flood plain levels of the Tanana River and its tributaries. Farther to the east, between George Lake and Tanacross, the terrain becomes more variable in composition and relief. The Tanana Valley is narrower here, and the route is compressed into a zone which is closely confined by the Tanana River and the north flank of the Alaska Range. It crosses hummocky moraine belts near the Johnson and Robertson Rivers, and fluvial surfaces ranging from outwash terraces to modern river flood plains predominate in most of the intervening areas. Colluvial deposits and bedrock also occur locally. The final 25 miles between Tanacross and Tetlin Junction cross massive outwash fans of the Tok River. These outwash surfaces tend to be nearly flat and very well drained. Local relief is negligible except where streams crossing the route are incised.

The route crosses the Tanana River near Tetlin Junction, then follows the valleys of the Tanana and Chisana Rivers southeastward toward the Canadian border. Its altitude rises gradually from 1,680 feet at the Tanana River crossing to about 1,850 feet at the Canadian border, with local relief usually 200 feet or less. This segment of the route is closely flanked to the north by the gently rounded ridges and nearly level upland surfaces of the Yukon-Tanana Upland, which rise to generally accordant altitudes of 3,000 to 3,400 feet. It is bordered to the south by the Tanana and Chisana Rivers and by the broad, lake-studded valley floor which attains a maximum width of 30 miles near the mouth of the Nabesna River. Foothills of the Alaska Range, 3,000 to 6,000 feet in altitude, flank the southern margin of the valley.

From Tetlin Junction to Paradise Hill, the corridor follows the valley floor and crosses mainly surficial deposits of late Quaternary age. The final 15 miles between Paradise Hill and the border traverse part of the Yukon-Tanana Upland. Low, bedrock-cored hills here alternate with muck-filled valleys.

Geology and Soils

Mineral Resources

1) Oil and gas - The Fairbanks alternative route will serve the Prudhoe Bay oil and gas fields as does the applied-for AAGPC pipeline system. It likewise serves the 19,504 square mile Yukon-Kandik province (as would the Interior and Fort Yukon alternative routes). Additionally, the Fairbanks alternative would serve the 5,440 square mile Middle Tanana basin (0.08 billion barrels of oil and 0.55 trillion cubic feet of gas). It also might serve the 3,840 square mile Copper River basin (0.16 billion barrels of oil and 1.20 trillion cubic feet of gas). (Alaska Open File Report #50, 1974) Figures 8.1.1.5-14 A and B show the location of these basins and the alternative Fairbanks route.

2) Coal - Scattered outcrops of subbituminous and lignite coals occur north and south of the Brooks Range and north of the Alaska Range. Reserves within 50 miles either side of the route exceed 77 million tons.

3) Minerals - A large number of mining claims have been located along the south flank of the Brooks Range and in the Livengood and Fairbanks areas. Most of these claims are for placer gold; however, several are for copper, lead, zinc, and antimony.

The Fairbanks alternative gas pipeline route crosses many metallogenic provinces starting in the Brooks Range and continuing southward. Most of these provinces have good to high potentials for gold, lead, zinc, antimony, and molybdenum. Refer to Figures 8.1.1.5-15 A and B.

Stratigraphy and/or Lithology

The following highlights bedrock characteristics along the route between Fairbanks and the United States-Canada border.

Schist predominates within the metamorphic assemblage, with gneiss and quartzite also present (Foster, 1970; Krinsley et. al., 1971). Granitic rocks of Mesozoic age form widespread and abundant intrusions into the metamorphic terrain. Tertiary volcanic rocks and related intrusions also are present, but they occupy a relatively limited area north of the route segment between Tanacross and Tetlin Junction. Tertiary units include basalt, gabbro, syenite, and undifferentiated mafic and felsic volcanic rocks (Foster, 1970). Refer to Figures 8.1.1.5-16 A and B.

Bedrock of the Yukon-Tanana Upland is particularly significant in planning a pipeline route east of Tetlin Junction, where the Fairbanks route lies north of the Tanana River. Between Tetlin and Northway Junctions, granitic rocks are the prevalent lithology marginal to the route, with gneiss, schist, and quartzite of the metamorphic assemblage present along a 10-mile stretch close to Northway (Foster, 1970). Farther to the southeast, the route is flanked to the north by granitic plutons, then by Quaternary sediments, and finally by a metasedimentary assemblage (phyllite, metaconglomerate, quartzite, and schist) through the final 11 miles across the Upland to the Canadian border (Richter, 1973).

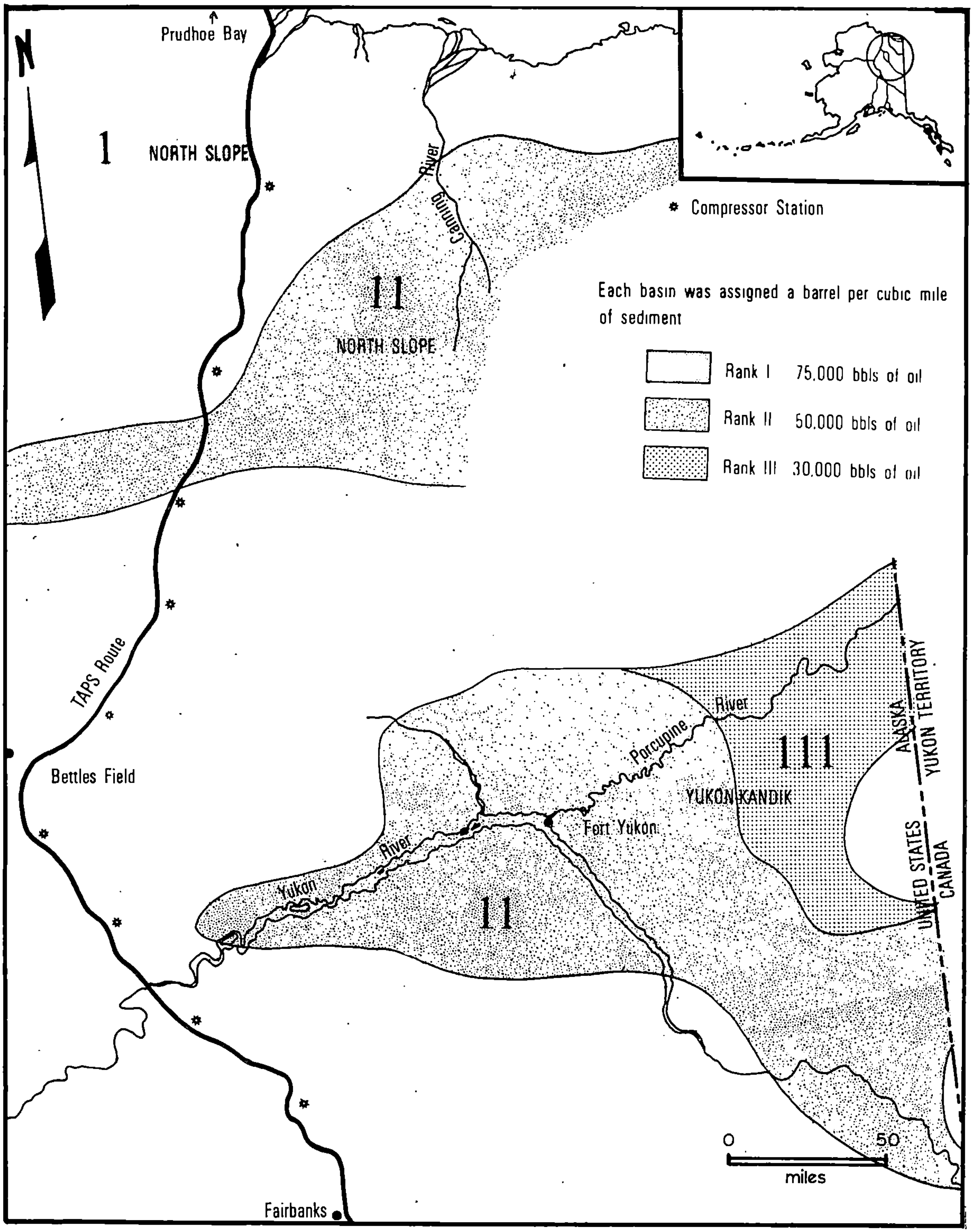


Figure 8.1.1.5-14A Oil and gas basins of the Fairbanks alternative pipeline route

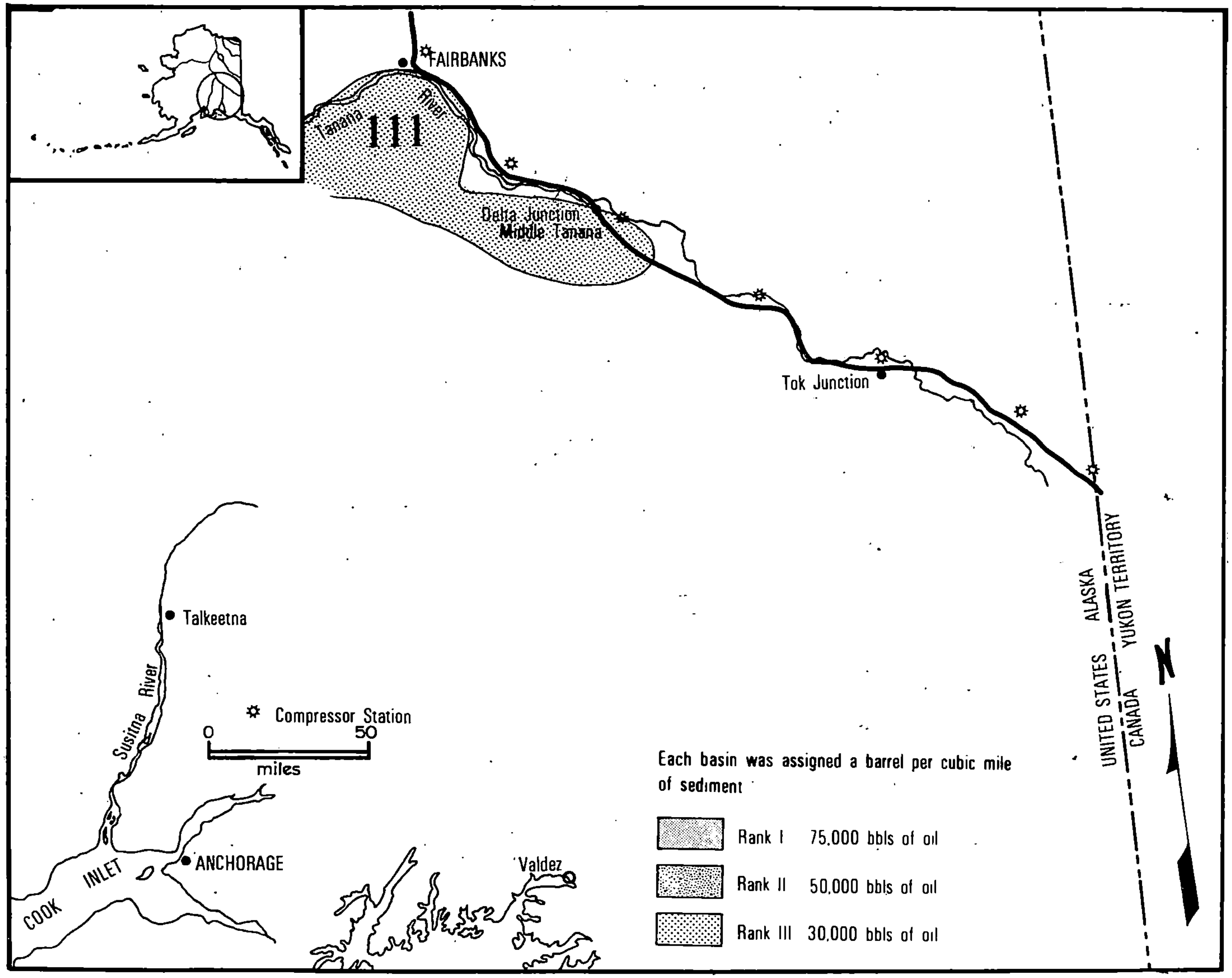


Figure 8.1.1.5-14B Oil and gas basins of the Fairbanks alternative pipeline route

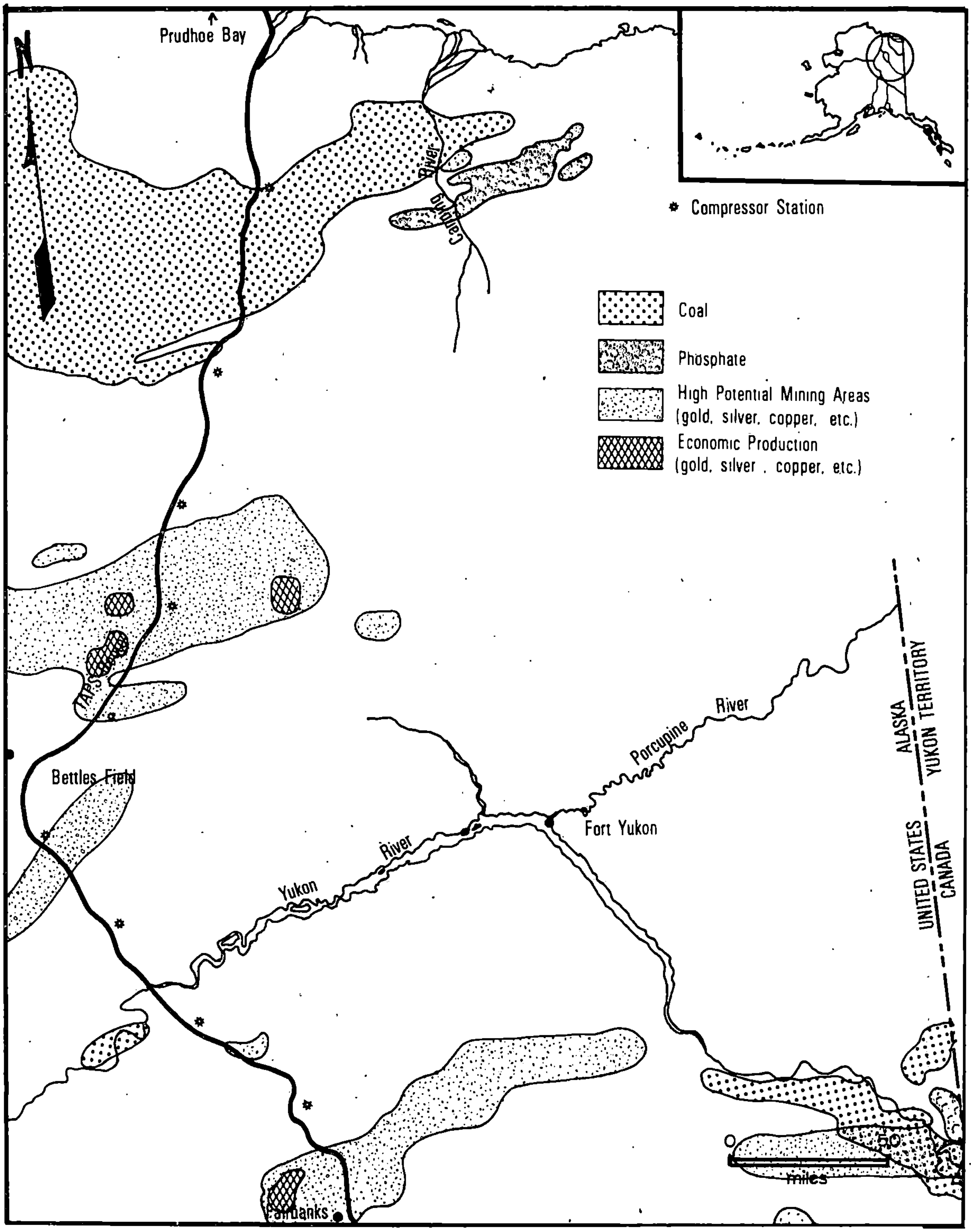


Figure 8.1.1.5-15A Mineral resources of the Fairbanks alternative pipeline route

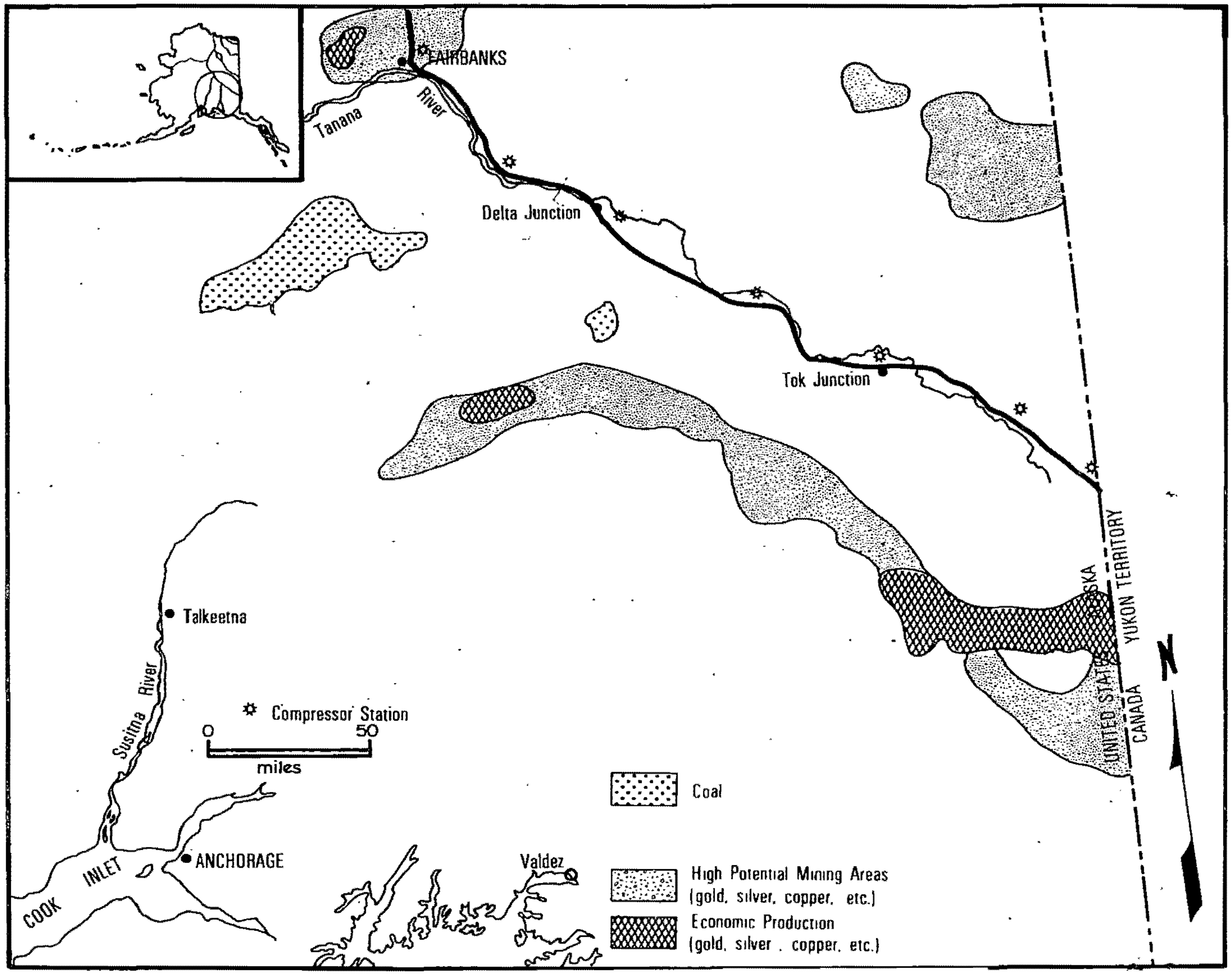


Figure 8.1.1.5-15B Mineral resources of the Fairbanks alternative pipeline route

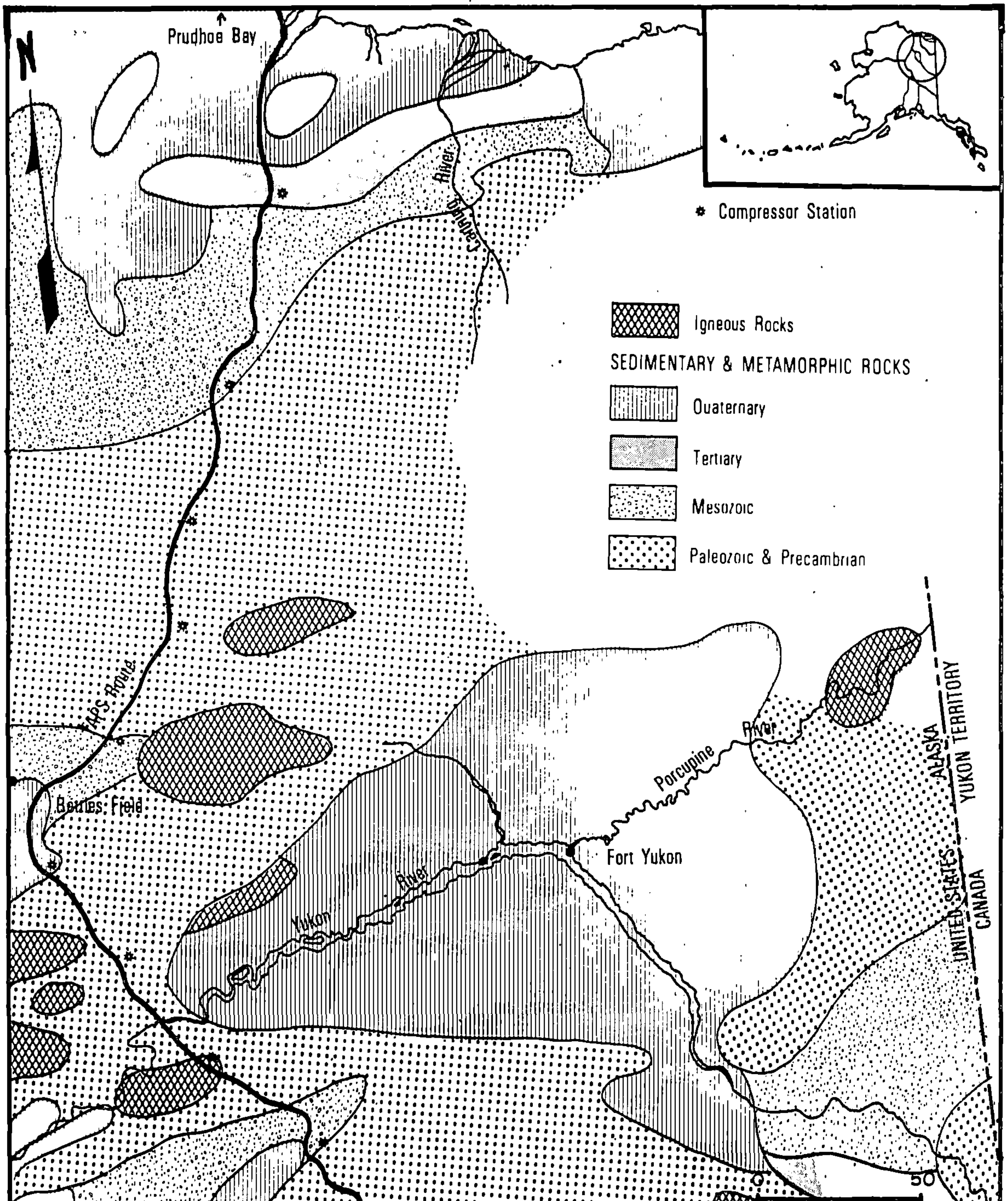


Figure 8.1.1.5-16A Geology of the Fairbanks alternative pipeline route

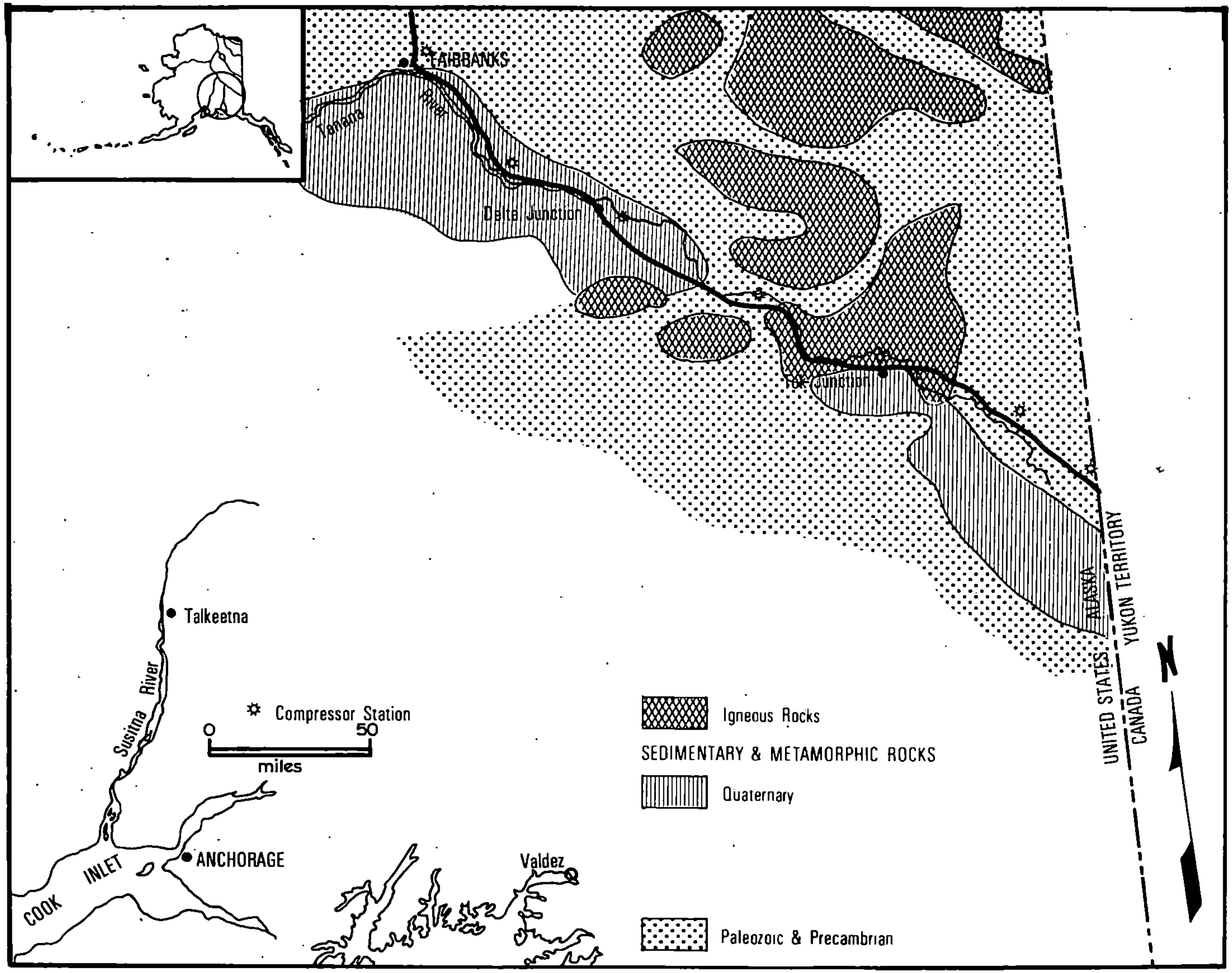


Figure 8.1.1.5-16B Geology of the Fairbanks alternative pipeline route

To the south, similar igneous and metamorphic rocks comprise the outer ridges, mountain blocks, and plateaus of the Alaska Range (Krinsley et al., 1971). Granitic rocks comprise most of Granite Mountain, a prominent northward protrusion of the Alaska Range between the Delta and Gerstle Rivers (Pewe and Holmes, 1964). Another large granitic intrusion borders the route between Johnson River and Dot Lake (Holmes and Foster, 1968). Gneiss, schist, and phillite predominate along the Alaska Range front from Dot Lake southeast to the Tanana River crossing near Tetlin Junction (Foster, 1970). Bedrock south of the route becomes significant again only within 15 miles of the Canada border, where the route traverses the metasedimentary assemblage described previously.

