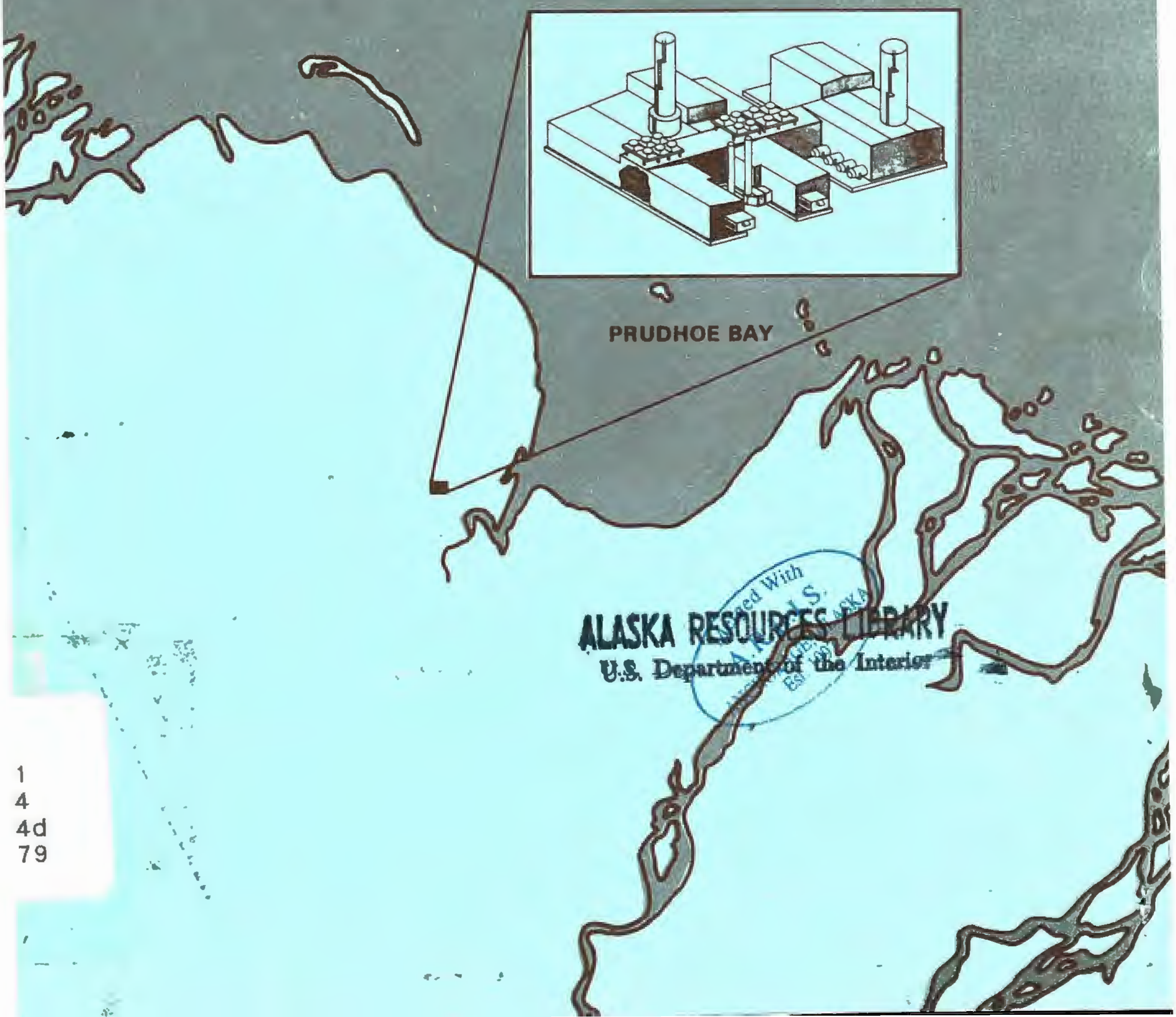
RC/EIS 0009D

FEDERAL ENERGY REGULATORY COMMISSION
Office of Pipeline
and Producer Regulation

July 1979

Prudhoe Bay Project

Draft Environmental Impact Statement



FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF PIPELINE AND PRODUCER REGULATION
WASHINGTON, D.C. 20426

PRUDHOE BAY PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT

CONSTRUCTION AND OPERATION OF A SALES GAS CONDITIONING FACILITY AT PRUDHOE BAY, ALASKA

"SGCF"

JULY 1979

Northwest Alaskan Natural Gas Transportation Company
Docket No. CP78-123 *et al*.