Straight parallel ridges and valleys suggest a northeast-striking structural trend through much of the area. A second trend at right angles is nearly as well developed, causing a roughly rectangular topographic pattern that is particularly well displayed on satellite photographs of this part of Alaska (Lathram, 1972). This pattern is partly obscured in areas of Cenozoic volcanism and intrusion (Foster, 1970), suggesting that it may have originated in pre-Tertiary time.

The Denali fault, a major structural feature which has been active in Holocene time, lies about 30 miles south of the route. It parallels the corridor through east-central Alaska, and intersects it 90 miles on the Canadian side of the Alaska-Yukon border.

Additional faults in the area have been mapped by Richter (1973), Foster (1970), Holmes and Foster (1968) Dewe and Holmes (1964), and Hamilton (1973). The first three of these reports show no faults cutting Quaternary sediments; the last two show several faults which appear to have remained active into Quaternary time.

Permafrost

Approximately 230 miles (31 percent) of the Fairbanks alternative route is located in a zone of continuous permafrost. Because the route generally traverses the flood plain of large rivers, permafrost is not usually near the surface. The remainder of the route (550 miles, 69 percent) discontinuous permafrost. (Figures 8.1.1.5-17 A and B.)

Throughout the entire 735-mile length, frozen zones include interstitial ice, massive ice lenses, and ice wedges in fine-grained soils. In frozen land or gravels, the ice generally occurs as coatings on clasts or as void fillings. Locally ice-wedge polygons, solifluction lobes, and pingos may be found.

Between Delta and Tetlin Junctions the permafrost table usually lies at a depth of 3 to 4 feet. Masses of perennially frozen ground are present here within fine-grained deposits such as colluvium, flood plain silts, peat deposits and loess (Holmes and Foster, 1968). The sites most favorable for near surface permafrost are:

> ...bogs and muskegs on kettles, abandoned channels, low flood plains and terraces, the piedmont and minor valleys of the Alaska Range foothills, poorly drained uplands of the foothills, and northward-facing slopes or the floors of minor valleys in the Tanana-Yukon Upland.

Although detailed data are lacking, permafrost probably is both thicker and more extensive in the unglaciated and slightly higher terrain along the route between Tetlin Junction and the Alaska-Yukon border. Scattered lenses of permafrost occur at depths of 2.5 to 3.5 feet in the dune deposits between Tetlin Junction and Northway Junction (Krinsley et al., 1971).

Soils

Soils of the Arctic Coastal Plain and Foothills are those already described in the applied-for AAGPC route, (2.1.1.4), the poorly drained loamy soils with overlying peat layer on the coastal tundra and uplands and the poorly drained gravelly and sandy soils in major drainages. Erosion potentials are low to moderate.

Soils of the coastal plain contain extremely ice-rich silt and fine sand overlying frozen sand and gravel. The mantle of silt and fine sand generally ranges from 5 to 15 feet in thickness. The underlying sand and gravel unit exceeds several hundred feet in thickness at the north end of this segment, but thins to the south.

Only the gravelly soils of steep slopes and sandy soils of drainages are relatively well drained and permafrost-free in the upper layer. In the Foothills, valley floors are generally flanked with slopes mantled by thick silty soils over bedrock. These silty soils, usually are extremely ice-rich.

In the discontinuous permafrost zone soils are composed of reworked windblown silt, frozen and unfrozen colluvial silt, sand and rock fragments, alluvial silt, sand and gravel, and dune sand. North of Fairbanks unconsolidated sediments are generally frozen and locally ice-rich. South of Fairbanks, much of the area is thawed; however, there are large accumulations of ice in some of the sediments, especially the fine-grained reworked silt.

Generalized location of soils of the Fairbanks alternative route are shown in Figures 8.1.1.5-18 A and B are summarized in Table 8.1.1.5-3. These include poorly drained, medium-textured soils with peaty surface layers of permafrost in drainages of major rivers, narrow stream valleys and on low slopes. Well-drained gravelly brown soils without permafrost occupy extensive areas on south slopes of hilly uplands in the Yukon-Tanana-Kokrine-Hodzana Highlands from the East Fork drainage to the Tanana Valley area.

Within the Fairbanks to Delta segment of the route, well-drained brown loamy soils occupy low slopes of the uplands near Fairbanks and in the Birch-Harding Lake areas; poorly drained loamy soils with an overlying flat layer occupy drainages from the uplands, and sandy alluvial soils interspersed with poorly drained loamy soils having permafrost occupy the terraces adjoining the Tanana River.

Moderately deep and well-drained brown soils are most extensive on the uplands along the route from Delta Junction to the Canadian border. Wet loamy soils with a thick overlying peat layer occupy low areas along the route in drainages, extending to low gravelly slopes of the upland along the upper Tanana River.

Erosion and Mass Wasting

The Fairbanks alternative routing north of Fairbanks contains no special problems of erosion or mass wasting that are significantly different from those described for continuous and discontinuous permafrost areas in

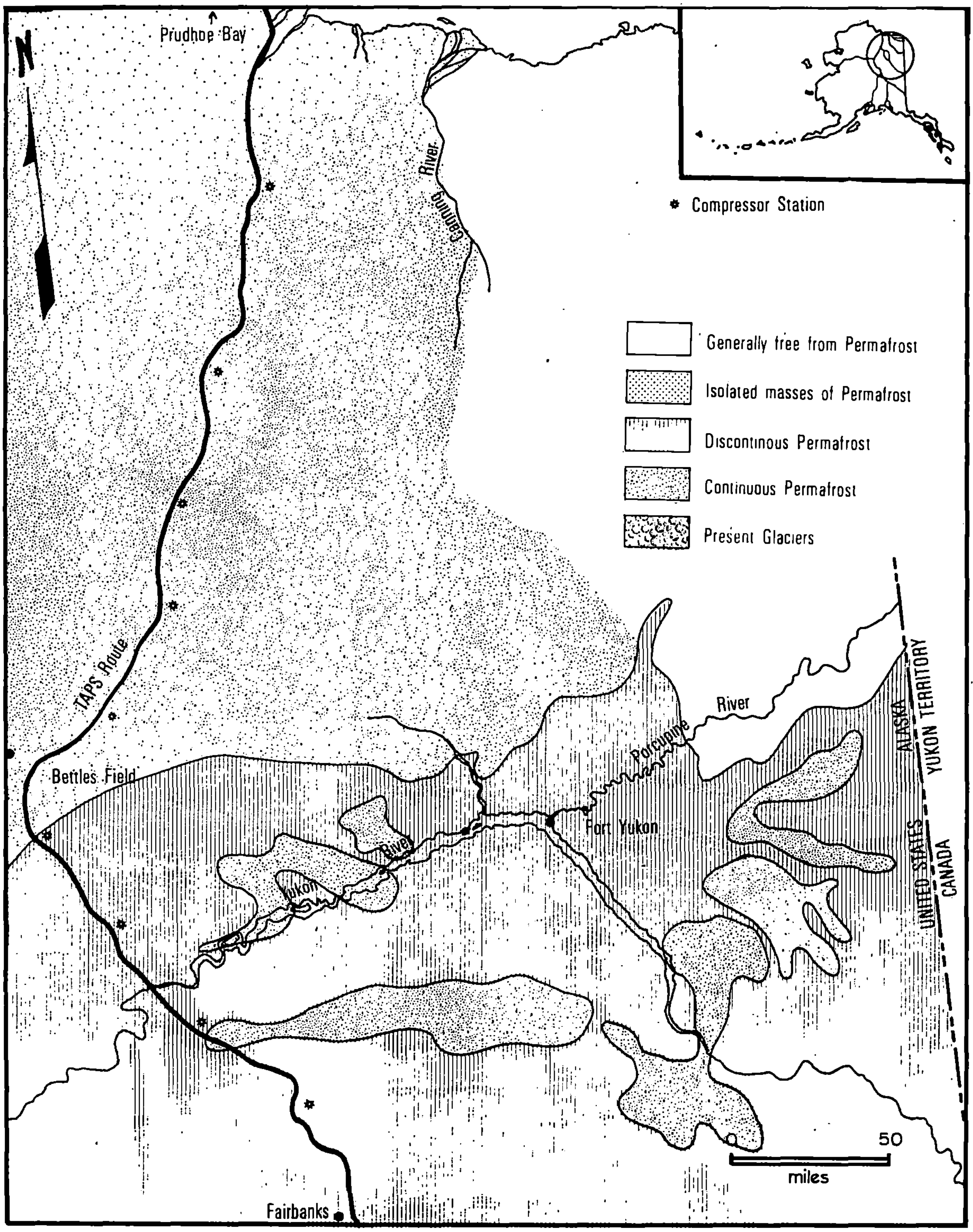


Figure 8.1.1.5-17A Permafrost of the Fairbanks alternative pipeline route

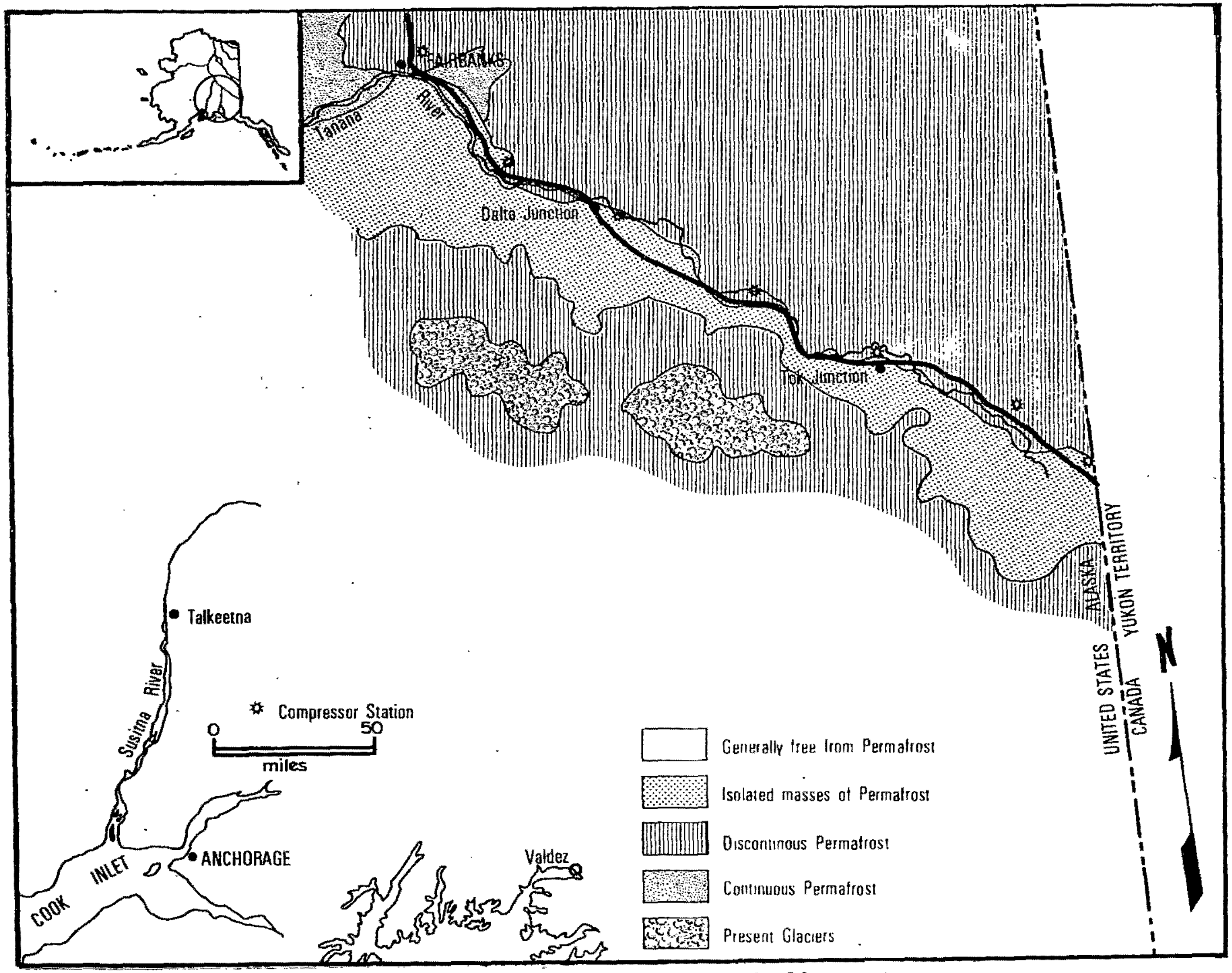


Figure 8.1.1.5-17B Permafrost of the Fairbanks alternative pipeline route

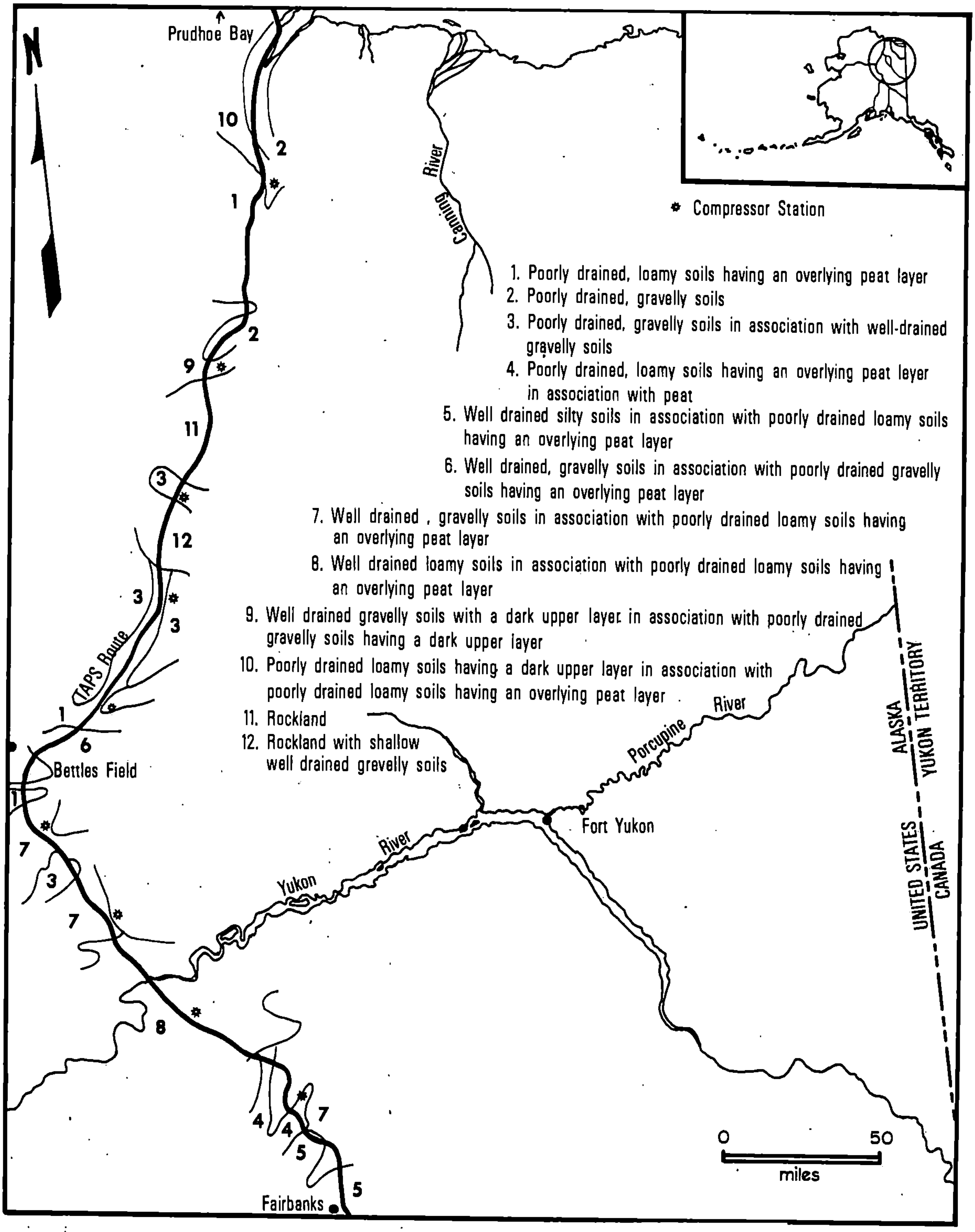


Figure 8.1.1.5-18A Soils of the Fairbanks alternative pipeline route

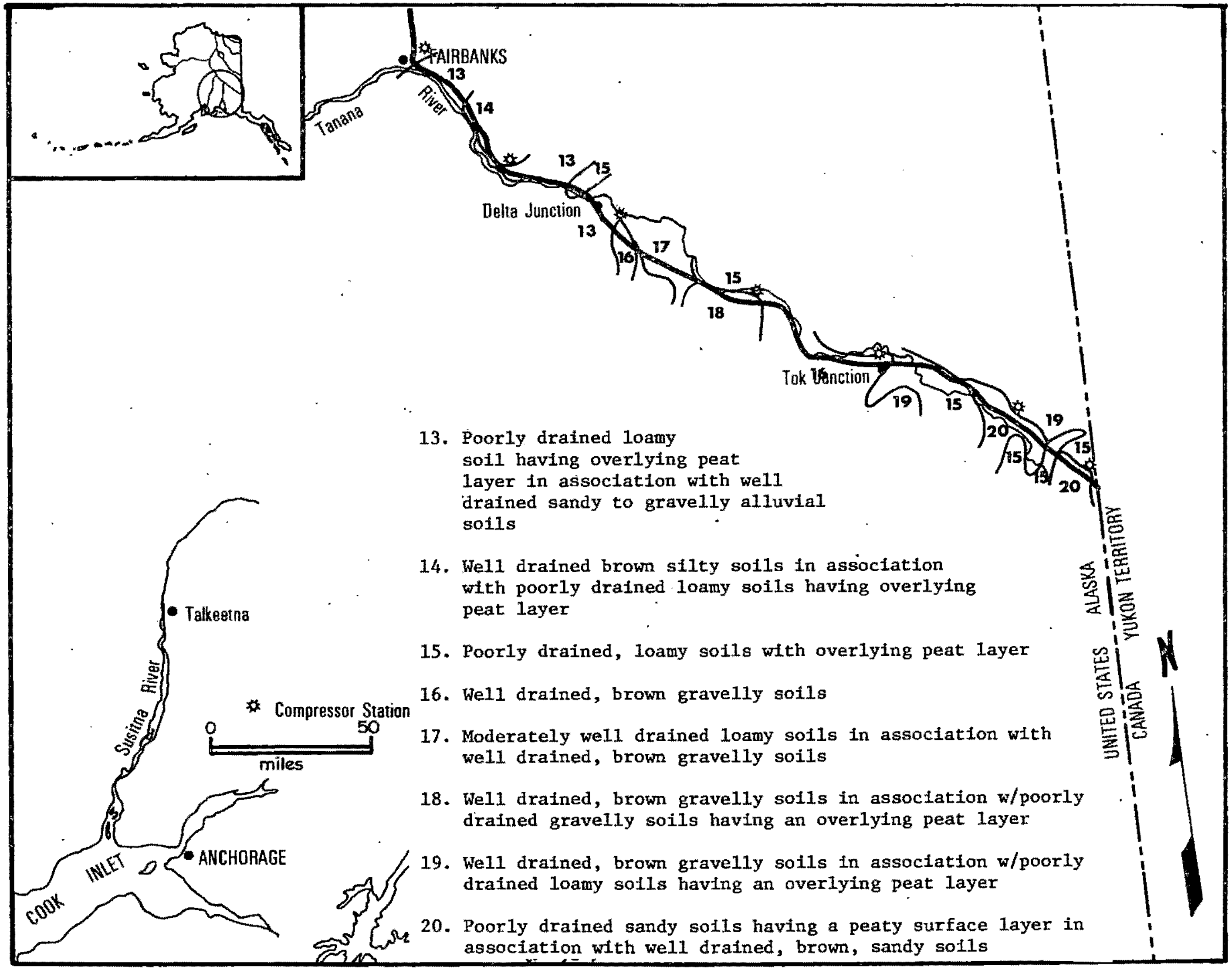


Figure 8.1.1.5-18B Soils of the Fairbanks alternative pipeline route

Table 8.1.1.5-3 Soils - Fairbanks alternative

Soil #	Description	Miles	Percent of total line	Location
1.	Poorly drained, loamy soils having an overlying peat layer	104	14.1	Arctic foothills Koyukuk River Valley
2.	Poorly drained, gravelly soils	73	9.9	Arctic Coastal Plain
3.	Poorly drained, gravelly soils in association with well-drained gravelly soils	27	3.7	South slopes of Brooks Range
4.	Poorly drained, loamy soils having an overlying peat layer in association with peat	11	1.5	Tolovana River Valley
5.	Well drained silty soils in association with poorly drained loamy soils having an overlying peat layer	13	1.8	Yukon Uplands
6.	Well drained, gravelly soils in association with poorly drained gravelly soils having an overlying peat layer	19	2.6	Uplands adjacent to Koyukuk River
7.	Well drained, gravelly soils in association with poorly drained loamy soils having an overlying peat layer	79	10.7	Kokrine, Hodzana and Yukon Highlands
8.	Well drained loamy soils in association with poorly drained loamy soils having an overlying peat layer	53	7.2	Yukon Highland
9.	Well drained gravelly soils with a dark upper layer in association with poorly drained gravelly soils having a dark upper layer	24	3.3	Upper foothills of Brooks Range
10.	Poorly drained loamy soils having a dark upper layer in association with poorly drained loamy soils having an overlying peat layer	16	2.2	Arctic Coastal Plains

Table 8.1.1.5-3 (cont'd.) Soils - Fairbanks Alternative

Soil #	Description	Miles	Percent of total line	Location
11.	Rockland	20	2.7	Brooks Range
12.	Rockland with shallow well drained gravelly soils	15	2.0	Brooks Range
13.	Poorly drained loamy soil having overlying peat layer in association with well drained sandy to gravelly alluvial soils	28	3.8	Tanana River terraces in the Fairbanks, Salcha and Delta areas
14.	Well drained brown silty soils in association with poorly drained loamy soils having overlying peat layer	47	6.4	Tanana Uplands from Eielson to Tanana River Crossing
15.	Poorly drained, loamy soils with overlying peat layer	24	3.3	Shaw Creek and Tetlin areas
16.	Well drained, brown gravelly soils	62	8.4	Delta Junction and Cathedral Rapids area
17.	Moderately well drained loamy soils in association with well drained, brown gravelly soils	27	3.7	Delta Junction area
18.	Well drained, brown gravelly soils in association w/poorly drained gravelly soils having an overlying peat layer	24	3.3	Dot Lake area
19.	Well drained, brown gravelly soils in association w/poorly drained loamy soils having an overlying peat layer	2	0.3	Gardiner Creek
20.	Poorly drained sandy soils having a peaty surface layer in association with well drained, brown, sandy soils	67	9.1	Tetlin Junction to Northway
	Total	735	100.0	

the preceding parts (2.1.1.1, 8.1.1.3, and 8.1.1.4), applied-for AAGPC route, Interior alternative, and Fort Yukon alternative, respectively.

Mass wasting hazards along the Fairbanks route from Fairbanks to Tetlin Junction consist mainly of falls, slides, and flows of rock and debris from steep-sided glacial deposits and from glacier-scoured and oversteepened bedrock slopes. Few problems would be anticipated within the generally flat to gently sloping terrain west of George Lake Lodge. Between George Lake Lodge and Johnson River, the route crosses a hummocky steep-sided end moraine of Late Wisconsin age. The slopes are still undergoing the lowering and smoothing characteristic of postglacial modification. Debris slumps and flows may be fairly common here, and large-scale slumping is especially likely where the moraine front is being undercut by the Tanana River. Between Johnson River and Dot Lake, granitic bedrock is relatively competent with falls and minor slides of frost-shattered rock debris. Debris slides and flows should also be anticipated where glacial drift occurs on steep slopes. In several places, organic silt deposits form sloping aprons at the bases of slopes (Holmes and Foster, 1968). The silts may be subject to rapid or slow flowage, especially where saturated by meltwater in spring or by streamflow in summer. From Dot Lake to Tetlin Junction, the route crosses about 16 miles of glacial deposits, followed by 20 miles of colluvium and alluvium, and finally 25 miles of outwash gravel. Mass-wasting problems within the glacial deposits are comparable to those described for the Johnson River area, and the nearly level outwash surface farther east should present problems only where steep terrace faces have been formed by postglacial incision of the Tok River. The intervening stretch of colluvial and alluvial deposits near Cathedral Bluffs would pose far greater potential problems. Solifluction may occur on sloping colluvial surfaces, and steep moraine fronts opposite Cathedral Bluffs are subject to more rapid debris slides and flows. Near Cathedral Bluffs undercutting of slope bases by the Tanana River may be a potential cause of large rotational slides. Steep bedrock slopes that overlook this segment of the route are composed of biotite gneiss and schist (Foster, 1970). Foliation attitudes, although variable, in some cases exhibit steep dips toward the valley.

Between Tetlin Junction and the United States-Canada border, slow flowage processes probably predominate. Minor slumps may occur in the sand deposits between Tetlin and Northway Junctions, but these would normally be limited in magnitude and frequency by the generally low relief and gentle slopes. The occasional, steep, river-cut bluffs that occur in gneiss, schist, and quartzite near Northway Junction (Foster, 1970) could cause rockfall and minor landslide problems. The final 15 miles of the route between Paradise Hill and the Canadian border are subject mainly to frost creep on ridge crests, solifluction on ridge and valley flanks, and perhaps earthflows where permafrost is especially shallow and ice-rich.

Earthquakes

Figure 8.1.1.5-19 shows the occurrences of recent earthquake activity along the Fairbanks alternative route.

North of 67° N latitude the level of seismic activity appears to be low; the largest known earthquake to occur within 100 miles of the route had a magnitude 4.7. From 67° N to Donnelly Dome, the seismic activity is relatively high. In July 1937, a magnitude 7.3 earthquake occurred southeast of Fairbanks. Landslides, mud boils, and ground fissures were observed (Bramhall, 1938) within 10 miles of the route. On June 21, 1967, a series of three magnitude 5.5 shocks occurred within a few miles of the route (Gedney and Berg, 1969). Surface faulting was not observed in either earthquake episode. In this section of the route, the seismic risk is

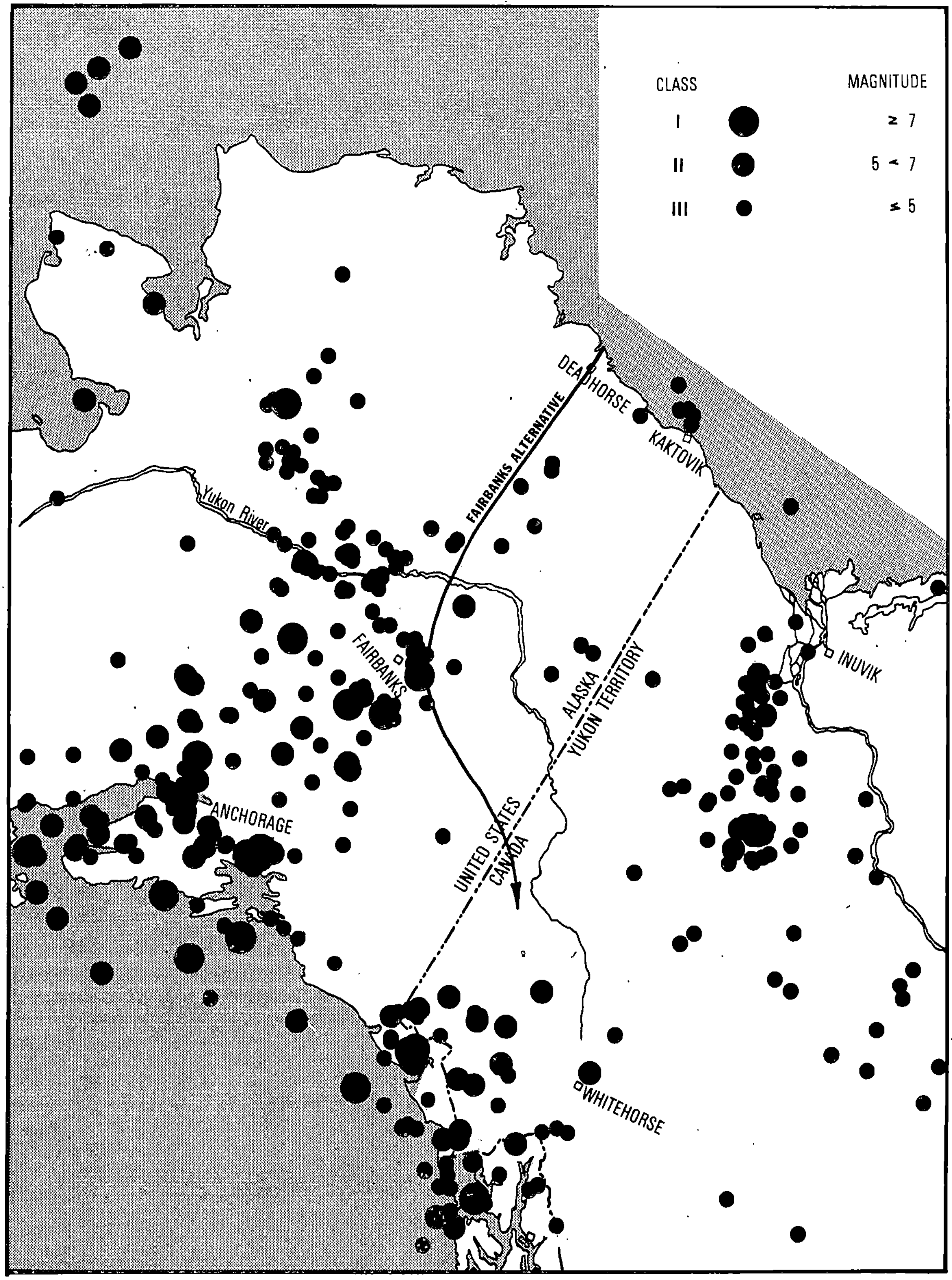


Figure 8.1.1.5-19 Earthquake hazards of the Fairbanks alternative pipeline route

substantial, although it cannot be correlated with recognizable tectonic features.

In October 1968, a magnitude 6.5 earthquake north of Fairbanks caused extensive landsliding and ground breakage within 30 miles of the route. Aftershock epicenters were located within 15 miles of the route (Gedney and others, 1969).

From Delta Junction to the Yukon border, the historic level of seismicity is relatively low. Epicenters of at least five shocks of magnitude 4.0 or larger have been located within 50 miles of the route, all to the southwest. The largest of these was about magnitude 6.0 and was located at a distance of 30 miles. A few earthquakes as large as magnitude 4.5 have been located essentially in the route northwest of Tetlin Junction. The uncertainties in the epicentral determinations are estimated to be on the order of 24 miles. Furthermore, epicenters of numerous small earthquakes delineate one of the more active faults transecting the route in the vicinity of 143.5° W longitude (Cedney et al, 1972).

An estimated 495 miles (67 percent) of the Fairbanks alternative route are located in zones where earthquakes of greater than 5.5 (Richter Scale) can be expected. Since this is the same area occupied by the trans-Alaska oil pipeline system, it can be assumed that engineering of a large diameter gas pipeline can successfully cope with expected earthquake activity.

Water Resources

Surface Water

The Fairbanks alternative route crosses 18 rivers and streams wider than 100 feet and 141 less than 100 feet wide. Additionally, there are many small, unnamed creeks and intermittent streams. Within the Arctic Slope drainage, the route closely parallels the Sagavanirktok and Atigun Rivers. Flow characteristics for the Arctic Slope are described for the applied-for AAGPC route (2.1.1.5).

Once across the Continental Divide in the Brooks Range, the route crosses the drainage basins of North and South Forks of the Koyukuk River, the Kanuti River, the Hess Creek, and the Tolovana, Chatanika, and Tanana Rivers. Major river crossings are Bettles, South Fork of the Koyukuk, Kanuti, Yukon, Chena, Salcha, and Tanana Rivers, and Phelan Creek.

The Fairbanks route closely parallels major portions of the Dietrick, Middle Fork of the Koykuk, Tanana, and Chisana Rivers in Alaska. Some 455 miles of the route are associated with the Tanana River.

Flow of streams in the Yukon Drainage varies considerably from north to south. Streams north of the Yukon River often freeze to the stream bottom over most of their width. This freezing causes icings to form on the channel and flood plains of the streams.

Water quality data are rather limited in the drainage. A considerable amount of data near Fairbanks suggested a general range of dissolved solids of 200 to 300 mg/l. Most of the streams have pH values higher than 7.0 as do the lakes in the area. Water is generally calcium bicarbonate type.

Ground Water

Ground water quality in the Arctic Slope Drainage generally reflects the quality of streams. Water is not generally available and is present only beneath the larger streams or at spring areas during winter months.

Ground water in the northern portion of the Yukon Drainage is very similar in quality to that found in the Arctic Drainge. Near the Yukon River where permafrost is discontinuous, water quality can be characterized as ranging from good to poor, alkaline, moderately hard to hard, and of a calcium bicarbonate type. Near Fairbanks and near most of the streams in this area, waters can have high iron content, and often high manganese content.

Present Water Use

None of the streams along the route are utilized as municipal supply sources either through reservoirs or through other bodies of water connected to the streams. Water may be drawn from streams by local residents for domestic use and by individual hunters or fishermen at certain times of the year, however.

No data are available on recharge rates in the areas in which ground water is utilized.

Hydrological Hazards

Ice jam flooding is generally restricted to larger streams such as the Yukon River or the Tanana River. To the south near the Alaska Range the pipeline route passes near small glacier-dammed lakes which have potential for outburst flooding. Flooding usually occurs with breakup in May or early June, but periodic flooding can occur later due to heavy rains.

Vegetation

Vegetation Types

Eight vegetation types are traversed by the Fort Yukon alternative route between Prudhoe Bay and the Canadian border. Approximate percentages are indicated in Table 8.1.1.5-4.

All types have been previously described in sections 2.1.1.6, 8.1.1.3, and 8.1.1.4 (applied-for AAGPC route, Interior alternative, and Fort Yukon alternative, respectively).

Figures 8.1.1.5-20 A and B show general locations of the above listed vegetation types.

There is a direct relationship between the degree of accessibility of any given area and the amount of vegetative disturbance. Although this disturbance is very noticeable, the percentage of affected land is quite small when compared to the right-of-way width.

No known plant species are threatened with extinction by the Fairbanks alternative route.

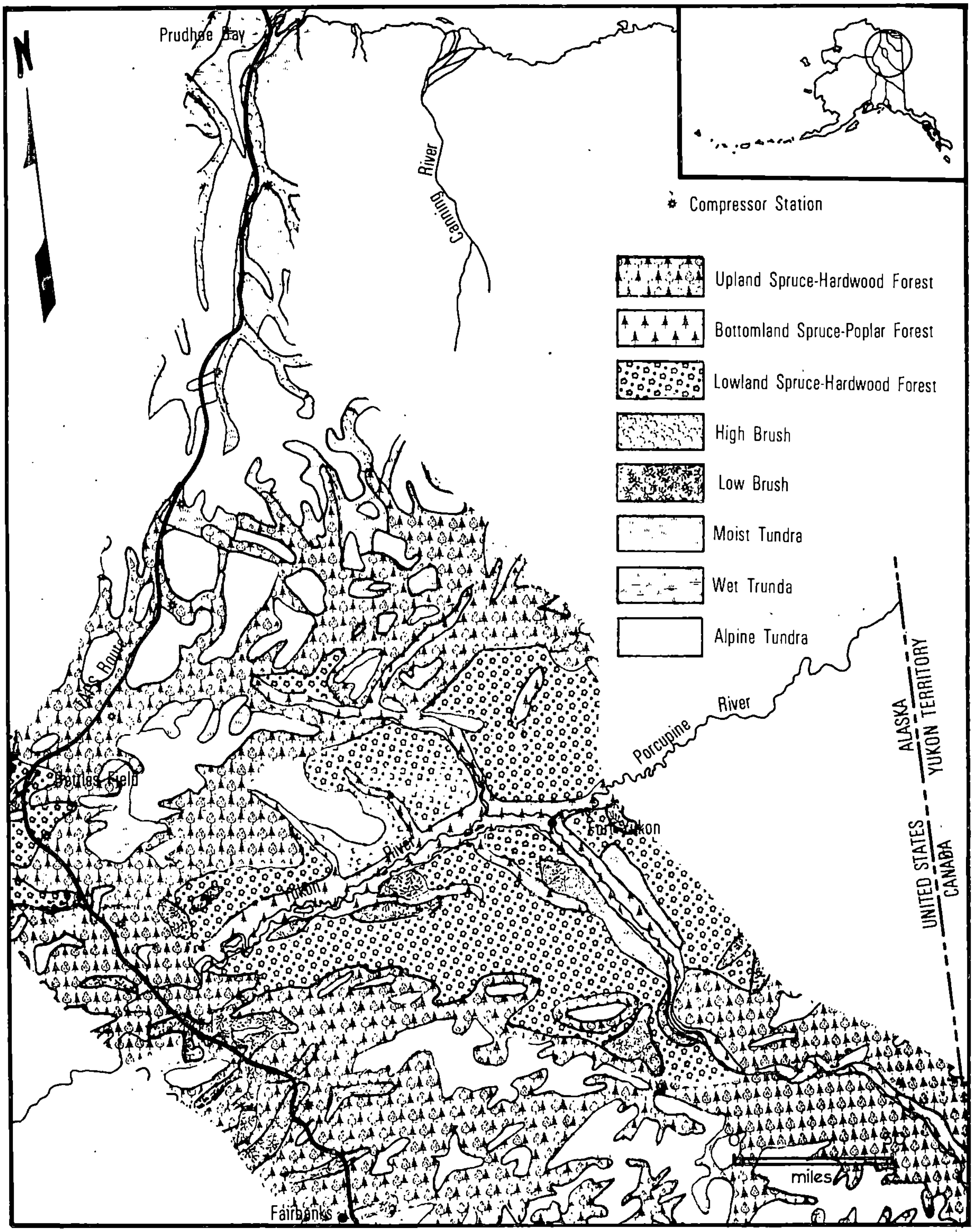


Figure 8.1.1.5-20A Vegetative type map of the Fairbanks alternative pipeline route

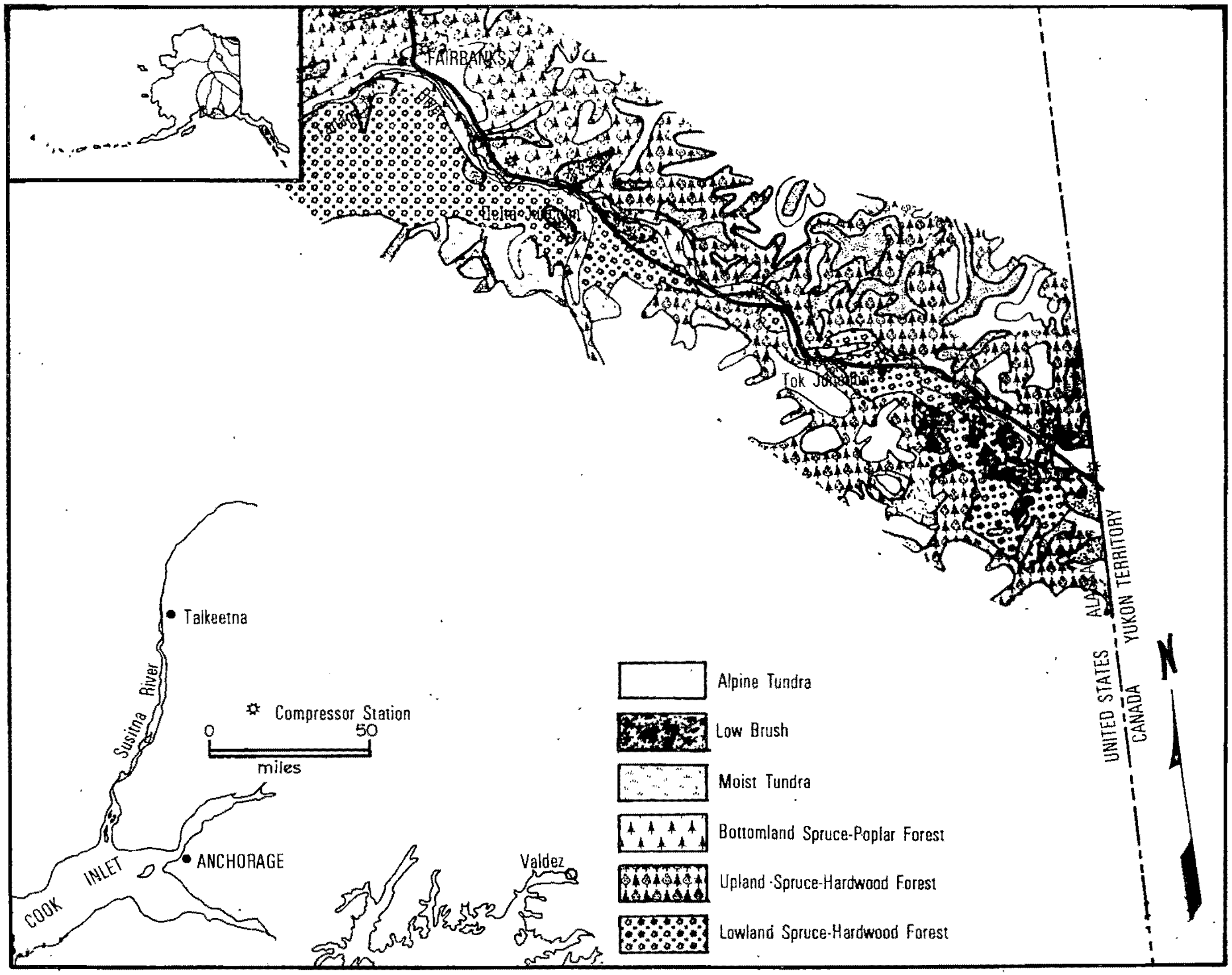


Figure 8.1.1.5-20B Vegetative type map of the Fairbanks alternative pipeline route

Table 8.1.1.5-4 Vegetation types

Vegetative Type	Miles	Approximate % of Alternative Route
Wet tundra	15	2
Moist tundra	81	11
High brush	74	10
Alpine tundra	66	9
Upland spruce - hardwood forest	250	34
Low brush, muskeg-bog	29	4
Bottomland spruce - poplar forest	95	13
Lowland spruce - hardwood forest	125	17
Total	735	100

Fire Hazard

Although all vegetation zones crossed by the route are subject to fire, they differ in their ability to carry a fire, once it has begun.

Man-caused fire potential exists mainly during the period of May through September. The exception will be the deep burning winter camp, warming, or other fires that reach peat beds of sufficient mass to sustain fires through winter months. These fires will burn to the surface and ignite surface fuels during the summer months.

Wildlife

Wildlife relationships for the Arctic Slope have previously been discussed in 2.1.1.7 and 8.1.1.4. The following discussion emphasizes Yukon River drainage wildlife relationships specifically with regard to the Fairbanks alternative route.

Mammals

Moose, bison, caribou, sheep, wolves, and black and grizzly bears are common, at least locally, along the Yukon drainage portion of the route. Furbearers include the wolverine, lynx, red fox, coyote, mink, marten, otter, weasel, beaver, and muskrat. Moose, wolves, and bears are common in the Dietrich River drainage, and sheep are found in the adjacent mountains. Aerial counts of sheep within 15 miles of the Fairbanks alternative gas pipeline route in mid-July 1970 indicated 1,375 sheep from the Continental Divide south to Wiseman.

Important winter ranges for caribou of the Arctic Herd are in Fort Hamlin Hills and south into the Ray Mountains. A large portion of that herd wintered there in 1970-71. This winter range has since been crossed by the new North Slope road. In excess of 100,000 animals may be in these areas in winter. See Figures 8.1.1.5-21 A and B.

Black bear densities were estimated at one per 20 square miles in the Yukon Flats, upstream from the pipeline location. Although black bears are more common in the forested lowlands, grizzlies predominate in the adjacent hills with large areas of alpine habitat. Hatler (1967) has estimated black bear densities in the Tanana Hills and Fairbanks area at one per 10 square miles and he reports black bears move into alpine areas in search of berries in late July to early August.

Birds

At least 161 species of birds have been reported from interior Alaska (Kessel, 1968) and perhaps three-fourths of these might be regularly encountered along the proposed pipeline route.

Table 8.1.1.5-5 gives the numbers of ducks migrating in the fall from principal waterfowl habitat within the Koyukuk River drainage, Yukon Flats, and in the Tanana-Kuskokwim lowlands. Portions of these are either adjacent to or downstream from the proposed pipeline route. Other species of ducks are found in fewer numbers. No reliable estimates are available for the number of white-fronted geese that migrate through the area but they probably number in the tens of thousands.