FOREWORD

On July 9, 1976, Alcan Pipeline Company (Alcan), now Northwest Alaskan Pipeline Company (Northwest Alaskan), filed an application before the Federal Power Commission (predecessor to the Federal Energy Regulatory Commission) in Docket No. CP76-433 for a certificate of public convenience and necessity to construct and operate pipeline facilities to transport Alaskan natural gas to the lower 48 states. In May 1977, the Commission recommended to the President that he select an overland pipeline project to transport Alaskan natural gas to the lower contiguous 48 states. On September 22, 1977, the President recommended that a certificate be issued to construct and operate a pipeline from Prudhoe Bay, Alaska, paralleling the Trans-Alaska Pipeline System (TAPS) to Big Delta, Alaska, and then following the Haines Pipeline/Alaskan Highway into Canada. From White Horse, Yukon Territory, the pipeline would continue through British Columbia and Alberta and reenter the United States at Eastport, Idaho. A second segment would continue on through Alberta into Saskatchewan and reenter the United States at Morgan, Montana.

The environmental impact of the pipeline was evaluated by the Commission staff in a 1976 supplement to its final environmental impact statement (FEIS), Alaska Natural Gas Transportation Systems: Alcan Pipeline Project. Under section 8(e) of the Alaska Natural Gas Transportation Act (ANGTA), the President was directed to determine the legal sufficiency of the FEIS for the transportation system which he approved. In his Decision and Report to Congress on the Alaska Natural Gas Transportation System (p. 133), the President found that the FEIS did comply with the requirements of the National Environmental Policy Act (NEPA). Under section 10(c)(3) of ANGTA, Congressional approval of the Decision created a conclusive presumption "as to the legal and factual sufficiency of the environmental impact statement submitted by the President relative to the approved transportation system and no court shall have jurisdiction to consider questions respecting the sufficiency of such statement under the National Environmental Policy Act of 1969." Congress approved the Decision by joint resolution on November 2, 1977. In its report to the President, made pursuant to section 6(d) of ANGTA, the Council on Environmental Quality (CEQ) "concluded that the environmental impact statements are legally and factually sufficient under NEPA and that they provide an adequate basis for selecting the corridor and the basic technology for an Alaska gas transportation system." 1/ CEQ went on to state, however, that "following a Presidential and Congressional decision on a pipeline corridor, federal agencies may not bypass further environmental analysis of the authorized system simply because broad program statements have been prepared and found sufficient under NEPA."

The Commission staff believes that no further consideration of the pipeline route selected by the President is necessary. However, after closer review, the staff has determined that the FEIS did not fully assess the environmental impact of the facilities which will be necessary to condition and process Prudhoe Bay gas prior to pipeline transmission. (Briefly, gas conditioning includes dehydration 2/ and removal of carbon dioxide (CO_2), while gas processing includes removal, fractionation and possible partial reinjection of natural gas liquids.) While many aspects of the conditioning and processing facilities have yet to be finalized, there is no doubt that such facilities will be expensive, will entail substantial construction, will require a significant lead time to complete construction in advance of the pipeline, and are a prerequisite to operation of the Alaska Natural Gas Transportation System (ANGTS).

Section 1(b) of the Natural Gas Act exempts from the Commission's jurisdiction "the production or gathering of natural gas." As a general rule which applies in this case, conditioning and processing facilities fall within the Natural Gas Act exemption. Accordingly, Commission certification of such facilities is not required, although under the Natural Gas Policy Act of 1978, the Commission must determine whether a conditioning and processing allowance should be included in or added to the wellhead

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1/ Report to the President on Environmental Impacts of Proposed Alaska Gas Transportation Corridors (Washington, D.C., July 1, 1977), p. 14.

2/ It is recognized here that dehydration facilities presently exist at Prudhoe Bay for the oil recovery process.

gas price, and what this allowance should be. Furthermore, sections 8(e) and 10(c) of ANGTA would have shielded construction and operation of the conditioning and processing facilities from the requirements of NEPA if the FEIS prepared during the prior Commission proceedings and transmitted by the President to Congress encompassed such facilities as a part of the approved transportation system. However, both the Decision and the FEIS appears to have considered the transportation system to start at the discharge side of such conditioning and processing facilities.