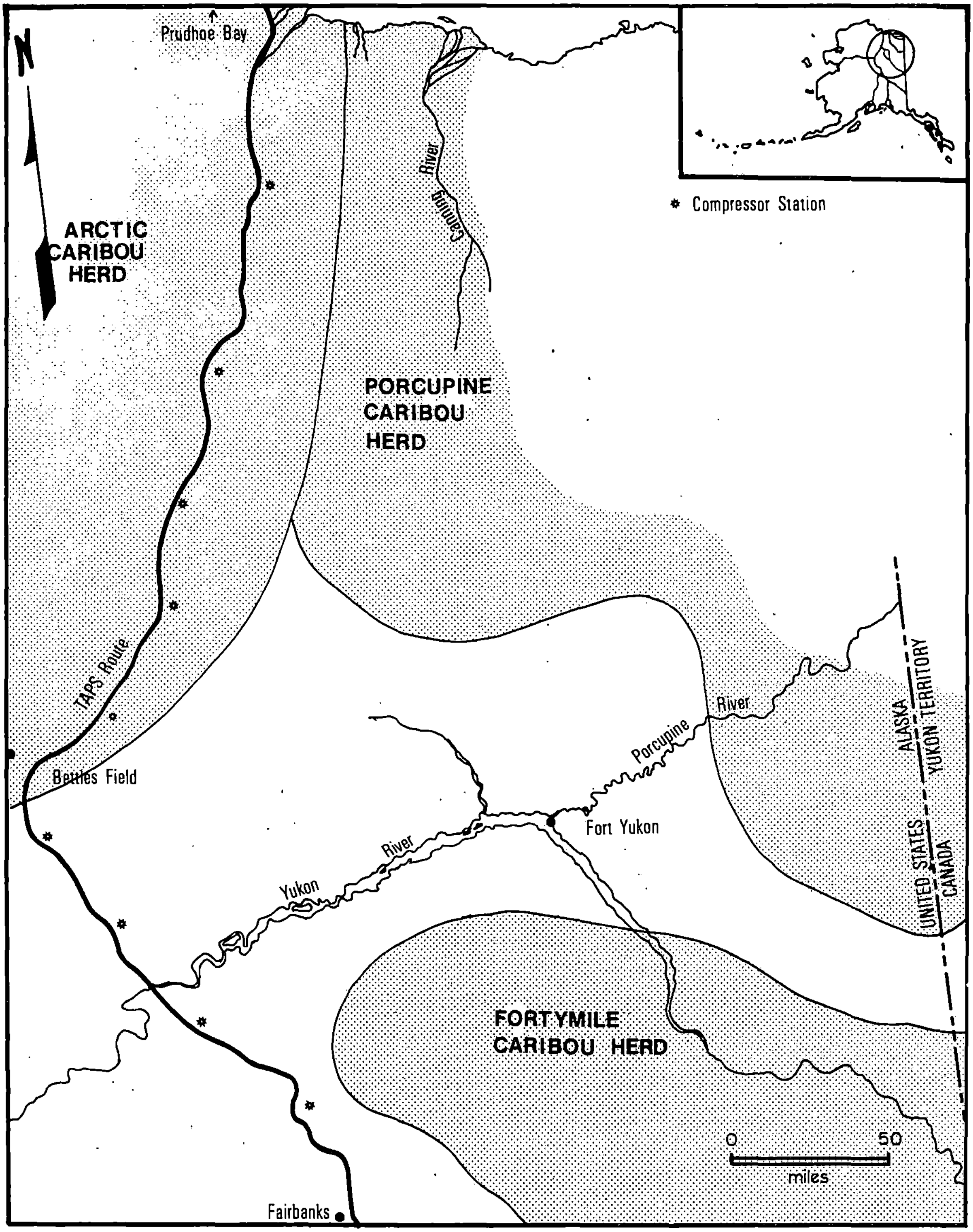


Figure 8.1.1.5-21A Caribou herds of the Fairbanks alternative pipeline route

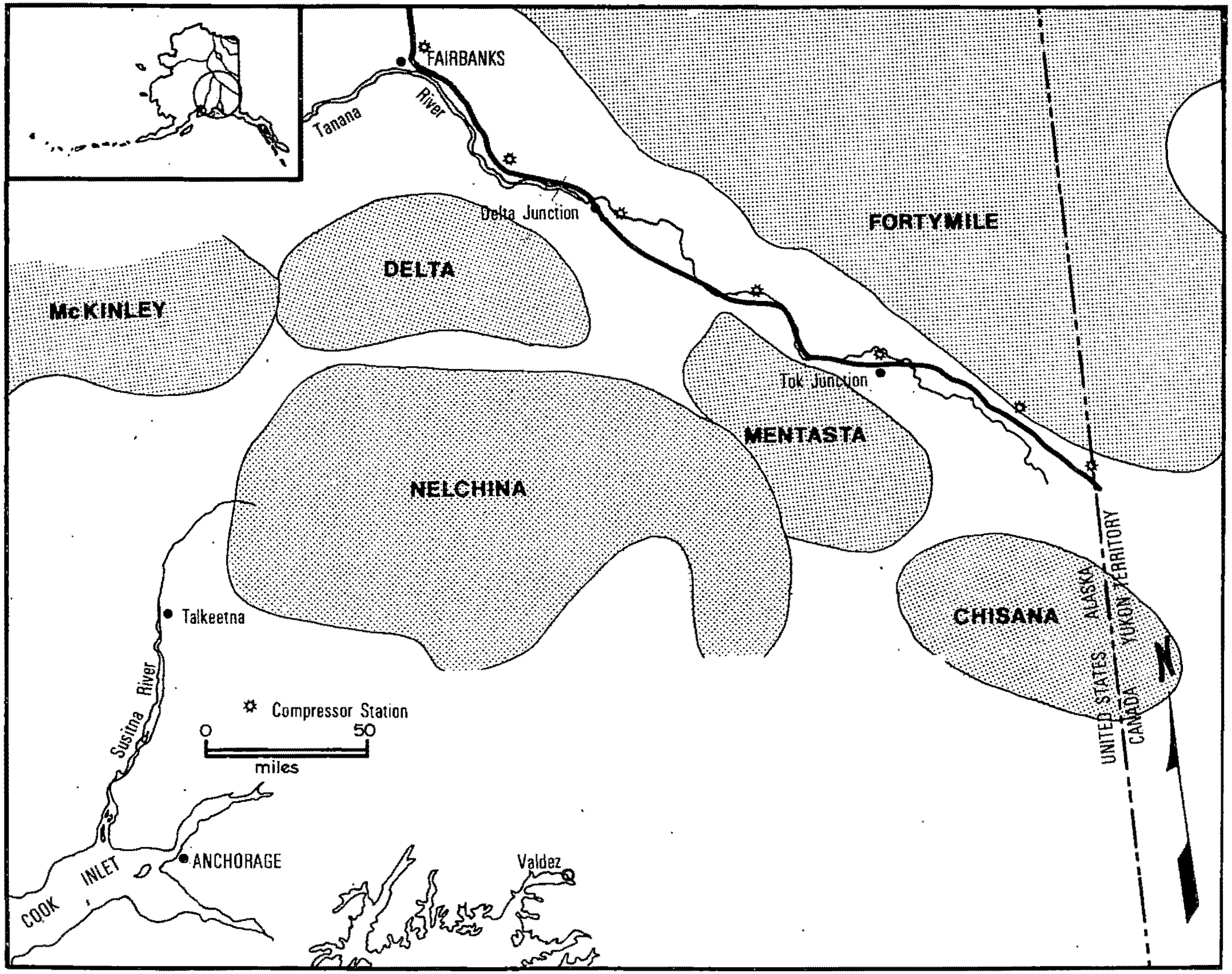


Figure 8.1.1.5-21B Caribou herds of the Fairbanks alternative pipeline route

Table 8.1.1.5-5 Estimates of migrating duck populations from habitat in the Yukon River drainage adjacent to or downstream from the route

Species	Koyukuk Drainage	Yukon Flats	Tanana-Kuskokwim
Mallard	92,000	130,000	80,000
Pintail	181,000	256,000	158,000
G-w teal	124,000	176,000	109,000
Am. widgeon	136,000	192,000	119,000
Shoveler	46,000	65,000	40,000
Canvasback	11,000	16,000	10,000
Scaups	159,000	225,000	139,000
Goldeneyes	40,000	57,000	35,000
Bufflehead	19,000	27,000	16,000
Scoters	41,000	58,000	36,000
Oldsquaw	11,000	2,000	1,000
Total	850,000	1,161,000	743,000

Approximately 85 miles of the Fairbanks alternative route cross good waterfowl habitat (Kanuti Flats the Ray River, the flood plains of the Tolovana and Chatanika Rivers, the oxbows and ponds along the Chena and Salcha Rivers, morainal ponds near Donnelly Dome). (Bartonek, 1969). It would also traverse several drainages entering Minto Flats, important both as a waterfowl hunting area for sportsmen from the Fairbanks areas and as a waterfowl production area.

King (1968) estimated from extrapolation of 13 years of waterfowl inventory data that somewhat fewer than 315 trumpeter swans, a formerly endangered and still rare species, were present in the lower Koyukuk Valley in spring. He also reported 340 adult and immature and 138 young trumpeter swans counted during a late-summer survey in 1968 in the Fairbanks area, which included Minto Flats and portions of the Tanana Valley, Wood River, and Kantishna River. Drainages of some of these areas are traversed by this alternative route.

Fish

The Yukon River drainage has long been noted for its salmon which migrate as far as 2,000 miles to the headwaters to spawn (see 8.1.1.4). These salmon, with their capacity for extremely long migrations, represent unique and irreplaceable races of their species. While the main economic value of these salmon is commercial and subsistence fishing, they also provide considerable sport fishing.

The tributaries to the Yukon River that flow directly out of the Brooks Range are the Dietrich, South and Middle Forks of the Koyukuk, and the Jim Rivers. All are relatively clear streams with gravel to cobble size beds. The commonest fish species are grayling, sculpins, suckers, and whitefish, although chum and a few chinook salmon migrate up the Koyukuk at least as far as Coldfoot. Also found are northern pike and burbot.

Threatened Species

The only known occurrence of a threatened species along this route is the peregrine falcon. Peregrine falcons nest at sites near Franklin Bluffs and in the Sagavanirtok Canyon.

Ecological Considerations

This route passes through the major vegetative ecosystems as listed in Table 8.1.1.5-6. Since ecological considerations have been discussed in sections 2.1.1.8, 8.1.1.3, and 8.1.1.4, the information is not repeated here.

Economic Factors

Economic Development

Income distribution is highly skewed in Alaska because of the relatively large number of Natives (Indian, Eskimo, or Aleut) living outside or at the margin of the cash economy. Significantly, of the 10 census divisions, with Native people accounting for more than half of the total population, all but one (Upper Yukon) had per capita income levels below $2,650. The Upper Yukon value reflects the inclusion of 200 or more oil field technicians at Prudhoe Bay at the time of the census. This compares

Table 8.1.1.5-6 Ecosystems

	Approximate percent of corridor
A. Tundra	
1. Wet tundra	2
2. Moist tundra	11
3. Alpine tundra	9
B. Taiga	
1. Upland spruce-hardwood forests	34
2. Lowland spruce-hardwood forests	17
3. Bottomland spruce-poplar forests	13
4. High brush	10
5. Low brush, muskeg-bog	4

to the statewide average of $3,765 per person. The remaining 19 (predominantly non-Native divisions) were closely grouped around the statewide average. Estimated population and employment for Alaska are listed in Table 8.1.1.5-7.

In the Fairbanks metropolitan area, per capita income levels exceed the statewide average, because of the relatively high concentration of managerial, administrative, and professional occupations, and the low concentration of Native settlements. In 1970, the Fairbanks Census Division had a per capita income level of $3,982. With the concentration of oil pipeline construction supervisory and logistical functions to develop in Fairbanks between 1974 and 1977 and the stimulus to local trades of project employee recreational visits, the average income level should rise considerably during the project years.

Away from Fairbanks and in the small number of communities located in the oil pipeline corridor (the extended effect zone), average income levels are considerably lower. State and local social and economic development programs and the earnings of local Natives gaining employment on the pipeline project will bolster incomes. Refer to Table 8.1.1.5-8.

Subsistence

Subsistence must be assessed in two strata; remote villages and villages served by existing ground transportation. Along the Fairbanks alternative route this roughly breaks on the Yukon River.

There are no villages directly associated with the Fairbanks alternative route north of the Yukon River. However, residents at Anaktuvuk Pass and Evansville/Bettles consume animals which might be affected by the Fairbanks alternative pipeline system. Table 8.1.1.5-9 summarizes the annual subsistence harvest and per capita consumption for these two communities.

It may be assumed that monetary cost of commodities to replace subsistence harvest would be similar to that described on the Interior Route (8.1.1.3); $600 to $1,000 per person per year based on Anchorage prices of corresponding goods and transportation charges.

There are no corresponding data for subsistence harvest of villages along the Alaska Highway. It is assumed to be less, although still significant, for two reasons. Commodities may be transported much more cheaply by truck than by air, the present mode north of the Yukon River. Secondly, also due to the highway, there are greater opportunities for cash employment.

Sociological Factors

Population

Tables 8.1.1.5-10, 11, and 12 display population data with particular emphasis on the Fairbanks alternative route segments.

By 1977, the projected base year for initiation of on-site construction activities for the gas pipeline, the Alyeska oil pipeline will have been largely completed. The temporary increase in oil pipeline employment will have largely receded.

Table 8.1.1.5-7 Alaska: estimated population and employment, 1961-1973

	1961	1970	1972	1973
Total Population (July 1)	236.7	304.6 2/	324.4	330.3
Total Civilian Work Force	75.5	114.8	131.3	137.8
Rate of Participation 3/	31.9%	37.7%	40.5%	41.7%
Total Unemployment	7.5	9.9	13.7	14.4
Percent of Civilian W.F.	9.9%	8.6%	10.4%	10.4%
Total Civilian Employment 4/	68.0	104.9	117.6	123.4
Self-Employed, Agriculture, Family Worker, Etc.	10.8	12.4	13.5	13.6
Government (Civilian)	23.8	35.4	40.5	41.9
Federal	15.6	17.0	17.2	17.3
State & Local	8.2	18.4	23.3	24.6
Mining	1.2	3.0	2.1	1.9
Contract Construction	4.1	6.9	7.9	8.2
Manufacturing	5.3	7.8	8.1	8.9
Distributive	22.7	39.1	45.6	48.8
Trans., Comm., Public Util.	7.2	9.1	10.0	10.4
Trade	8.1	15.4	17.1	18.2
Finance, Inc., Real Estate	1.5	3.0	3.7	4.1
Services & Miscellaneous	5.9	11.6	14.8	16.1

1/All work force and employment date = 12 month average, in thousands of persons, for calendar year.
2/Final 1970 Census Estimate adjusted to July 1, 1970.
3/Rate of participation = Total Civilian Work Force divided by Total Population.
4/The Total Civilian Employment may not equal the sum of individual industry employment figures due to rounding.

Source: Department of Labor, 1974.

Table 8.1.1.5-8 Industrial sources of personal income in Alaska (1970)

	Personal Income Originating in Named Industry	
	millions of current dollars	percent of total
Farms	1	.1
Fishing	21	1.6
Mining	54	4.2
Coal mining	1	.1
Crude petroleum and natural gas	49	3.8
Other mining	3	.2
Contract construction	119	9.2
General building contractors	36	2.8
Highway and heavy construction contractors	61	4.7
Special trade contractors	22	1.7
Manufacturing	68	5.3
Food processing	18	1.4
Logging, lumber, and pulp	17	1.3
Chemicals	3	.2
Other	30	2.4
Wholesale and Retail	150	11.6
Wholesale trade	32	2.5
Eating and drinking places	27	2.1
Other retail trade	91	7.1
Finance, Insurance, and Real Estate	35	2.7
Banking	14	1.0
Other Finance, Insurance and Real Estate	21	1.6
Transportation, Communications, Public Utilities	120	9.3
Railroad transportation	6	.4
Highway freight and warehousing	20	1.6
Water transportation	9	.7
Air transportation	38	3.0
Other transportation	4	.3
Communications	33	2.6
Electric, gas and sanitary services	10	.8
Services	130	10.1
Hotels and other lodging places	10	.8
Personal services	10	.8
Business services	24	1.9
Repair services	5	.4
Amusements and recreation	3	.2
Professional, social and related services	74	5.7
Government	590	45.8
Federal military	219	17.0
Federal civilian	197	15.3
State government	98	7.6
Local government	76	5.9
TOTAL	$1,289	100.0

Sources: ISEGR, 1971a, p. 35.

Table 8.1.1.5-9 Estimated useable weights in pounds of subsistence harvest and avg. per capita consumption

Resources Harvested	Anaktuvuk Pass	Evansville/ Bettles
Mammals	153,695	27,765
Fish	3,500	1,150
Wildfowl	900	210
Berries	400	850
Greens/Roots/Vegetables	--	540
TOTALS	158,495	31,515
Current Resident Native Population July 1973 2/	123	21
Per Capita Resource Consumption July 1973	1,298	1,500

1/For mammals, wildfowl, and fish, figures are based on estimates of dressed weight for each resource. For berries, greens/roots/vegetables gross weights of harvest are given.
2/Based on Alaska Native Enrollment - Summary 1973. U.S. Department of the Interior, Bureau of Indian Affairs.

Table 8.1.1.5-10 Baseline population projections for the Fairbanks alternative route segments, 1970-1978

Segment	1970	1974	1977
Arctic 1/	3,000	4,300	5,400
Interior 2/	52,600	57,200	66,200

1/ Arctic includes the northern part of the Upper Yukon Census Division and all the Barrow Census Division.

2/ Interior includes the southern part of the Upper Yukon, the Fairbanks and Southeast Fairbanks, and the northern one-half of the Valdez-Chitina-Whittier Census Divisions. The portion of the Valdez Census Division included accounts for communities in the Copper River Valley (Gulkana, Glenallen, Copper Center, etc.).

Source: Table 2A.7-2. See Figure 2A.7-1 for boundaries of study areas.

Table 8.1.1.5-11 Rate of growth of population

Period	Average Annual Rate of Growth (%)
1960-1970 (actual)	2.95
1970-1974 (estimated)	4.25
1974-1977 (projected)	6.05

Table 8.1.1.5-12 Baseline populations for census divisions, 1970-1977

Place	1970 1/	1974 2/	1977 2/
Northwest	13,181	14,600	16,500
Northern Upper Yukon 3/	335	1,700	1,400
Interior	56,144	60,700	69,000
Southern Upper Yukon 3/	1,349	1,700	1,700
Fairbanks	45,864	49,000	56,200
Southeast Fairbanks	4,179	4,500	5,100
Yukon-Koyukuk	4,752	5,500	6,000
Alaska	302,361	357,200	426,000

1/ Department of Commerce.

2/ Department of Labor, 1974 (mid-year).

3/ The Upper Yukon Census Division has been divided into a Northern Section (North of Brooks Range) and a Southern Section. Thus, Kaktovik, Deadhorse, and Prudhoe Bay are in the Northern Upper Yukon Sector, while such communities as Fort Yukon, Stevens Village, and Evansville (Bettles) are in the Southern Upper Yukon Sector.

Table 8.1.1.5-13 indicates, to the extent of available data, ethnic strata within the population. Population data are provided in Tables 8.1.1.5-14 and 15.

Government

The North Slope Borough has been discussed in 2.1.1.10. Also discussed in that section is Kaktovik, which has typical Native village organization.

Fairbanks and the North Star Borough of which the city is a part comprise Alaska's second largest metropolitan area. Fairbanks was incorporated in 1903 and operates under a city council with a professional city manager.

Delta Junction, a second-class city incorporated in 1960, is the only other incorporated community along the Fairbanks alternative route.

Education

The striking fact about the education profile of persons living along the route is the high percentage of persons who have completed high school or some college in Fairbanks and Southeast Fairbanks compared with those in other parts of the state.

Data in Table 8.1.1.5-16 illustrate the contrast. These data reflect both the impact of the military personnel and the urban setting of Fairbanks on area educational characteristics. The Upper Yukon Census Division is the only census division in the Interior which reports perceptively lower educational values than the other divisions in the area.

Fairbanks is the location of the University of Alaska and a community college stresses vocational skills.

Health

Health care in the Interior Region centers around Fairbanks. The military health service and the civilian health system are most developed in Fairbanks. Military personnel, who numbered approximately 15,000 in 1970, will likely continue to use the military health service system which will expand or contract as required.

The civilian health system, and its physicians, nurses, and hospitals, will be reasonably adequate except during the peak of the oil pipeline construction which will have declined by 1977. It is possible, however, that by 1977 there will be a need for additional doctors because of projected continued strong growth. It is probable that hospitals in Fairbanks may be able to meet the need for additional beds by 1977 when expansion of facilities catches up with population changes induced by the Trans-Alaska Oil Pipeline.

Fairbanks also serves as a major regional center for health care. Commonly, persons in the Arctic, Upper Yukon, and Yukon-Koyukuk Regions go to Fairbanks for hospitalization. Any increased load related to accidents and serious illness during the pipeline construction will fall mostly upon Fairbanks facilities.

Table 8.1.1.5-13 Communities, population and native enrollment along the Fairbanks alternative route

Community	1970 Census			ANCSA Native Enrollment 1973 [1]	Total Current Population Estimate
	Native	Non-Native	Total		
Anaktuvuk Pass	97	2	99	135	125
Fairbanks & Vicinity	1,818	44,046	45,864	[2]	49,000
Delta Junction	10	693	703	[2]	730
Evanville (Bettles Field)	14	43	57	76	80
Mentasta Lake	64	4	68	104	65
Northway	10	30	40	203	192
Stevens Village	72	2	74	173	56
Tanacross	77	7	84	150	97
Tetlin	108	6	114	113	107
Tok	26	188	214	12	274
Wiseman	-	-	0	49 [2]	Unknown

[1] Natives must enroll in a particular village, not necessarily current place of residence, to receive benefits under the Alaska Native Claims Settlement Act.

[2] Not an authorized Native village for ANCSA purposes.

Table 8.1.1.5-14 Race and sex of selected census divisions and villages, 1970

Census Division and Place	White		Indian		Aleut		Eskimo		Other		Sex 1/ Ratio
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Barrow	216	114	6	4	1	0	1,192	1,110	18	2	116.5
Anaktuvuk Pass	1	1	0	0	1	0	55	42	0	0	130.2
Upper Yukon	484	104	488	419	5	2	98	65	16	3	184.0
Prudhoe Bay	45	0	0	0	0	0	4	0	0	0	N.C.2/
Kaktovik	10	5	0	0	0	0	63	44	0	0	146.0
Deadhorse	148	0	2	0	0	0	13	0	0	0	N.C.
Stevens Village	2	0	44	28	0	0	0	0	0	0	164.3
Fairbanks North Star	25,599	17,334	491	529	33	21	336	466	1,885	1,200	134.6
Southeast Fairbanks	2,054	1,364	241	248	2	2	8	12	157	101	143.4
Delta Junction City	350	312	3	1	0	0	2	1	17	17	112.4
Fort Grealy	1,058	518	5	6	0	0	1	8	136	78	198.4

1/Sex Ratio = Number of males divided by number of females times 100.
2/N.C. = not computed.
Sources: ISEGR, 1972a, 1972b

Table 8.1.1.5-15 Age characteristics of selected census divisions and villages, 1970

Census Division and Place	Persons 15 Years and Younger		Persons 60 Years and Older		Persons Between Ages 15 and 60 Years		Demographic Dependency Ratio
	Number	%	Number	%	Number	%	(DDR)1/
Barrow	1,132	42.5	122	4.6	1,409	52.9	89.0
Anaktuvuk Pass	45	45.5	6	6.0	48	48.5	118.6
Upper Yukon	511	30.3	124	7.4	1,049	62.3	60.5
Prudhoe Bay	0	0.0	1	2.0	48	98.0	2.0
Kaktovik	46	37.4	9	7.3	68	55.3	80.8
Deadhorse	0	0.0	1	0.6	162	99.4	0.1
Stevens Village	28	37.8	5	6.8	41	55.4	80.5
Valdez City	322	32.0	53	5.3	630	62.7	59.5
Fairbanks North Star	14,863	32.4	1,149	2.5	29,852	65.1	53.6
Southeast Fairbanks	1,365	32.7	133	3.2	2,681	64.1	56.0
Delta Junction City	213	30.3	9	1.3	481	68.4	46.2
Fort Greely	529	29.1	8	0.4	1,283	70.5	41.8

1/Demographic Dependence Ratio (DDR) is the number of persons under 15 and over 60 divided by the number of persons between 15 and 60 multiplied by 100.

Source: ISEGR, 1972a.

Table 8.1.1.5-16 Educational characteristics of selected census divisions, 1970

		Years of School Completed (Percentage of Population)						
	Not Completing Any Years of School	Elementary School			High School		College	
Census Division		1-4 yrs.	5-7 yrs.	8 yrs.	1-3 yrs.	4 yrs.	1-3 yrs.	4 yrs. or More
Barrow	15.1	17.3	26.8	13.3	8.4	9.0	3.6	6.5
Upper Yukon	11.4	13.6	12.7	11.3	11.9	20.0	12.6	6.5
Fairbanks	0.7	1.0	2.6	5.6	15.2	41.9	16.4	16.6
Southeast Fairbanks	3.6	2.0	7.8	8.1	15.6	33.9	14.7	14.3

Source: Reproduced from Table 2A.7-18, which was derived from Department of Commerce, 1970.

Public Safety

Problems of law enforcement for areas in the Interior Region outside of Fairbanks are similar to those faced in other rural areas. The Alaska State Troopers Division must patrol a large area with too few troopers. By 1977 this condition will probably have been improved somewhat, in view of the state's improved financial condition.

Fairbanks has had an increasing crime problem. The crime rate has grown at a faster rate than the population. Some of the reasons for the growing rate may be the increasing population density, changes in age, sex, and racial structure of the population, marital stability of the population, and climate. The increase in density means more impersonal interactions among people which may reduce the informal social norms governing deviant and criminal behavior. A decrease in the average age of the population, and a preponderance of males is also consistent with high crime.

The ebb and flow of seasonal workers in the construction field and transients associated with military activities may also contribute to a high crime rate. The transient population varies with the climate; however, the large extremes in weather also influence the crime rate. For instance, a crime is more likely to occur when it is dark than in the daylight.

All of the above factors except climate will be influenced by the oil pipeline. It seems reasonable to assume that by 1977 the crime rate for Fairbanks will be greater than it is at present, but the magnitude of the increase is open to question. Assuming a "normal" ratio of one policeman to every 400 persons the Fairbanks North Star Borough will need about 140 policemen in 1977. This is a projected increase of 180 percent over 1974 levels, which will place strains on the existing organization and personnel with respect to the increased level of work and administration as well as financial requirements.

Land Use

Existing and Potential Land Use

The Fairbanks alternative route is located entirely within an established transportation corridor. The trans-Alaska oil pipeline system will occupy this corridor from Prudhoe Bay to Delta Junction. (At Delta Junction, the oil pipeline swings south approximately 250 miles to Valdez.) The entire length of the Fairbanks route from Prudhoe Bay to the United States-Canada border is accessible by road. The last link (365 miles) was constructed during 1974 when a two-lane gravel road was built between the north bank of the Yukon River and Prudhoe Bay. At this time it is not known how far north of the new highway bridge across the Yukon River the public will be permitted by the State. Accordingly, land uses are or will be controlled by the fact that a major transportation corridor has been established.

Refer to Figures 8.1.1.5-22 A and B for land ownership along this route. All 735 miles of Fairbanks alternative in Alaska are directly associated with established transportation networks. No existing national park, forest, wildlife refuge, or wild and scenic river areas are involved. Approximately 10 miles of the route near the Canadian Border is within the proposed Wrangell Mountains National Forest. No other proposed forest, national parks, refuges, or wild and scenic rivers are involved. No areas of potential wilderness are involved.

Since there is a question about land use north of the Yukon River other than for transportation of oil, the following discussions deal with the remainder of Fairbanks alternative route, i.e., south from the Yukon River, into the Tanana valley, and southeasterly to the Canadian border.

Agriculture and Forestry--Nearly 8.5 million acres eastward from Tanana and the vicinity of Lake Minchumina to the Canadian border near Snag are considered suitable for crop cultivation. Suitable land includes river plains and slopes up to 1,500 feet between the Yukon-Tanana uplands and the Alaska Range. Some 3.6 million acres are suitable for production of cultivated crops. The crop lands include approximately 810,000 acres which are lowlands of the Tanana and tributary rivers, and another 840,000 acres located on the Yukon-Tanana uplands east of Nenana. Two small extensions of upland soil occur near Delta and Tanacross, adding 70,000 acres.

Forestry potential in the Tanana Valley section of the route is moderate. From Fairbanks east, stands of white spruce and birch have some commercial potential, though there is little present use because of land status restrictions. There is high demand for timber from State lands in the area around Fairbanks.

Several small sawmills operate around Fairbanks and there is a mill at Delta Junction and another small operation between Delta and Tok Junctions.

Figures 8.1.1.5-23 A and B show areas considered to have potential for agricultural or commercial timber production.

Industrial--Since this alternative route parallels the trans-Alaska oil pipeline, the entire route can be considered an industrial transportation corridor. The areas of intensive industrial development are limited to Prudhoe Bay and Fairbanks. Scattered along the route are various pumping stations and related facilities. A petroleum refinery will be built at North Pole, near the city of Fairbanks.

Residential Areas--Most of the route is uninhabited. At various points along the entire route construction camps are being built for the trans-Alaska oil pipeline construction project which will continue to be occupied for some time.

Because of its location on the Yukon River and the highway connection southward to Fairbanks it is probable that a new community will develop at this oil pipeline and highway crossing of the Yukon River. Should a public surface transportation network develop north of the Yukon River it is possible that the oil pipeline construction camps at Prospect, Dietrich, and Sagwon will become centers for community development, commercial, residential, and recreational uses.

The Fairbanks area is the primary residential area along this alternative route. Low density urban areas near Fairbanks are spreading outward from the downtown area resulting in a suburban complex along all major roads.

Tok, on the Alaska Highway, is connected with Southcentral Alaska by the Glenn Highway which runs southwesterly to the Richardson Highway just north from Glennallen. Just east of Tok, the Taylor Highway originates and proceeds in a northerly direction to Eagle on the Yukon River. There is a spur from the Taylor which turns easterly, connecting with Canadian roads to Dawson City and Whitehorse.

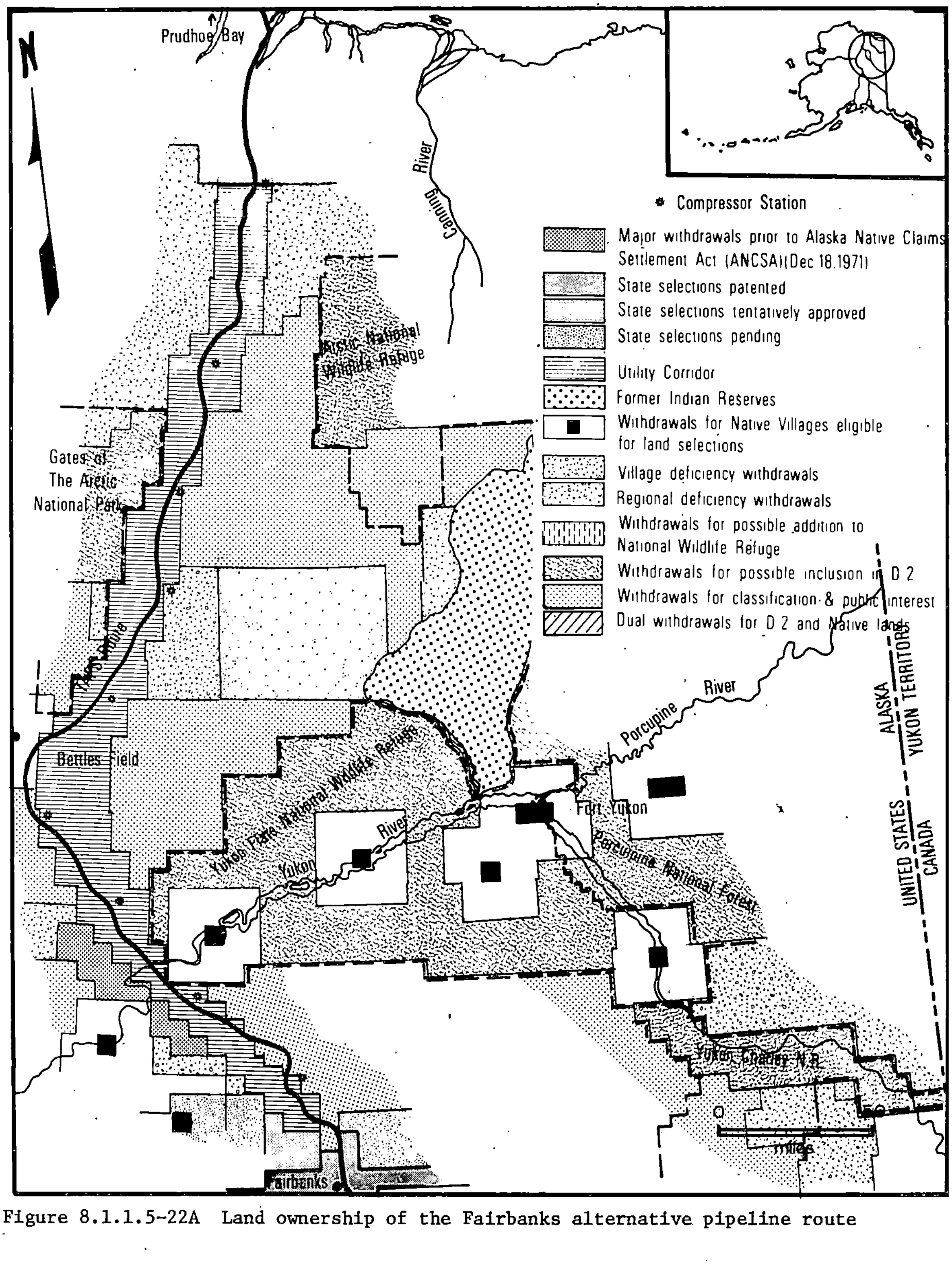


Figure 8.1.1.5-22A Land ownership of the Fairbanks alternative pipeline route

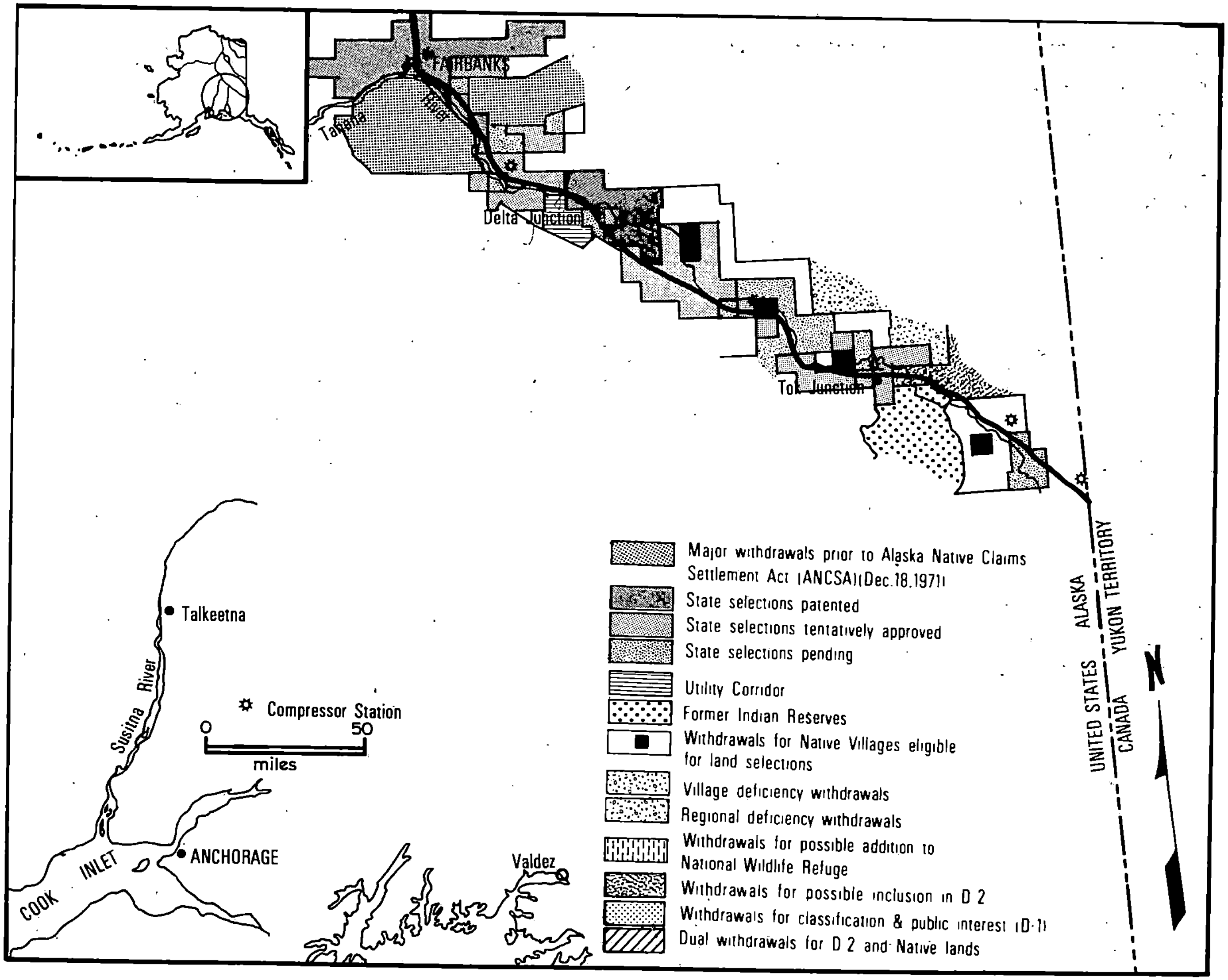


Figure 8.1.1.5-22B Land ownership of the Fairbanks alternative pipeline route

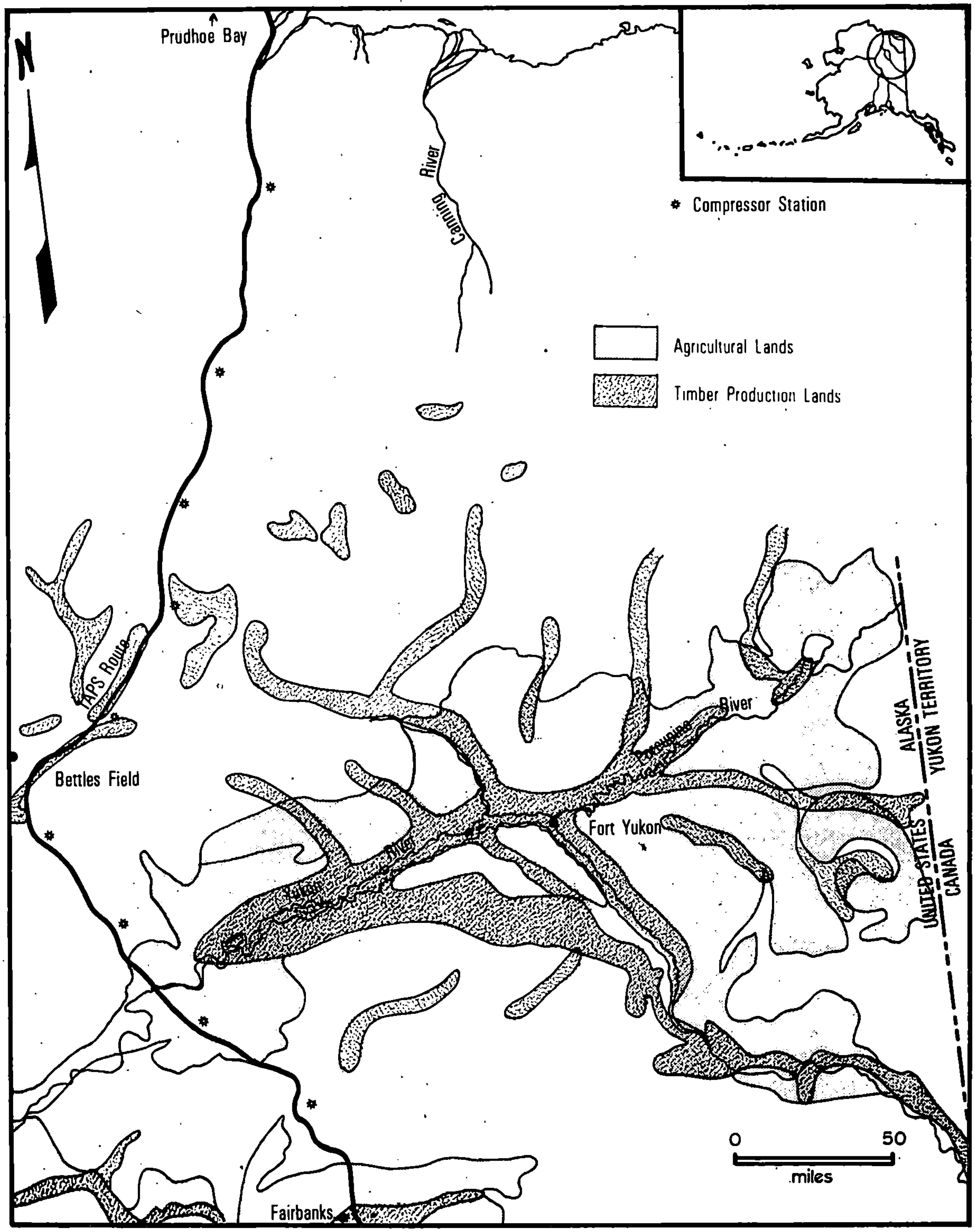


Figure 8.1.1.5-23A Forestry and agriculture potential of the Fairbanks alternative pipeline route

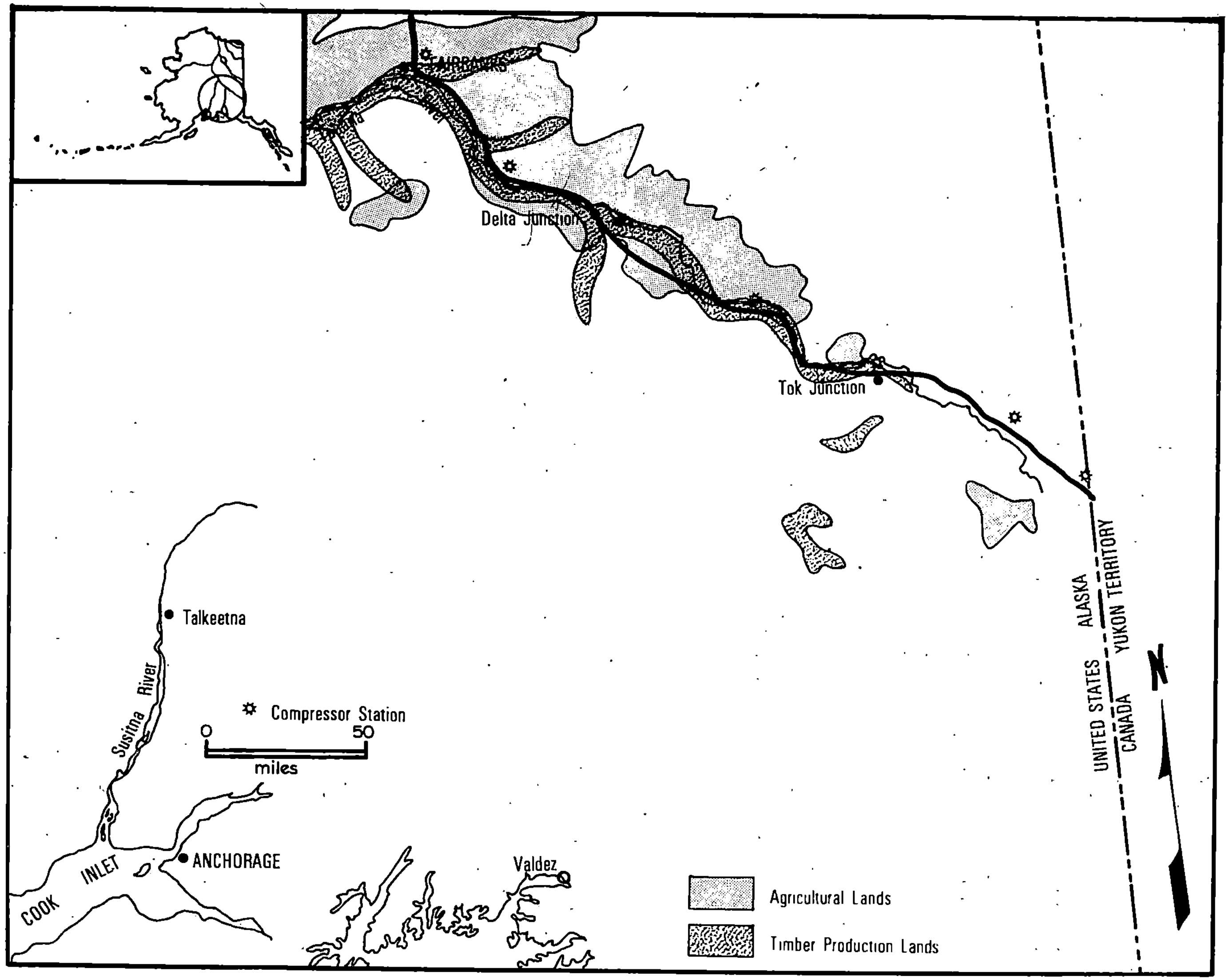


Figure 8.1.1.5-23B Forestry and agriculture potential of the Fairbanks alternative pipeline route

Eastward from Fairbanks there are several small communities including North Pole, Delta Junction, and Tok. Military installations along the route include Eielson Air Force Base, Fort Wainwright, and Fort Greely.

Transportation--Fairbanks is the road and air hub of interior Alaska. All major highways either originate or terminate there. In addition, it is the northern terminus of the Alaska Railroad. Fairbanks International Airport serves several major airlines. Pan American uses FIA for refueling on its Circle Route flights. FIA is also the major supply point for air transport logistics to the North Slope.

Delta Junction is the terminus of the Alaska Highway where it joins the Richardson Highway which connects Valdez and Fairbanks.

The Yukon is navigable by shallow draft barges for 4 months of the year in the area. The water depth above Fort Yukon sometimes limits transportation. Maintenance of the Yukon River as an open transportation artery is the subject of an international treaty.

The route parallels the Tanana River from Fairbanks to Delta Junction. The Tanana River from its confluence with the Yukon River upstream to Fairbanks is navigable.

Transmission Facilities--There are no major utility networks north of Fairbanks. Several villages and small cities along the trans-Alaska pipeline route have independent facilities of their own. In the smaller villages, electricity is often provided by a privately owned generator (Archibald, 1974).

Water distribution methods vary with the size of the community. Small villages do not have water distribution networks; they often draw their water from local lakes or a community well.

Sewage is collected in honey buckets in the smaller villages; the larger villages have septic tanks. Conventional sewage systems are found only in the larger communities.

Fairbanks, the second largest city in the state, has all the facilities one expects in a medium-size city of 45,000. Electricity, water supply, and sewage collection activities are carried on at a level surpassed only by Anchorage.

A small diameter pipeline and related facilities extends along this route from the Canadian border to the Fairbanks area.

All cities south of Fairbanks are linked by telephone with Anchorage. The villages do not have direct telephone communications, but rely on a radio-telephone system.

Land Ownership and Withdrawals

The first 66 miles of the route are within land owned by the State of Alaska. Then the route enters Federal lands and is contained within a utility corridor withdrawal (PLO 5150, as amended). Near Fairbanks it reaches an area owned by the State of Alaska, except for two areas withdrawn for military purposes: Eielson Air Force Base and Fort Greely. From Fairbanks to Tanacross the route is entirely through State owned or selected lands.

Native villages of Dot Lake, Tanacross, and Northway have selection rights along the route. The former Tetlin Indian Reservation is skirted. Healy Lake is surrounded by lands owned by the State, but will also have selection rights along the route.

The final approximate 10 miles are within lands included in the proposed Wrangell Mountains National Forest. (See Figures 8.1.1.5-22 A and B.)

Table 8.1.1.5-17 summarizes the approximate land ownership relationships along the Fairbanks alternative route. It should be noted that these are gross approximations for State ownership since much of the area has been transferred into private ownership. This is especially true of the route where it passes through the Tanana River Valley.

Archeological, Historical, and Unique Areas

Archeological Areas

Archeological surveys of the trans-Alaska oil pipeline route were started in the planning stages of that system. Some 200 sites yielded artifacts and data to the archeologists who conducted this investigation. Archeological work continues as elements of the oil pipeline are built.

Records of sites are contained in the Heritage Resource Survey, a statewide depository of cultural resource information maintained by the Alaska State Historic Preservation Officer. Applicability of these data to the Fairbanks alternative is dependent on how closely the gas line follows the oil line. For example, Cook (1975 as cited by IRI, 1975) states that movement away from the line by as little as 200 feet could disclose previously unknown and important archeological sites. The segment from Prudhoe Bay to Okorukuyik Creek is covered in section 8.1.1.4.

That portion of the alternate route between Delta Junction and the Border does not benefit from a systematic archeological inventory as described above. The route follows a highway, the construction of which may, or may not, have destroyed archeological resources which were present.

Paleoenvironmental Settings

Although the northern end of this corridor may have been partially glaciated, the boundaries of maximum glaciation are imprecisely known in this region and we place this corridor entirely in the Intermontane Paleoenvironmental Zone. During the past 40,000 years this corridor in interior Alaska is noted as an area where forests have repeatedly advanced and receded with even minor fluctuations in climate.

The present tundra in the northern portion of the corridor represents a succession over the past 7,000 to 8,000 years from tundra vegetation like that around modern Barrow to the present composition which includes shrub species and some dwarf tree species. These chronological shifts in vegetation have followed climatic trends since the last (Wisconsin) glaciation and were determined from pollen spectra from Chandler Lake and near Barrow (Colinvaux, 1967 as cited in IRI, 1975).

Along the corridor south of the present tree line, the vegetation and climate shifts did, however, leave a small forested area along the Yukon River which survived through the most recent glaciation. During the glacial

Table 8.1.1.5-17 Approximate land ownerships associated with the Fairbanks alternative route

Ownership	Miles	Percent
Federal Utility Corridor*	360	49
Proposed Wrangell Mountains National Fores	10	1
Military and other Federal	89	12
State	252**	35
Native	24	3
	735	100

*Occupied by Trans-Alaska Oil Pipeline System.
**Much of area has been transferred to private ownership.

maximum this small forest area, surrounded by tundra and steppe, survived to reforest larger areas of central Alaska after the recession of the glacier.

On a paleoenvironmental basis, archeological potential varies for this corridor from high for all ages near the Yukon to moderate near the north end for the earliest time periods.

In light of recent findings in France (Francois Bordes: Personal Communication, 1975 as cited in IRI, 1975) that Middle Paleolithic hunters and gatherers lived very near glaciers, the periglacial portion of this segment and others could contain sites of great antiquity. The evidence at the France site indicates a human adaptation to the bioclimatological conditions near glaciers prior to the time period for which we consider human habitation of Alaska likely.

Near the Yukon and along the Tanana Rivers this corridor remained predominantly forested throughout the Wisconsin Glaciation (Hopkins, 1967 as cited in IRI, 1975). The paleontological record for both plants and animals is more extensive than for many other areas of Alaska and shows that both tundra and forest ecosystems have existed in close proximity for the 40,000-year period considered here. Archeologically, this corridor has been continuously bioclimatically suitable for human occupation throughout this entire time span.

The short Ladue River segment in the Intermontane Paleoenvironmental Zone crosses the Yukon-Tanana Uplands from the Tanana River to the Canadian border. During Pleistocene glaciations this area remained unglaciated, though near the extensive ice-covered Alaska Range. Like portions to the north, this corridor has significantly higher elevation than nearby lowlands along the Tanana, and during the period of drier and colder climate coinciding with the Wisconsin Glaciation maximum the forest likely retreated to a narrow strip along the Tanana River, leaving the highlands with a tundra or steppe setting until the gradual readvance of the forest to its present state.

The Ladue River followed by this corridor is a minor stream compared with the Tanana River and its relatively broader and deeper valley. The archeological potential is likely correspondingly less than along the larger streams at lower elevations.

During the Wisconsin Glaciation this corridor in Intermontane Paleoenvironmental Zone was unglaciated and probably contained a remnant of coniferous forest along the Tanana and Chisana Rivers. During this period the location of the corridor on the lee side of the Alaska Range likely resulted in a drier and colder climate than today, as the high, glacier-covered area to the south would have then produced a more pronounced "rainfall shadow" than it does now.

Although not glaciated, the lower part of the route has been affected by glacial outwash sediment and watered by glacier-fed streams. The climate has probably never been strictly arctic, nor has the area had an extensive and long-enduring tundra ecosystem. Like the Yukon valley, this portion of the corridor has had a continuously suitable bioclimatological setting for human occupation for the last 40,000 years. Although the potential for containing pre-Wisconsin Glaciation archeological sites is moderate, the potential for coverage of earlier sites by recent alluvial and aeolian sediment is high in this corridor which was near the glacial boundary.

Archeological Summary

The many archeological sites reported for this segment span the range of human occupation from Paleoarctic sites to recent Athapaskan camping localities. XBD R-4, situated in the Tanana River valley east of Big Delta, contains materials reflective of Kluane Lake artifacts of the Paleoarctic Tradition; while the Campus Site FAI R-6, adjacent to the University of Alaska, has yielded distinctive wedge-shaped cores, semi-polyhedral cores and microblades that pertain to the core and blade industries developing about 6,000 years ago in the interior. LIV 004, LIV 007, and LIV 012 all represent components of the Northern Notched Point Tradition.

The most thoroughly investigated region adjacent to this corridor is in the vicinity of Healy Lake, approximately 15 miles from the right-of-way. The Village site (XBD 020) excavated by Cook and McKennan (1971 as cited by IRI, 1975) yielded four cultural levels in stratigraphic sequence dating from 11,090 B.P. to a historic Athapascan component. Stratified components from the Garden Site (XMH 204) confirm the sequence of occupation. Several sites including XMH 213-16 and LIV 001 are Athapaskan sites of pre- and post-contact periods. Sites XMH 205-211 provide additional indications of cultural continuities in this archeological zone.

Alaska Heritage Resource Survey records contain no additional information to supplement the 63 archeological sites listed in the trans-Alaska oil pipeline corridor.

Archeological Evaluation

In terms of known archeological sites, this segment is one of the most critical for exhaustive survey work in all areas of potential impact. A major caribou range today and in all probability richly productive for hunting in the past, this predominately forested intermontane zone has revealed cultural materials within the pipeline corridor reflecting human occupation from as early as 10,000 B.C. to the present.

The pipeline abuts the eastern edge of the Batza Tana obsidian outcrops where it skirts Caribou Mountain. Because this obsidian zone has been one of the most prolific sources for fluted points and other tools of the glassy, volcanic material the impacted area may well contain sites offering evidence linking this natural resource with obsidian implements found in regions as far distant as Driftwood Creek, Healy Lake, Fairbanks and the Putu site on the Sagavanirktok River (Alexander, 1972). Such information would help explicate the relationship of channel-flake industries to other technological traditions and could provide as well indications of ancient patterns of trade and migration (IRI, 1975).

It is also important to note that the pipeline traverses regions utilized by both the earliest Eskimo (Denbigh) and Athapascan (Tuktu-Denali) peoples. The discovery of evidence in this transitional zone may help clarify the difficult problem of distinguishing the respective socioeconomic traditions and provide more detailed information on developmental processes in the formation of distinctive Eskimo and Indian cultures.

Recent scientific investigations in this sector are beginning to clarify the chronology and affiliation of Early Man sites in the interior. The evidence from Healy Lake and artifacts discovered in association with now-extinct Pleistocene fauna along tributaries of the Tanana (FAI R3, FAI R5) suggest that the area may be one of the most important for potential discovery of Paleoindian sites. The presence of materials reflective of the Paleoarctic Tradition (XBD R-2, XBD R-4), the Northern Notched Point

Tradition (LIV 004, LIV 007, LIV 012) and microblade industries (FAI 001, HEA 005, HEA 008) indicate as well the need for careful survey. A second critical problem is the lack of information pertaining to the changing socioeconomic patterns by interior Indian groups. Particular attention to pre- and post-contact sites of Athapaskan affiliation would be valuable for interpretation of the minimal data now available.

As the summary of the environmental characteristics indicates, the lower part of this corridor crosses one of the most favorable areas for continuous human occupation and this provides an ideal situation for recovery of new information on developmental sequences in the area. This route, as well as several others, traverses traditional Athapascan territory. The orientations of historic and immediate prehistoric tribal units to major river arteries (Osgood, 1936; McKennan, 1965; Nelson, 1973) suggests that archeological sites within the impacted corridor could reveal potentially valuable information for ethnoarcheological studies which expand our understanding of earlier economic patterns and social systems. At present, the only sites with Kutchin or Han Athapascan components for which temporal sequences are available are the Dixthada site near Mansfield Village and the Klo-Kut site in northwestern Canada. (Morlan, 1969)

Historic

The Alaskan Interior contains numerous historic sites of the Gold Rush era, including dredges, steamboat relics, saloons, and courthouses. Some may deserve restoration and, possibly, reactivation, in their historical context. Particularly south of Fairbanks, historical resources are abundant along the route.

In the Brooks Range, above the Arctic Circle, lies the old mining center of Wiseman, which served as the supply center for gold miners in the central Brooks Range. Thirty old buildings remain intact in Wiseman.

Roadhouses sprang up along all the major routes of travel in Alaska at about 15-mile intervals, offering meals and beds, often at exorbitant rates, to travelers in the primitive and harsh country between population centers. At one time for instance, approximately 50 roadhouses lined the road between Valdez and Livengood. Depending upon the precise routing, several of the sites used for roadhouses might be directly involved with the Fairbanks alternative.

Historic Evaluation

The segment from Prudhoe Bay to Oksrukuyik Creek is covered in 8.1.1.4.

Early explorers along the northern coast ignored this inland area; hunting and trade was profitable enough just along the coast and in the immediate inland area. Early explorers of interior Alaska disregarded the area for the same reason; the furs they wanted could be obtained along the Yukon and its tributaries. A few missionaries visited the more accessible portions of the region, but the apostolic purpose was deterred as easily as the traders.

The river valleys and some portage routes were summarily explored under United States government-sponsored expeditions, first by Lieutenant Allen in 1885 and then by Alfred Brooks in 1901. By 1900 the high hopes of prospectors around the upper Koyukuk and the various Forks had drawn river steamers and supply agents to the area. These men provided basic manuscript maps of navigable areas.

The expectations of these traders and prospectors are reflected in the United States Geological Survey maps published at that time. The 1906 map shows several "cities" along the route. These include Jim City, Soo City and Seaforth City, all on the South Fork of the Koyukuk, and Dall City, further to the east and on Dall River. These were prospectors' camps occupied in the winters of 1898-1900 by prospectors on their way to Coldfoot. These "city" sites correspond to those currently listed on maps as prospectors' camps along the winter trail and were probably used as mining activity moved northward to Wiseman after 1911.

Settlement of this area by white men was almost non-existent before Fairbanks established itself as the hub of interior Alaska in the first decade of this century.

Robert Kennicott is the first white man of record to scientifically survey the lower Tanana region. This he did in the early 1860's while employed by the Western Union Telegraph as superintendent of the scientific part of that company's overland route. In 1875 Arthur Harper and B. Yates ventured into upper regions of the river. They crossed by Indian trail from the mouth of Mission Creek to the Tanana and floated down to the confluence of the Tanana with the Yukon. In 1876 Jack McQuesten went upriver 350 miles for purposes of trading with the Indians; Arthur Harper and Captain Al Mayo ascended the river for 200 miles 2 years later. None of these traders are known to have made maps or published any account of their journey. Bob Bean, the first trader to attempt to establish a post in the valley, was tragically unsuccessful. In 1876 Bean and his wife and two children built a cabin only 75 miles up the river and offered trade goods at a higher price than was charged at the Yukon posts. The enraged Indians murdered Mrs. Bean and attempted to murder the trader, who escaped with the children.

The first mapping of the Tanana was done in 1885 by Lieutenant Allen, who also wrote an account of his journey along much of the river.

The 1890's saw occasional prospecting along the river, as well as visitations by traveling missionaries. In 1892 Mr. Prevost, an Episcopalian missionary, traveled up the Tanana to the future site of Fairbanks and across the Goodpastor River to the Forty Mile. He reported visiting 32 Indian villages. Visitation by missionaries was not uncommon by that time.

The first official exploration of the entire river valley was made in 1898 by Peters and Brooks of the U.S. Geological Survey. Their map of Tanana tributaries, as well as that map resulting from Lieutenant Herron's military survey of the region in 1896, was inaccurate. It was the unofficial map drawn up by Judge Wickersham's Mt. McKinley expedition of 1903 that was used by the prospectors throughout that decade.

In 1901 E. T. Barnette established a trading post, Barnette's Cache, at the present site of Fairbanks, then a desolate location on the Chena Slough. The post was established here merely by chance: the steamer carrying Barnette and his goods could go no further because of the sandbars. Simultaneously, Felix Pedro was prospecting the area and convinced Barnette of the prospector's need for a supply post right where Barnette was located. The first winter's trade was good, but it was from furs instead of gold. The 1902 strike of Pedro brought immediate attention and many prospectors. No resultant outpouring of gold materialized, and the region was hastily deserted. The next year, however, gold began to flow, yielding $40,000 in 1903, $600,000 in 1904, $6 million in 1905, and $9 million in 1906.

By 1906 Barnette's Cache had been renamed Fairbanks, was the new headquarters of the Third Judicial District which had previously been at Eagle, and could claim even a railway, telephone service, electric lights and a water system. This was due to the foresight of Barnette, who had offered free land to anyone wishing to build at his site. Chena, a rival site now almost forgotten, might have developed the way Fairbanks did, had not its greedy developers established exorbitant land prices.

The roadhouses, railroad and riverboat stops, and gold-mining camps along this segment and other access routes to Fairbanks all resulted from the successful attempt to develop the area, the last center for Alaskan gold mining.

Preliminary exploration of part of this area was conducted between 1885 and 1887 by Lieutenant H. T. Allen of the United States. He reported the two Indian sites of Nandell, a former village, and Tetling's, now known as Tetlin Junction. Allen gave Nabesna River its name, which is from the Indian word for the Upper Tanana. Nabesna Village was established as a mining camp in 1909.

Later explorations in the area included that of A. H. Brooks and W. J. Peters in 1898. They are responsible for naming many streams between Tetlin Junction and the Canadian border.

Unique Areas

The following sites near the Fairbanks alternative from Prudhoe Bay to Canadian border have been studied for possible designation as Natural Landmarks. The studies were contracted by the National Park Service and undertaken by the Tundra Biome Center (University of Alaska), the Arctic Environmental Information and Data Center of the University of Alaska, the Lawrence Radiation Center, and Robert Detterman of the U.S. Geological Survey.

The sites are of two general types: ecological and geomorphic. See section 2.1.1.11 for a listing of the prescribed criteria.

Ivishak-Saviukviayak Rivers--Located 10 miles east of the Sagavanirktok River in the foothills of the Phillip Smith Mountains, the rivers are fed by springs throughout the year. Aufeis deposits are prevalent. The area was glaciated during the Wisconsin Age, and several moraines were left as the glaciers receded. Two areas along the Ivishak-Saviukviayak have been studied for designation as Natural Landmarks. One has significant glacial features; the other arctic river features.

Toolik River Plain--Located between the Toolik and Sagavanirktok Rivers, 20 miles south of the Arctic Coast, is a significant example of an arctic coastal river alluvial plain. Three areas along the Toolik have been studied for designation as a Natural Landmark because of significant plain, river, and permafrost features.

Atigun Gorge--Located west of the Sagavanirktok River, 20 miles south of its confluence with the Ribdon River, is a steep-walled canyon cut by a Pleistocene glacier. The Atigun River, which heads in the Endicott Mountains, flows through the gorge. Exposed rock faces in the gorge date from the Mississippian Period. The area is very scenic and has been studied for designation as a Natural Landmark.

The Franklin Bluffs and White Hills--Areas are similar to the Badlands of South Dakota, with cliffs of multi-colored rock exposed by erosion. These cliffs also are traditional nesting sites for the endangered peregrine falcon.

In addition, the Joint Federal-State Land Use Planning Commission has considered establishment of a system of ecological reserves in Alaska. The following areas have been nominated for special protection in such a system:

Galbraith Lake--Special archeological values and the location of an oil pipeline construction camp and airstrip. Revegetation studies have been conducted since 1970 of natural and disturbed *Eriophorum* tundra, alpine, and transitional vegetation.

Dietrich River--Includes a riverbottom white spruce stand at treeline. About 12 acres.

Dall Mountain Watershed--The reserve would include a complete watershed for hydrological studies. Primary vegetation is upland black spruce, birch shrub heath, and alpine tundra which is winter caribou range. About 25,000 acres.

Dall Hot Springs--Subarctic hot springs. Located in the Kokrines-Hodzana Highlands, the site was apparently a bathing place more than 50 years ago. The site is less than 1/4 mile from the new road constructed to Prudhoe Bay.

Ray River Hot Spring--Also located in the Kokrines-Hodzana Highlands, the origin of the spring is believed to be an intrusive granite mass in older volcanic and sedimentary materials. The site was used in bathing and vegetable farming in the 1900's by miners.

Caribou-Poker Creeks Research Watershed--About 25,000 acres, this is an established (1969) research area on State-owned land where an undisturbed watershed with black spruce, paper birch, quaking aspen, and related vegetation can be studied to determine hydrologic, climatic, and environmental relationships of a taiga environment.

Wickersham--Site of a recent (1971) forest fire, eroding fire lines, mud flows, and related effects caused by fire fighting methods are evident. Revegetation of the 1971 burn and the effect of fire on soil and air temperature, permafrost, soil water, and energy regimen are being studied by the Institute of Northern Forestry. A valuable area, in conjunction with the Caribou-Poker Creeks, in assessing effect of various disturbances on these forest and soil types. About 15,000 acres.

Fox Tailings--Tailings from early gold dredging operations. Could provide valuable information on revegetation of surfaces of known age.

Salcha River--An ideal study stream for populations of king and chum salmon, grayling, and other indigenous populations.

Harding Lake--Lake and birch forest. About 1,000 to 2,000 acres.

Shaw Creek Experimental Area--A 95-year-old paper birch stand. About 1,000 acres where studies of paper birch seed production and white spruce establishment can be studied.

Robertson River--River bottom white spruce at the confluence of the Robertson and Tanana Rivers (both glacial). Stand represents a commercial white spruce type in the upper Tanana River Valley.

Esthetics and Recreation Resources

Esthetics and Wilderness

North of the Yukon River most areas adjoining the Faribanks alternative route (with the exception of oil production and transmission facilities at Prudhoe Bay) are de facto wilderness. This is not to say that man's impact has been totally absent, but it has been localized. Historically, man has occupied villages and from such seasonal locations roamed the vast expanses, leaving little trace of his passing.

South of the Yukon along this alternative route there is increasing evidence of human activity. From north of Fairbanks to the border, the route is entirely altered. Yet, in most areas, a few miles laterally from the route places one back into at least "back country" terrain.

Recreation Facilities

Existing--There are no established recreation facilities north of the Yukon River near the Fairbanks alternative route. Proceeding southward from the Yukon River are two small public campgrounds (Tolovana River and Tatalina River). In the Fairbanks area the city maintains numerous parks for day-use activities.

Along the Alaska/Richardson Highway southeasterly from Fairbanks are 10 public recreation areas. The largest, Harding Lake Recreation Area, has 89 camping units and 52 picnic units.

Air Quality

With three categoric exceptions air quality along the Fairbanks alternative route from Prudhoe to the United States-Canada border via the Alaska Highway is considered to be very high. Exceptions are as follows:

1) Prudhoe Bay oil and gas field.

2) Small towns and population enclaves along the highway between Fairbanks and the border.

3) Fairbanks with its particular combination of air related circumstances. Fairbanks has unique and acute air pollution problems because of very strong air inversions and ice fog conditions. Prevailing directions for ground wind and near wind speeds for Fairbanks are shown in Table 8.1.1.5-18.

Table 8.1.1.5-18 Ground winds, mean speed, and prevailing direction Fairbanks, Alaska, elevation 436 feet

Month	Mean Speed	Prevailing direction	Month	Mean Speed	Prevailing direction
Jan.	2.8	N	July	6.2	S.W.
Feb.	3.8	N	Aug.	5.9	N
Mar.	4.8	N	Sept.	5.9	N
April	6.4	N	Oct.	5.3	N
May	7.5	N	Nov.	4.0	N
June	6.7	S.W.	Dec.	3.0	N

Source: E.D.S. Charts

Environmental Noise

Data on environmental noise associated with the Fairbanks alternative route are not available. North of the Yukon River the route is closely associated with a transportation corridor for the trans-Alaska oil pipeline and a highway. Adjacent areas, however, are undeveloped and are expected to have little environmental noise other than that produced by nature. South of the Yukon River the route is near an established highway. In Fairbanks noise levels are expected to be typical of a community of comparable size except that Fairbanks has a very high proportion of aircraft use because of its location as a major air center. From Fairbanks southeast to the Canadian border, the route is closely associated with an established highway.

Environmental Impacts Caused by the Fairbanks Alternative Route

Summary of Significant Impacts

Major impacts expected if the Fairbanks alternative route is selected for construction of a gas transmission system are similar in some instances, but others differ significantly from those expected for the applied-for, the Interior alternative, and the Fort Yukon alternative routes.

Permafrost--Impacts are similar to those discussed for the applied-for route except that more than 69 percent of the Fairbanks alternative crosses discontinuous permafrost. Frost heave forces associated with frost bulb formation around the pipe in such regions are increased over those expected in regions of continuous permafrost and the proposed mitigating measure (surcharge) has yet to be demonstrated. Unchecked frost heave forces increase the possibility of pipe differential loading and threaten pipe integrity.

Wildlife--Because most of this alternative route parallels the trans-Alaska oil pipeline system, some of the impacts will be cumulative. Fish populations may be severely damaged by two pipeline crossings which could interfere with spawning and block fish passage.

Air Quality--Ice fog, a severe meteorological condition, limits winter travel in Alaska's Interior, particularly in Fairbanks where exhaust emissions trapped in ice fog could not only halt pipeline construction, maintenance, and repair activities during parts of the winter, but also endanger public health.

The following analysis of anticipated environmental impacts reflects some uncertainties. Experience in arctic construction is adequate to predict the probable degree of expected change to the existing environment; and where available data are not adequate, the impact analysis so indicates. Similarly, impacts are evaluated on the basis of what may happen if major project elements now planned by AAGPC for the applied-for route cannot be achieved.

Impact of the Fairbanks Alternative Route on Climate

As discussed in 1.1.1.3, the construction, operation, or repair of this system will have little, if any, impact on climate. It will not affect regional temperatures, winds, or precipitation. Available information suggests that micrometeorological changes will result from compressor station emissions. (See Air Quality.)

Impact of Climate on the Fairbanks Alternative Route

Major construction phases will be initiated during the period when the ground surface is frozen. Some construction is planned for the mountainous areas during the summer season.

Weather conditions over interior Alaska can be very adverse, with frequent wintertime inversion and conditions for ice fog formation.

Impact of the Fairbanks Alternative Route on Topography/Landscape

Some landscape changes in topography will be caused by borrow areas, ditch mounds, and buildings. (See Topography for applied-for AAGPC route, section 3.1.1.2.)

A major portion of the Fairbanks alternative route is located in forested, rolling topography and is associated with a major existing transportation system. Therefore it is believed the overall impact of the Fairbanks alternative on topography will be slight.

The greatest impact on topography and landscape will result from new large structures.

The overall impact of the alternative pipeline will produce local topographic/landscape modifications from (1) borrow areas and establishment of a low linear ditch mound and (2) construction of large buildings and towers.

Impact of the Fairbanks Alternative Route on Geology

Mineral Resources

The construction and operation of a gas pipeline will have little if any impact on the development of hardrock minerals and energy producing minerals except for oil, gas, sand, and gravel. The highways and oil pipeline construction would require approximately 5.9 million additional yards of gravel. In many areas the old and new riverbeds are the primary sources. Consequently, as gravel requirements increase along this route stream hydrology and water quality can be adversely affected.

Permafrost

The 735-mile-long Fairbanks alternative pipeline system will not affect the overall distribution or abundance of permafrost in Alaska. Permafrost will affect the pipeline. The route crosses 230 miles of continuous permafrost. Impacts in this zone are expected to be similar to those described in the applied-for AAGPC route (3.1.1.3) and the Interior alternative (8.1.1.3). The remaining 505 miles (69 percent) are in the discontinuous permafrost zone. Impacts in this zone are expected to be comparable to those described for the applied-for route through Canada as it passes through discontinuous permafrost areas (see Canada, permafrost).

Earthquakes

The seismic zonation applied to the trans-Alaska oil pipeline, which is now under construction within part of the proposed Fairbanks alternative route, is also applicable to a chilled, buried natural gas pipeline. These zonations from the Federal Task Force on Alaska Oil Development, (SITF 1972), are as follows: Prudhoe Bay 5.5 magnitude and Donnelly Dome 7.5 magnitude.

U.S.G.S. information indicates that the potential for an earthquake of magnitude of 7.0 to 7.5 should probably be considered in the Fairbanks area.

Several faults delineated by earthquake epicenters obviously must be considered active. Further studies including geologic field investigations are required to define zones of potential surface offsets and to assign design fault offsets and ground motions to specific faults, and to design the pipeline system to accommodate the seismic event. Impacts from seismic events are considered minor.

Impact of the Fairbanks Alternative Route on Soils

Impacts on soils caused in the Fairbanks route are expected to be comparable to those discussed for the applied-for AAGPC route and the Interior Route (3.1.1.4 and 8.1.1.3, respectively).

Impact of the Fairbanks Alternative Route on Water Resources

Surface Water

Overall impacts on water quality are expected to be similar to those described for the applied-for AAGPC Route (3.1.1.5) and the Interior Route (8.1.1.3).

Ground Water

Ground-water conditions along the alternative route are highly variable, primarily reflecting permafrost conditions. Impacts on ground water are similar to those described along the applied-for route, section 3.1.1.5 and the Interior route, section 8.1.1.3.

The relation of any diverted ground water flows on maintenance of the nearby hot oil pipeline system is not known.

Streams and Rivers

This route will cross 159 rivers and streams between Prudhoe Bay and the United States-Canada border. Impacts on the pipeline are similar to those described for the applied-for route, section 3.1.1.5 and the Interior route, section 8.1.1.3.

Impact of the Fairbanks Alternative Route on Vegetation

Approximately 4,500 acres of existing underbrush and forest will be destroyed by the construction of permanent spur roads, airfields, compressor stations, communication sites, borrow pits, and other structures. An additional estimated 8,000 acres will be disturbed during construction by the use of temporary work pads, snow and ice roads, and temporary winter trails.

Secondary impacts resulting from construction and operation of the alternate pipeline will affect an additional, but undetermined, area through changes in various physical conditions of the plants' environment. These secondary impacts which modify habitats will result in greater long-term changes in plant communities, and the functioning of the various ecosystems, than the seemingly more severe short-term construction impacts.

Forest Resources

Some merchantable quality forest would be cut in crossing the Bottomland Spruce-hardwood and Upland Spruce-hardwood type.

Indications are that an area 120 feet wide would be cleared, and the route traverses approximately 227 miles of commercial forest. Over much of this distance, a closed forest canopy does not exist and timber stands of merchantable quality and quantity are widely scattered.

A cleared right-of-way 120 feet wide and 227 miles long will result in the cutting of trees from 3,630 acres. Without an inventory, it is difficult to estimate the volume of timber involved, but it would be at least several million board feet. Where the route crosses river terraces containing white spruce stands, the volumes may exceed 10,000 board feet per acre.

While the volumes to be cut sound high, they are scattered so that their loss would not be economically significant. Local stands would have value to nearby users and could be salvaged for local use.

The right-of-way clearing will leave a rather straight line across the landscape. (See esthetics for this impact evaluation.)

Major secondary impact on the forest production could come as a result of insect epidemics which could be associated with slash piles and scattered or decked logs.

The pipeline presence and operation will have an indirect but long-term effect on all vegetation. Site modification will include changes in soil moisture, surface drainage, soil temperatures, nutrient availability, microrelief, and the depth of the active thaw layer. The cold buried pipeline and the depth of the mound of dirt over it will, at various places, impound, impede, and divert the normal flow of surface and subsurface water despite the use of granular fills and cross drains (ditch crossings) to allow its passage (see Water Resources).

Wetland plant communities upslope from the line which are deprived of their normal water supply will gradually be replaced as plant species better adapted to drier sites become established. The downslope changes occur more slowly than the upslope changes, but the ultimate results will be the same, i.e., replacement of the present natural vegetation by a new mosaic of communities.

Lower soil moisture in the pipeline berm, reduced soil temperatures over the chilled pipe, and increased microrelief will create another set of conditions alien to the present plant communities and will probably result in at least two new sets of communities growing along the crest and side slope of the pipeline mound. These changes in plant species occurrence and communities will radically modify the landscape through which the pipe passes and make its location easily visible to the knowledgeable observer.

Wildfire

This route encounters various vegetation types and plant communities that have specific wildfire characteristics.

Although all vegetation zones crossed by the alternative route are subject to fire, they differ in their ability to carry a fire, once it has begun (See vegetation Figures 8.1.1.5-20 A and B; and Table 8.1.1.5-19).

Impact of the Fairbanks Alternative Route on Wildlife

The construction of this alternate pipeline system will affect wildlife populations in the following ways: (1) direct and indirect harassment or project-caused disturbance during critical periods of an animal's life cycle; (2) increased harassment and/or destruction of wildlife because of better access to area; (3) the introduction of pollutants to the ecosystem; (4) the inability of certain species of wildlife to adapt to man's presence; and (5) the direct or indirect destruction of wildlife habitats. Because most of this alternative route closely parallels the trans-Alaska oil pipeline system, many of the impacts e.g.,noise pollutants from gas compressor sites added to noise and pollutants from oil pump stations, will be cumulative.

Because there is no precedent for this combination of petroleum product transportation systems, the additive effects, while based on best judgment, are mainly tentative. Refer to Figures 8.1.1.5-24 A and B which show sensitive wildlife areas.

Caribou

As with the Fort Yukon Alternative (8.1.1.4), the most severe primary impacts of the proposed pipeline on caribou will be those affecting caribou behavior and population dynamics rather than habitat.

Aircraft disturbance would be experienced year-around and would be concentrated at the airstrips and helicopter landing pads. Disturbance during the summer by low flying aircraft will affect a great number of animals, but it is the harassment in winter that can have the severest direct impacts on individual animals. In midwinter, when the daily energy balance of a caribou is low, harassment by aircraft, snowmachine, or other project-associated vehicles can cause the animal to expend more energy than it can acquire from the available forage, thus placing the animal in a negative energy balance. Repeated harassment will lead to death of that individual.

In summary, it is expected that the operation and repair of this system could have some adverse impact on the Arctic Caribou Herd by changing its behavior and shifting it away from traditional areas. This could lead to a long-term reduction of the herd.

Table 8.1.1.5-19 Ability of vegetative fuels to carry fire

Vegetative	Rate of spread	Resistance to control
Upland spruce & hardwood	High	Medium
Lowland spruce & hardwood	High	High
High brush	Low	High
Low brush	Medium	High
Bottomland spruce & poplar	Medium	High
Moist tundra	Medium	Medium
Alpine tundra	High	Low

Moose

Winter construction activities, besides destroying critical habitat, may also disturb moose collected in river valleys enough to displace them from the area. On an already limited range, this disturbance and displacement may adversely affect an individual's energy balance and result in death.

Overall, the construction, operation, and repair of this system is expected to have minor impact on the moose population. Most will be caused by the additional disturbance within the whole utility corridor.

Dall Sheep

Dall sheep in the Brooks Range tend to concentrate in winter and spring on south-facing slopes in areas of reduced snow accumulation. Two such areas are immediately adjacent to this alternative system. They are the north side of Atigun Canyon and at the head of Dietrich River near the Chandalar Shelf. Lambing also takes place in these concentration areas, and at mineral licks used by the sheep in spring and early summer. They are located very near the alternative pipeline right-of-way. Mountain sheep populations utilizing these areas would experience considerable stress even under the best of construction and pipeline operation conditions.

Sheep are usually frightened by aircraft. The noise is probably the main reason (Price, 1972), but the presence of the airplane may also play a role. Such disruptions interfere with normal behavior patterns and generate increased physiological stress. The significance of disruption of behavior patterns on the well-being of Dall sheep has not been fully evaluated, but it is known that disturbance immediately following birth can result in a substantial decrease in survival of the newborn young (Pitzman 1970; Klein 1973).

If repeated hazing occurs during a short period of time the net result can be a significant increase in mortality in the harassed population.

In summary, the additional impact to Dall sheep because of this system is expected to be minor. The present road and oil pipeline which are being built have already affected the sheep, and the gas pipeline would add to the surface and air disturbances.

Buffalo (American bison)

A small herd of buffalo inhabits an area adjacent to the Fairbanks alternative route. This herd (200+ animals) is centered near Big Delta.

The primary impact of pipeline construction would be disturbance of these animals. Harassment by ground vehicles or aircraft, especially during calving or wintering periods, would be adverse to the herd's well-being.

Most of this herd's range is far enough from the alternative line so that food sources will not be reduced.

In summary, this pipeline is expected to have little if any impact on this herd's traditional food source or its total population. Disturbance by noise or harassment will be the worst problem and may cause loss of a few individual buffalo.

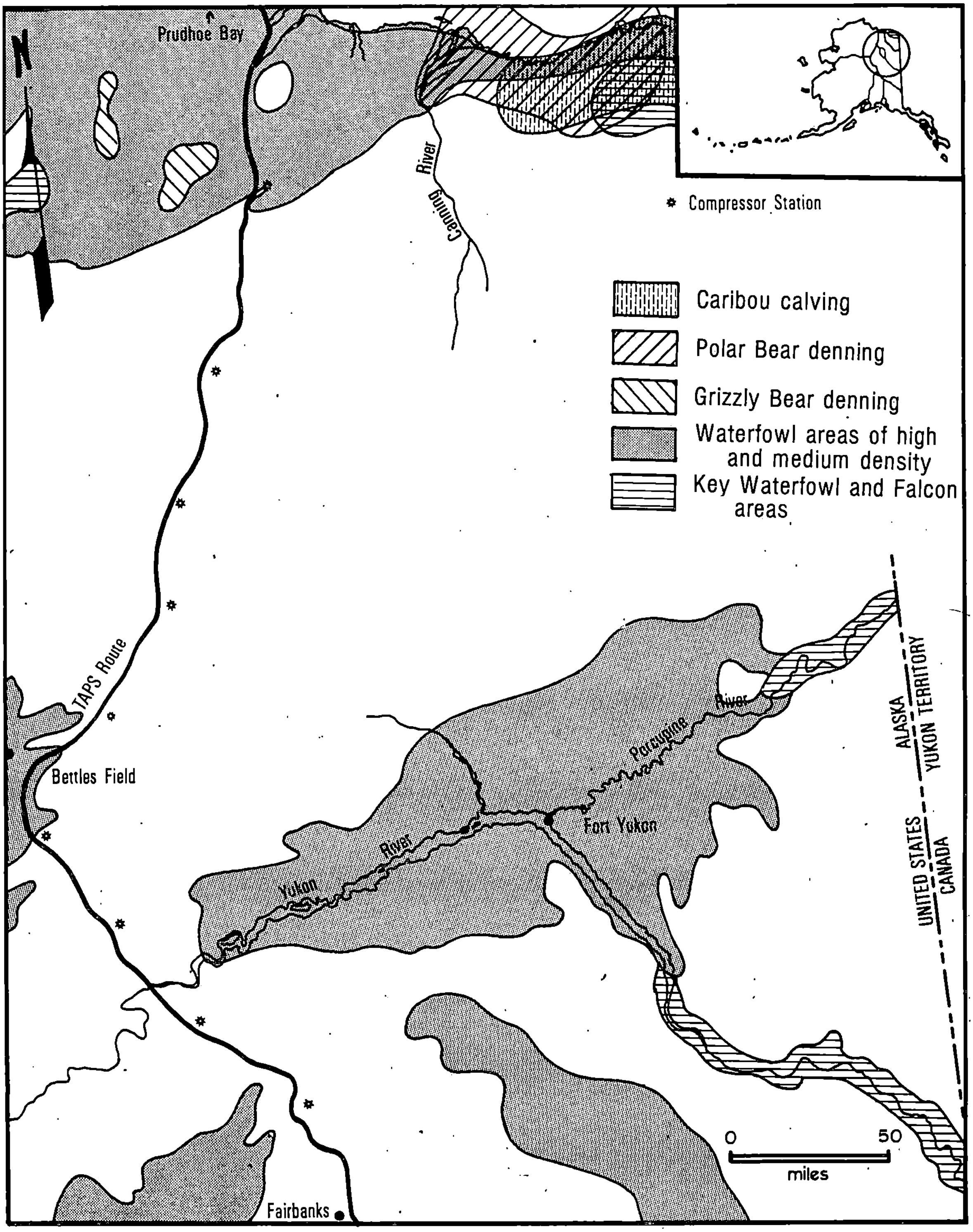


Figure 8.1.1.5-24A Sensitive wildlife areas of the Fairbanks alternative pipeline route

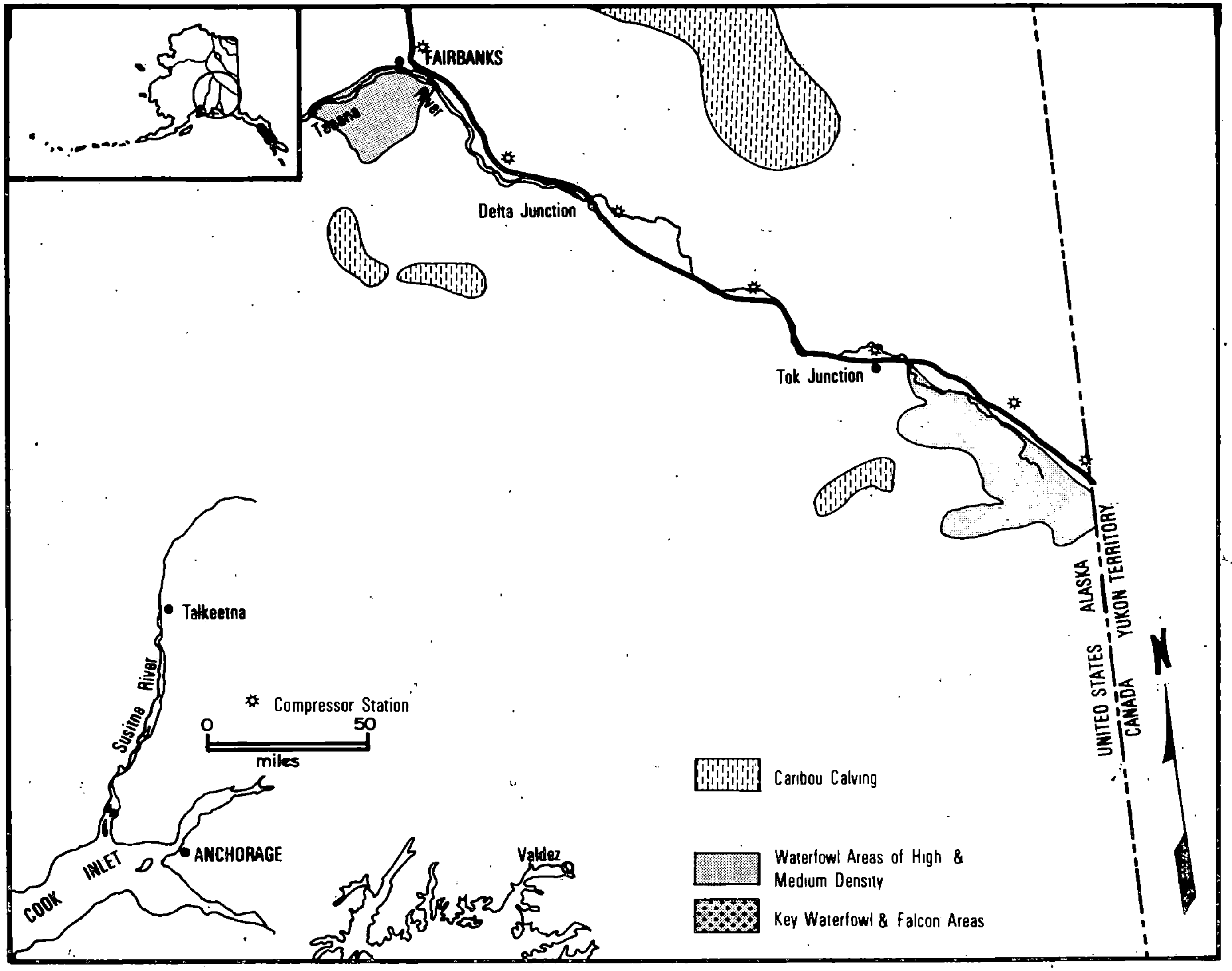


Figure 8.1.1.5-24B Sensitive wildlife areas of the Fairbanks alternative pipeline route

Wolves

Impacts on wolves will be similar to those described for the Fort Yukon alternative route, section 8.1.1.4.

Bear

Impacts on polar, grizzly, and black bears will result mainly from the increase in human activity both in the air and on the ground. These would be similar to those described for the applied-for AAGPC route (3.1.1.3) and the Interior Alternative (8.1.1.3).

Birds

Potential conflicts between the pipeline and bird populations can occur from disturbance, habitat destruction, pollution, and direct mortality. Some of these impacts are unavoidable, but many are avoidable, depending on the location of various facilities, construction practices, and scheduling of activities.

The construction phase of this alternative gas pipeline system would not be devastating to bird resources in general, but it would contribute to an ever-increasing attrition of bird populations through exploitation and deprivation of habitat which would be added to that habitat lost through construction of the Alyeska oil pipeline.

The number of birds that would be displaced by this habitat loss is not known. However, birds displaced by habitat modification, while not killed outright, are removed from the breeding population and thus contribute no further offspring during their lives. This occurs because they can seldom find suitable substitute breeding habitat which is not already occupied by others of their species. Thus, when habitat is lost, the population eventually stabilizes at a lower level.

Approximately 85 miles of the Fairbanks alternative route traverse good waterfowl nesting habitat and cross several major and many minor drainages flowing into internationally important waterfowl production areas. Disturbance would probably drive away, at least temporarily, all birds from the sites of construction activity and some birds from adjacent areas. Although the tolerance of birds to disturbance varies with species, season, stage of nesting, and type of disturbance, it has never been qualified. Observations suggest, however, that geese, swans, loons, cranes, and raptors are generally less tolerant of disturbance than most small passerines, shorebirds, and some ducks. (SITF, 1972)

Some species may accommodate to new and increased disturbance, whereas the detrimental effects of increased disturbance could be cumulative on other more sensitive species, such as nesting whistling swans or raptors. The area adjacent to the Alyeska oil pipeline would have already been disturbed.

Fish

Available information is inadequate to assess the potential biological effects of the heat loss to streams from the Alyeska oil pipeline (+140 to 180° F; +60° to 80° C) now under construction. If stream areas were to be warmed, biological adjustments would also occur in bottom dwelling and associated organisms. The adjustments would range from imperceptible to actual changes in species composition. The effect of a warming influence on bottom-dwelling and associated organisms would depend on numerous factors, including the temperature differential at the mud-water interface, the area of the stream affected, the degree of turbulence, and others. Information on the species composition of bottom-related organisms for these areas is not available (SITF 1972).

In contrast, the presence of chilled (-10° to 25° F, -5° to 1° C) gas pipeline buried beneath these same streams will cause other biological adjustments of bottom dwelling and associated organisms. The primary impacts of the construction and operation of the gas pipeline can be broadly categorized as increases in suspended particles, reduction in dissolved oxygen, creation of barriers (culverts), and introduction of pollutants, all of which will all be directly inimical to fish life. 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 severest short-term environmental degradations.

The ongoing operation of trans-Alaska oil pipeline maintenance camps, pumping stations, and revegetation program may already have stressed the oxygen levels of the streams to their carrying capacities. Further oxygen-demanding actions from this project may increase the biological oxygen demand beyond the streams' capacity and will kill all living stream organisms.

Cumulative effects caused by the interaction of this project and the Alyeska oil pipeline project will also cause changes and/or additional mortality to fish life.

Important unanswered questions include the following: (1) How much of a migration delay can each species tolerate? (2) Will fish migrate through a construction zone if the stream is not blocked? and (3) Will alternate spawning areas be used? Damages to affected populations could be extensive if these unknowns are not resolved.

In summary the most critical impacts will be at crossings of small streams where the formation of the frost bulb could interfere with passage of migrating fish. Many streams crossed south of the Yukon River contain anadromous fish which spawn in these streams. Damages to affected populations could be extensive. Impacts of water withdrawal on fish during winter are considered similar to those for the applied-for route, section 3.1.1.7.

Threatened Species

The peregrine falcon nests along the Fairbanks alternative route in the Arctic Foothills area. Nesting sites have been identified and the new road and the oil pipeline are being routed away from them. It is assumed that facilities associated with the Fairbanks alternative route similarly will be located away from traditional nesting areas of the peregrine falcon. No other endangered species of animals or plant life are known to occur along the Fairbanks alternative route.

Impact of the Fairbanks Alternative Route on Ecological Considerations

Refer to discussion in 3.1.1.8 and 8.1.1.3 as these are considered to be similar to ecological factors associated with the Fairbanks alternative route.

Impact of the Fairbanks Alternative Route on Economic Factors

The economic impacts of the Fairbanks-Alaska alternative route as developed by the University of Alaska econometric model (Scott, 1975) described in section 8.1.1.1 include: a property tax of $44 million, construction employment of 6,845, a capital value (pipe and compressors) of $2.2 billion, an increase in gross state product of $249.7 million, a total state employment effect of 23,900, an increase in real wages and salaries of $199.6 million, population growth of 33,400, an addition to personal income statewide of $572.7 million with an increase in per capita income of $463, and a total addition to state revenues of $156.5 million. All figures are for 1980.

Impact of the Fairbanks Alternative Route on Sociological Factors

Sociological factors and impacts have been discussed in detail in Sections 2.1.1.9 and 3.1.1.9 of the AAGPC proposed route analysis.

Sociological impacts will range from beneficial impacts such as cultural opportunities because of greater demand, to such adverse impacts as increase in crime, lower standards of housing, greater traffic problems, and an accelerated rate of decline of Native culture. Sociological impact may be considered less disruptive than other alternative routes because few communities not already affected by the oil pipeline will be involved.

Impact of the Fairbanks Alternative Route on Land Use

Land Ownership and Planning

There is no comprehensive land use plan for lands traversed by the Fairbanks alternative route. Since it is located within an area already dedicated to transportation, it can be assumed that construction, operation and repair of the Fairbanks alternative pipeline system will not change land use in the immediate area.

(See Section 3.1.1.11 of the AAGPC proposed route discussion on Land Use Planning.)

The Bureau of Land Management has prepared a preliminary Management Framework Plan for the oil pipeline portion of this route. This plan for the corridor area is currently in the public review and comment process.

Transportation

Constructing a pipeline parallel to the highway will cause a significant increase in traffic on the highway. This traffic will increase the annual maintenance costs.

Residential Areas

The construction activities would not necessarily directly affect the residential area, since there is enough open space in which to construct the line without invading residential areas. The impact on residential areas will result from increased demand for housing for construction workers, and after the project was constructed, housing for the people operating the system. Small residential areas in Alaska are not capable of reacting to large housing demands in relatively short periods of time. This leads to use of substitute housing, such as trailers and campers, often poorly placed, thus affecting other resources. Other related impacts are discussed in the Economic and Sociological sections for this alternative route.

Impact of the Fairbanks Alternative Route on Historic, Archeological, and Unique Area Values

Historic Values

Remnants of Alaska's early history are scattered along the Fairbanks alternative route. The locations of many of these sites are well known and protected. Some sites are still in use, such as the Sourdough Roadhouse, which has been entered in the National Register of Historic Places. The adverse impacts of the proposed pipeline on these sites would be minor if minor alignment changes are made.

Several still visible old trails would be crossed. Although only short segments of such trails would be disturbed, the visual and esthetic impact to people using the trails could be adverse.

The exact locations of some former trading posts and old villages are unknown. If studies presently being made fail to find these, the areas would need close monitoring during clearing and construction for the pipeline.

AS workers and others move north of the Yukon, vandalism and artifact hunting probably will increase in old mining areas such as Wiseman. This could cause a significant impact if old buildings or artifacts were destroyed or removed.

Archeological and Paleontological Values

Some sites have been identified near the alternative route. In general, however the extent of impact on the archeological and paleontological resources along the route is not known and cannot be assessed until a right-of-way survey is completed.

Surface surveys along the trans-Alaska oil pipeline already show that many sites exist and that the country is quite rich in both archeological and paleontological sites. For example, in the section between Livengood and Prudhoe Bay, 189 sites are listed.

Potential impacts of the system on prospectively valuable archeological areas include: destruction of sites without scientific investigation; destruction with partially completed scientific investigation; vandalism of unexcavated, partially excavated, or accidentally opened sites and; removal of artifacts (surface finds are often of great significance in the Arctic).

Archeological values may have an adverse impact on the completion of the system. Provisions of the National Historic Preservation Act of 1966, Executive Order 11593, and the Aecheological and Historic Preservation Act (P.L. 93-291) require archeological values to be identified and protected. Thus, it is possible that the pipeline may be rerouted within the approved corridors to comply with this Act.

Unique Areas

Several "unique area" studies have been conducted during recent years to identify and suggest protection of areas in Alaska prior to land development. These studies generally conclude that there is a need to preserve some of our natural environment, whether it is physical, biological, or both, in as nearly an undisturbed condition as possible. The sites may be simply natural, important, or unique aquatic or terrestrial ecosystems, geological formations, or habitats of rare plant and animal species. From studies conducted by the University of Alaska and several Federal agencies, the Joint Federal-State Land Use Planning Commission for Alaska recommended in 1973 that a systematic statewide analysis of nominated Science Research and Natural Areas be undertaken to develop a balanced and representative statewide system of such areas.

Eight areas near this route were nominated. These sites are as follows, from north to south along the route: Franklin Bluffs, Atigun Canyon, Galbraith Lake, Dietrich River, The Dolomites, Fox Tailings, Show Creek Experimental Area, and Robertson River.

The Franklin Bluffs site (size not specified) is located along the Sagavanirktok River. These bluffs are a prime nesting area for the endangered peregrine falcon (see 8.1.1.4 and 5 for discussion of falcon in this area). Studies have been conducted in this area on falcons and fish by the State Department of Fish and Game, University of Alaska, and Canada. Much of the natural undisturbed bluff area is just above where the pipeline would pass through a narrow valley. The oil pipeline is under construction.

Winter construction activities will not directly affect these birds, but they can be adversely affected by disturbance from aircraft or human presence while nesting and raising their young. Thus, spring and summer operations and maintenance activities are most likely to affect the peregrine falcons by flushing them from their nests.

To serve its original purpose as a natural study area, this site would have to remain relatively undisturbed. Steps have been initiated to move human activities and pipeline facilities to minimize disturbance from the oil pipeline activities. New or additional disturbances caused by the construction, operation, and repair of the Fairbanks alternative pipeline system on peregrine falcons are unlikely, since procedures established on the oil pipline to protect nesting sites would also be used in planning a gas pipeline.

The Atigun Canyon site includes an unspecified area adjacent to the present road and oil pipeline, which is being constructed through the Antigun Canyon. The purpose of setting aside the area is to study natural and disturbed Eriophorum tundra, alpine, and transition areas. A revegetation study is also under way. In 1970 and 1971, the University of Alaska conducted Dall sheep studies because it was an important lambing ground, with one of the highest concentrations of Dall sheep in the Brooks Range.

Because of the road and pipeline disturbance and the fact that this area is being used to study the effects of disturbance of man, the impact of another pipeline is considered likely to be insignificant.

The Galbraith Lake site is also close to the road and oil pipeline. It was established as a study area, with fish studies from 1969, revegetation studies since 1970, and University of Alaska archeological studies in 1970 and 1971.

The purpose of setting aside this area is considered the same as for Atigun Canyon, and the impact from the pipeline is likely to be the same, also.

The Dietrich River site is a 12-acre stand of river bottom white spruce located at tree line. Elevation is 2,600 feet. The site was nominated to preserve this unique stand. It is also near the road and oil pipeline which are now being built. In the original plan, the oil pipeline was to go through the stand, but was re-routed. If this site is left undisturbed and the gas pipeline is also routed around it, the site should suffer no impact.

The Fox Tailings include gravel spoils from the golddredge operations near Fox, and date back to the 1920's and 1930's. They provide an unusual opportunity for the study of progressive weathering, soil formation, and plant succession on surfaces of known age. At present, many of the tailing piles are being destroyed as urban growth from Fairbanks encroaches on the area and as tailings are used as a gravel source for construction.

Maps of the area and the potential routing considered by AAGPC indicate that the line will go through the tailing piles.

The impact of the gas pipeline on the Fox Tailings is unknown, since other uses are consuming the tailings and the exact route of the alternative pipeline is unknown.

The Shaw Creek Experimental Area is now 40 acres with a suggested expansion to 1,000 acres. No research is in progress, but studies concerning paper birch seed production in a 95 year-old stand and white spruce establishment in the paper birch type were conducted in the past. It is located in gently rolling topography at an elevation of about 1,120 feet.

The gas pipeline could adversely affect this site if it were to go through it.

The Robertson River site is a commercial stand of white spruce and associated successional vegetation. Site size is suggested to be 1,000 to 2,000 acres. The site is located at the confluence of the Robertson and Tanana Rivers, both glacial streams. It is considered a representative stand and an alternative location would be on the Gerstle River.

The gas pipeline route is upstream from this site and consequently, should not affect it.

Impact of the Fairbanks Alternative Route on Recreational and Esthetic Resources

Recreation

During construction, there would be moderate recreational use of areas along the pipeline by workers. Construction would inconvenience travelers and vacationers on highways along the route. Most of the recreation activity would be in the late spring, summer, and early fall. Use would increase even in the winter months where roads are open and maintained.

Recreation use will include hunting, fishing, boating, hiking, mountain climbing, cross-country skiing, snowmobiling, sightseeing, photography, and related activities. Unless steps are taken to provide adequate recreation facilities, such as campgrounds, picnic areas, overlooks, boat access sites, trail heads, parking areas, turnouts and rest stops, damage to the terrain from uncontrolled recreational use and a general degradation of recreation and esthetics could result. Unregulated use by all-terrain vehicles, trail bikes, snowmobiles, and other off-road vehicles could have significant adverse impacts by permanently scarring the landscape, damaging the vegetation, compacting the soil, causing erosion, harassing the wildlife, and disturbing non-mechanized recreationists.

As people become aware of recreational opportunities created by pipeline-related activity, they will use these opportunities more and demand recreational facilities with the attendant impacts described above. New recreational resources will be discovered, with resulting demands for their exploitation and/or preservation. Increased visitation will increase costs to taxpayers.

Nearly all the alternative line south of the Brooks Range will require the clearing of brush and forest cover. This will significantly alter the natural environment and will degrade the route's recreation value, particularly where long straight clearings are visible from the road.

Within several miles of the line, the recreational experience of ground-level recreationists will be affected by increased noise from construction and operation of the line. Noises will result from blasting (temporary and short-term), aircraft, vehicles, compressor operation, and gas flowing through the pipe (nearly continuous and lasting throughout the life of the pipeline). Noise will become particularly noticeable because of the combination of the road, oil pupmp stations, and gas compressor stations.

On-the-ground viewers also will be able to see from great distances such facilities as communications towers, buildings at compressor sites, block valves, ports, etc. At times, the pipeline mound will be visible from a distance to those hiking in the mountains. Lights on communications towers and at compressor stations will be visible over long distances at night.

The regular (i.e., non-natural) shape of compressor sites, gravel pads, airstrips, and roads will give a manmade appearance to the presently natural landscape.

It is expected that air quality will be affected by the operation of the construction equipment. Enough water vapor probably will be released from the construction operation to create periodic fogging and icing conditions in and adjacent to the pipeline right-of-way and maintenance station pads.

Increased sport fishing coupled with slow fish growth rates will reduce the numbers of trophy sized fish and could reduce the total available fish, thus reducing the attractiveness of the area to fishermen and other recreationists.

Esthetics

In all cases, there is an accompanying road, sometimes with other utilities. From Prudhoe Bay to Delta Junction there is also the trans-Alaska oil pipeline. Esthetic impacts should be viewed in terms of adding another pipeline (or utility) to an area already partly disturbed by man (i.e., it is not comparable to building a pipeline across any area currently undisturbed by man).

Many of the esthetic impacts have already been discussed under recreation. Because of the existing development along most of this route, the addition of another pipeline will have only minor impacts on the esthetic values.

Impact of the Fairbanks Alternative Route on Air Quality

Exhaust Emission

Except for the rapidly developing industrial complex at Prudhoe Bay and the populated Fairbanks area, air quality along this alternative corridor is high. Fairbanks has a unique inversion situation where at times carbon monoxide levels exceed the State and National Ambient Air Quality Standard levels by as much as 200 percent.

For the months of January, February, and December 1972, the 9 ppm 8-hour ambient air standard was exceeded on 73 percent of the days at the downtown post office. Eight-hour average carbon dioxide concentrations exceeded 9 ppm on 37 percent of the days, 15 ppm on 9 percent of the days, and 20 ppm on 3 percent of the days during 1972 (Gilmore and Hanna, 1974).

Compressor Stations--The Fairbanks alternative system would include the construction of 17 compressor stations between Prudhoe Bay and the United States-Canada border.

Their operational exhaust emission characteristics would be similar to those described for compressor stations in Canada. Information from Canada indicates that each station will probably contain a 30,000 hp gas turbine compressor and gas refrigeration unit powered by a 17,000 hp gas turbine. Although each compressor station will be automated, maintenance and emergency living quarters for 30 people will be provided at each.

Compressor stations in Canada are described as producing oxides of nitrogen in quantities up to 220 parts per million (ppm); sulfur dioxide not more than 1 ppm; less than 10 ppm of carbon monoxide; less than 5 ppm of unburned hydrocarbons; and approximately 7,200 gallons of water vapor per hour. (See applied-for AAGPC route for EPA Air Quality Standards) In addition, routine maintenance will result in the release of some natural gas. Except for the natural gas, exhaust emission into the air at compressor stations would be in excess of 600° F (315° C). Total heat will exceed 10 million calories per second (CAGPL, 1974). Of the exhaust emissions, heated water vapor will be the most evident and will produce a visible plume in an arctic environment. Heated water vapor, in combination with other exhaust components, will form condensation nuclei favoring the formation of fog or ice in cold temperatures. During the summer months, the visibility of the compressor stations would be accentuated by the water vapor plume.

The first compressor site at Prudhoe Bay would be located within the industrializing area of Prudhoe Bay. Therefore, it would, as a construction camp, have a small, localized, but unknown incremental and temporary degrading impact on air quality.

The only other compressor station near a large population center is the one located approximately 12 miles east and north of Fairbanks at an elevation of 1,000 feet.

For some time, Fairbanks has had unique and acute air pollution problems created by both surface air inversions and ice fog conditions.

Fairbanks is surrounded by low-lying hills on the northwest, north, and northeast. These hills range from approximately 500 to 1,000 feet above the city and thus form a natural boundary in these directions for a meteorological airshed which opens out into the very large and broad Tanana River Basin to the southwest, south and southeast.

The interior of Alaska is subjected to numerous and persistent high-pressure atmospheric systems, during which times calm weather conditions often occur. Prevailing directions for ground wind and mean wind speeds for Fairbanks are listed in Table 8.1.1.5-18.

Gilmore and Hanna (1974) indicate that surface inversions are present in Fairbanks during more than 60 percent of all nighttime atmospheric soundings. During December and January, when little diurnal fluctuation in the weather takes place, surface inversions are present in more than 80 percent of both day and night soundings. The winter inversions are usual for the following reasons: (1) They are among the strongest in the world (gradients of 20° to 30° C/-100 m are not uncommon); (2) They persist for long periods (a full week is not unusual and durations in excess of 240 consecutive hours have been recorded); (3) They begin at the snow surface and extend upward for only 50-89 m; (4) They are sharply defined at the top by an abrupt order of magnitude decrease in temperature gradient; and (5) They virtually decouple the dense surface air layer from the overlying air. During stable winter inversion conditions, the cold surface layer air stagnates and remains calm with winds less than 2 m/s, even though winds only 500 m aloft may exceed 15 m/s. These inversions cause Fairbanks to have a severely restricted dilution volume, and thus a very high air pollution potential.

As previously stated, this severe meteorological condition existing in winter and the present ground traffic patterns combine to create carbon monoxide levels that can exceed the State and National Ambient Air Quality Standard levels by as much as 200 percent.

Ice fog is one of the unique problems existing in arctic climates, especially in Fairbanks. Refer to applied-for route, section 2.1.1.1 for a dicussion on ice fog.

The impact of the compressor station east and north of Fairbanks on existing air quality is considered likely to be major. With the inversion conditions which now exist and consequent health hazards, any degradation would be intolerable. Indications are that the prevailing upper air winds would dominate at the elevation where exhaust emissions and water vapor would be introduced. This would cause contaminates to move generally downwind, but still within the inversion layer, adding to an already dangerous condition.

The other 15 compressor stations are located away from inhabited areas. The impact of these sites on existing air quality by the addition of heated water vapor plume into the atmosphere will be significant at all areas where there is little apparent human activity. (See Section 3.1.1.14, AAGPC proposed route, for detailed air quality discussion.)

<u>Construction Camps</u>--Construction along this route would require a number of camps, the location and number of which are unknown. Indications from the proposal for the AAGPC proposed route are that each compressor site would have 500 to 800 persons. The impact of these and possibly other construction camps on existing air quality is expected to be small, localized, and unknown, though temporarily adverse. (See discussion in Section 2.1.1.14.)

Vehicle and Construction Equipment--The Fairbanks alternative pipeline would use many bulldozers, pipelayers, various excavation equipment, compressor drills, pipe benders, crushing units, tractor-trucks, and trucks in the 1/2- to 16-ton class. There is no estimate as to how many pieces of equipment or the amount of fuels or lubricants that would be used for surface and air transportation.

Operation of construction equipment will release unknown amounts of unburned hydrocarbons, oxides of nitrogen, carbon monoxide, carbon dioxide, sulfur dioxide, sulfur trioxide, water vapor, and suspended particulates. Major construction activities will be concentrated during the winter months and will provide impacts on air quality similar to those described for compressor stations. The major difference is that construction equipment will not be in a fixed location and will be used for a short time. Therefore, the impact of construction equipment exhaust on air quality is expected to be minor.

Port Area--The only port area associated with this route is the one already in use at Prudhoe Bay. (See AAGPC proposed route analysis for details.)

Impact of exhaust emissions at the existing Prudhoe Bay port site is considered modest though there would be an incremental reduction of air quality in the area.

Summary--The impact of exhaust emissions from construction and initial operation on existing air quality is considered likely to be local, short term, and modest for the Fairbanks alternative route facilities in the Prudhoe Bay area. Impacts on air quality along the route also would be local and short term, but because air quality in such areas is now natural, additions of exhaust emissions may be significant.

The major long-term impact of exhaust emissions on air quality will be associated with the compressor stations in Alaska. These impacts are considered likely to be major because of ice fog originating from water vapor plumes. In Fairbanks, where additional contaminants may be trapped under an inversion, public health may be endangered.

There may be secondary impacts on human safety as a result of ice fog. (See Environmental Hazards.)

Dust

Prevailing strong winds in August and September pick up and carry substantial amounts of fine dusts from beaches, lake shores, and streambeds. (See AAGPC proposed route analysis for details.) In addition to smothering, wind-driven particles have an abrasive effect upon plants with tender growth.

Large amounts of gravel borrow from many sites will be used to construct facilities and for selective backfill material. Excavation and transportation of materials will provide new sources which will add dust to the environment.

The impact of dust from the Fairbanks alternative pipeline construction activities is likely to be local. In addition to wind-carried dust, dust from operation of fixed-wing aircraft and helicopters from sand and gravel airfields and pads will produce unknown but long-term secondary impacts on vegetation to the downwind side of dust sources. It is expected that some borrow areas will be required for long-term maintenance of the project. Long-term, incremental but unknown amounts of dust would be added to the environment from these sites.

The existing trans-Alaska oil pipeline haul road would be used for transportation of construction materials to the Arctic Slope. Addition of dust to the environment by vehicles using the gravel road would be incremental and local. There is no basis on which to estimate how much dust might be created, but it is thought likely to be of slight consequence.

Release of Natural Gas

Data supplied to the Canadian Government (CAGPL, 1974) indicate routine maintenance procedures at compressor stations will result in the release of some natural gas. During station startup, the main gas and propane compression turbines will expel approximately 150 Mcf (thousand cubic feet) of unburned natural gas. Assuming that there are 15 miles between automatic block valves, pipeline failure or emergency shutdown would result in discharge of up to approximately 3,750 Mcf of natural gas into the atmosphere. The natural gas will be odorless.

Impact of the Fairbanks Alternative Route on Environmental Noise

Noise from Construction Equipment

The north end of this route is associated with the Prudhoe Bay Field where environmental noises are created by exploration and developmental drilling for oil and gas and operation of motorized vehicles and aircraft. Existing levels of environmental noise in this area are not known but because of the preponderance of motorized equipment such as diesel drilling platforms, noise is pronounced locally. Most noises are transitory, e.g., they move through an area (aircraft) or are placed in another location after a period of several days to months (drilling rigs).

The system will add to the existing level of noise all along the remaining portion of the route in a similar fashion. Noises associated with construction (truck, trenching equipment, pipelayers, etc.) will be at a location for only a short period (several days to a week or more) and, therefore, will be transitory.

Operation of mechanized equipment for extraction of sand and gravel will cause noise during periods of removal. At that time there will be impacts on wildlife from the noise of that equipment (see sections 3.1.1.7, Wildlife, and 3.1.1.15, Environmental Noise). Most of the construction equipment will be diesel engine powered. Typical noise levels in dB at 50 feet from construction equipment are given in Table 3.1.1.15-1. These levels are found while the equipment is operating and are similar to noise levels on the pipeline construction site. The collection of equipment operating during excavation is estimated to produce a sound equivalent level of 84 dB at 50 feet.

Aircraft Noise

It is not known if aircraft will be used as the primary means of transportation, since the route is paralleled by a road.

Noise caused by low-flying aircraft and helicopters will have an adverse impact on wildlife. The distances at which wildlife react to aircraft noise are presented in Table 3.1.1.15-4. The extent of noise impacts on wildlife depends on: (1) type of aircraft, (2) frequency of exposure, (3) altitude of aircraft, (4) time of year, (5) amount of suitable alternative habitat, (6) present extent of habitat utilization, and (7) the carrying capacity of the available habitat areas (see sections 3.1.1.15, Environmental Noise, and 8.1.1.5, Wildlife).

Noise from Compressor Stations

The estimated distances at which residences will be affected by an L_{dn} of 55 is 7,800 feet. The distances at which wildlife react to compressor station noise are presented in Table 3.1.1.15-2. Refer to the section on wildlife for a description of wildlife habitat along the route.

Noise from Blasting

Explosives would be used to dig certain parts of the pipeline route in Alaska. There is no indication of where blasting will be done or the size of the explosive charge since the technique for explosive excavation of a pipeline trench in permafrost is still under development. The applicant proposes to excavate most of the pipeline trench during the winter, when most wildlife species are absent from the area. The impact of the noise from blasting the pipeline ditch on resident moose is not known. Repeated disturbances, such as blasting, however, may cause the animals to move to new areas. The effect that relocation may have on animal survival will depend on the amount of alternative habitat, the present extent of utilization, and the carrying capacity of all available habitat areas.

Impact of Wintertime Repair of the Fairbanks Alternative Pipeline System

Wintertime repairs of the system will create impacts similar to those described for initial construction.

Impacts of Nonwinter Repair of the Fairbanks Alternative Pipeline System

The AAGPC proposed route discussion has an example of a "worst case" nonwinter emergency repair. It sets forth details on the type of equipment to be used and its effects.

Under the "worst case" conditions, both as to site of repair work and the time of the year the repair work would be undertaken, there will be substantial local adverse impacts on vegetation, soil, permafrost, water quality, and wildlife resulting from nonwinter emergency repair of the system. Nonwinter repair will be more destructive than winter repair.

8.1.1.6 42-inch Pipeline Alternative

On March 3, 1975, AAGPC filed a Fourth Supplement to its original Application to construct and operate a 48-inch chilled, buried pipeline system from Prudhoe Bay to the United States-Canada border. This supplement suggests substitution of a 42-inch line for the applied-for 48-inch system.

The following discussion describes the 42-inch alternative pipeline system and evaluates anticipated impacts. For the purpose of this analysis it is assumed that the 42-inch system could be substituted for the 48-inch system along the applied-for route and any of the alternative pipeline routings discussed in 8.1.1.1 (Offshore), 8.1.1.2 (Coastal), 8.1.1.3 (Interior), 8.1.1.4 (Fort Yukon), and 8.1.1.5 (Fairbanks).

Description of the 42-inch Alternative Pipeline System

Location

The selection of an alternative design of the Applicant's applied-for pipeline system to utilize 42-inch diameter mainline pipe will not alter the alignment of the pipeline or the location of any auxillary or ancillary facilities, except to move the measurement station originally proposed to be located at Compressor Station CA-05 in Canada, in the Applicant's March 21, 1974, filing, to Compressor Station CA-04, at Mile Post 176.0 in Alaska. (See 1.1.1.1 through 9 for description of the applied-for AAGPC 48-inch system.)

The 42-inch pipeline system will have 0.700-inch wall thickness; 70,000 psi, minimum yield strength; and maximum allowable operating pressure of 1,680 psia, with a throughput capacity of 2.256 bcf/d (billion cubic feet per day) with initial installation of two compressor stations. With the addition of two other stations, the ultimate throughput will have an estimated 3.5 to 4.5 bcf/d capacity.

Two compressor stations will be required for the second operating year, which means additional granular material will be required earlier than with a 48-inch line to enlarge the pads at these sites. The additional granular material required is estimated by AAGPC as approximately 90,000 cubic yards at Station CA-02 and 115,000 cubic yards at Station CA-04.

Material would be obtained from the borrow sources discussed for the applied-for AAGPC route in 1.1.1.1 through 9.

Facilities

Compressor stations suggested for the 42-inch alternative are to be single-unit 30,000 hp (ISO) with refrigeration facilities the same as proposed for the 48inch supply line. According to AAGPC, smaller horsepower units may be more desirable when design can be based on more precise projections of throughput. AAGPC states that there is no basis for selecting smaller units at this time.

Schedule

Construction of compressor stations CA-02 and 04 and the measurement station at CA-04 will begin in the summer of 1979 and continue until mid-1980. The building materials for the stations will be delivered to the coastal stockpiles during the summer of 1978, and the mechanical/electrical portions in the summer of 1979.

The use of 42-inch mainline pipe would reduce the pipe tonnage by approximately 50,000 tons; however, the addition of the two compressor stations and measurement stations would add approximately 18,000 tons, resulting in a net reduction in total tonnage from 336,000 tons, as filed in March, 1974, to 304,000 tons for the 42-inch alternative system.

The basic logistics plan would be reduced by approximately 10 percent in total tonnage transported to the various construction stockpile sites because of lighter weight pipe.

Operating and Maintenance Concepts

A design utilizing 42-inch supply lines, rather than 48-inch supply lines, would not cause any significant change in the system operating and maintenance concepts on the Arctic Slope. Operating two additional compressor stations, CA-02 and 04, during the first 5 operating years would slightly increase operating costs and manpower requirements during that period. It does not change the Pipeline Maintenance and compressor station operating plan. Operation headquarters will be at Prudhoe Bay.

Costs

Estimated cost for the 42-inch system is $598.2 million. A list of unescalated costs is shown in Table 8.1.1.6-1.

Work Force

AAGPC estimates that the peak work force needed to construct the 42-inch alternative will be 4 percent higher than for the 48-inch line. The increase is due to the installation of two additional compressor stations and the metering station in Alaska as part of the initial system. The permanent work force stationed at Prudhoe Bay by AAGPC will increase from 39 to 47 because of the additional operating compressor stations.

Summary

The AAGPC states in its March 3, 1975, supplement:

> Applicant has not determined whether it would be desirable to construct its system with 42-inch pipe, rather than 48-inch, and submits that further information relative to gas availability would be useful in making a determination. Accordingly, the Applicant submits the material herewith so that the limited physical and economic differences...may be analyzed currently, so that a choice between them (42-inch vs. 48-inch) may be made....

It is emphasized that the Applicant has not amended its application pending before the Department of the Interior to construct a 42-inch pipeline system instead of a 48-inch system for the applied-for route or any of the alternative pipeline routings through Alaska, but has only submitted a supplement to the application. The same problems exist in regard to pipe fracture toughness and external loading as those stated for the 48-inch pipeline.

Description of the Existing Environment of the 42-Inch Alternative AAGPC Pipeline System

The AAGPC substitution of the 42-inch alternative pipeline system will follow the same route as the applied-for AAGPC 48-inch pipeline system. It will have the same facilities built in the same locations except that the measuring station would be moved from Compressor Station CA-05 in Canada to CA-04 in Alaska. Available information indicates the overall physical

Table 8.1.1.6-1 Estimated costs of facilities and construction for a 42-inch system (AAGPC)

Item No.	Description	Costs by Calendar Year ($000) 1976	1977	1978	1979	1980	Total in service 1980
1.	Land (no fee purchase)						
2.	Pipeline	11,984	38,798	106,194	124,963	108,170	390,109
3.	Compressor stations		2,993	20,118	27,921	10,797	61,829
4.	Buildings & improvements		276	3,063	9,194	3,967	16,500
5.	Measuring equipment			556	3,564	3,920	8,040
6.	Transportation equipment				672	3,358	4,030
7.	Communications equipment	895	1,034	2,927	2,870	409	8,135
8.	Tools & work equipment				725	3,626	4,351
9.	Office equipment		1	3	13	63	80
10.	Pre permit costs	10,000					10,000
	Sub Total	22,879	43,102	132,861	169,922	134,310	503,074
11.	Allowance for funds used during construction	1,800	7,200	20,000	39,800	26,300	95,100
	Total Construction Costs	24,679	50,302	152,861	209,722	160,610	598,174

characteristics of facilities at CA-04 will not change appreciably as a result of the addition of the measurement station. Accordingly, the environmental description for the applied-for AAGPC 48-inch pipeline system in 2.1.1.1 through 15 applies to the 42-inch alternative.

It is further assumed that a 42-inch pipeline system along any of the alternative routes would be similar; therefore, environmental descriptions for 8.1.1.1 (Offshore), 8.1.1.2 (Coastal), 8.1.1.3.1 (Interior), 8.1.1.4 (Fort Yukon), and 8.1.1.5 (Fairbanks) apply to the 42-inch alternatives.

Environmental Impacts Caused by the 42-inch Alternative Pipeline System

The 42-inch alternative pipeline system involves construction and operation of two compressor stations in Alaska as part of the initial system. These compressor stations are at sites evaluated in the applied-for AAGPC 48-inch pipeline system. All four compressor station locations were evaluated in 3.1.1.1 through 16 on the basis of ultimate operation of a 48-inch pipeline. The impacts are the same as those evaluated for a 48-inch pipeline system.

Constructing the two compressor stations as part of the initial 42-inch pipeline system will require an estimated additional 205,000 cubic yards of gravel from borrow sites identified for the AAGPC applied-for 48-inch pipeline system. Additional gravel will be required to construct compressor station pads, but no new impacts will result from the 42-inch alternative system. Impacts from commitment of a nonrenewable resource (gravel) are considered significant.

Construction of a measuring station at the Alaskan compressor station site CA-04 is a transfer of facilities from the Canadian Station CA-05 and is expected to create no additional, significant impacts in Alaska since the Canadian and Alaskan stations are located in similar environments.

Early construction of two compressor stations may be construed to have fewer impacts because:

1. Disruption of wildlife and environment resulting from construction activities will be reduced by concentrating more construction in a single early time period. (Construct 42-inch pipeline, two compressor stations, then several years later, two more compressor stations vs. construct 48-inch pipeline, then several years later, all four compressor stations).

2. Borrow sites associated with the two stations can be reclaimed immediately rather than later, or temporarily restored and then reactivated.

Addition of approximately 200 more workers for 6 months during peak construction is considered likely to cause no appreciable change in social and economic effects discussed in 3.1.1.9 and 10. Addition of 8 more people at Prudhoe Bay (total 47) only accelerates a staffing increase, which is necessary when compressor stations become operational. As noted, four compressor stations were considered in the applied-for AAGPC 48-inch pipeline. Accordingly, the stationing of new personnel at Prudhoe Bay will cause no impacts other than those which will occur with the 48-inch system.

In summary, it appears that a 42-inch alternative pipeline system will create no impacts different from those expected from the applied-for 48-inch AAGPC pipeline.

The above impacts will be similar in degree for any 42-inch alternative pipeline routings in Alaska. However, because of increased length, total impacts for a 42-inch pipeline on the alternative routes will be greater. For example, if a 4 percent increase in peak work force is required to construct an additional (but unknown) number of compressor stations on the Interior alternative route, the 200 additional workers needed for these 2 years will cause considerably more social and economic effects than the 4 percent (only 100 workers) for 6 months. It is not possible to evaluate these additional impacts since the location of the work force and its length of stay for the 42 inch alternative system are not known.

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