Therefore, because the processing and conditioning facilities represent a substantial construction project required for the operation of ANGTS, because of the delicate ecological balance of the North Slope, and because the environmental impact of the facilities has not been fully evaluated in any official document, the Federal Energy Regulatory Commission (FERC) has assumed the responsibility as lead agency in preparing this assessment of the environmental impact of the gas conditioning and processing facilities. 1/ It is only the unique circumstances of ANGTS which have prompted this assessment. These unusual circumstances in no way establish a precedent for environmental analyses of similar facilities by the Commission in other ratemaking actions.

1/ The staff is particularly indebted to the Environmental Protection Agency's Office of Environmental Review in Washington, D.C. and its Region X Office, Environmental Evaluation Branch, in Seattle, Washington for their significant effort in assisting the FERC staff in preparing this EIS. Specifically, the Environmental Protection Agency, utilizing the contractual services of Wapora Inc., provided sections B.1, B.4, B.5, C.1, C.4, C.5, and H.5 and appendices D, E, and F of this EIS. In addition, they provided substantial imput to sections B.3, B.8, C.3, C.8, H.3, and I of the EIS. Other Federal and state agencies which will issue permits regulating these facilities and/or which participated in preparing this impact statement include the U.S. Army Corps of Engineers, U.S. Department of Transportation, U.S. Department of the Interior, and the State of Alaska.

On March 2, 1979, Northwest Alaskan Natural Gas Transportation Company filed a supplement to Docket No. CP78-123 et al., requesting a Commission order approving the design specifications for a 48-inch diameter pipeline with a maximum working pressure of 1,260 psig and initial compression capacity of 2.4 billion cubic feet per day (Bcfd) expandable to 3.2 Bcfd. Since this docket treats many of the overall issues associated with the ANGTS, it will be utilized as the lead docket for this environmental impact statement.

This DEIS is unusual in a number of other aspects. The FERC staff has prepared this EIS even though an application for the necessary processing and conditioning facilities has not been filed before the FERC. It has assumed that the participating producers may have some underutilized facilities at Prudhoe Bay, such as construction camps, that may be reused for this proposal and thus reduce some of the impacts of this project; however, this DEIS will analyze the impacts of this project as though combined use would not occur.

The project assessed in this DEIS is assumed to be the project proposed in a multivolume study prepared by the R. M. Parsons Inc. in 1978 for a consortium of North Slope gas and oil producers, gas carriers, and gas purchasers. Copies of the Parsons report are available for public viewing at the Commission's Office of Public Information, Room 1000, 825 North Capitol Street, N.E. Washington, D.C. 20426 and EPA's Region X Office, 11th Floor Library, 1200 Sixth Avenue, Seattle, Washington 98101.

The Parsons analysis of site, process, and design preferences is based on a number of assumptions that may or may not be correct. Some of these issues will be determined by Commission decisions within the next few months. Two critical issues--pipeline pressure in the Alaskan segment and the maximum allowable CO_2 concentration--will determine the percentage of the heavier natural gas liquids that can be transported in the pipeline without operational problems and influence both the type of conditioning process chosen and the location of the facility.

FEDERAL ENERGY REGULATORY COMMISSION

OFFICE OF PIPELINE AND PRODUCER REGULATION

DRAFT ENVIRONMENTAL IMPACT STATEMENT SUMMARY SHEET

Northwest Alaskan Natural Gas Transportation Co.
Docket No. CP78-123 et al.

1. This Draft Environmental Impact Statement (DEIS), prepared by the staff of the Federal Energy Regulatory Commission, is related to an administrative action.

2. This administrative action initially arose from applications filed by Northwest Alaskan Pipeline Company (Northwest Alaskan) for a certificate of public convenience and necessity to construct and operate pipeline facilities to transport Alaskan natural gas to the lower 48 states. On September 22, 1977, the President recommended that a certificate be issued to construct and operate such a pipeline from Prudhoe Bay, Alaska, paralleling the Trans Alaska Pipeline System (TAPS) to Big Delta, Alaska, then along the Haines Pipeline/Alaskan Highway, through Canada, and back into the United States.

The Commission staff believes that no further consideration of the pipeline route selected by the President is necessary. However, after closer review, the staff has determined that additional environmental assessment is warranted for the facilities necessary to condition and process Prudhoe Bay gas prior to pipeline transmission. While these types of facilities normally do not require Commission certification, the Commission staff believes that the uniqueness of the Alaskan Natural Gas Transportation System warrants presenting further information to the public.

On March 2, 1979, Northwest Alaskan Natural Gas Transportation Company filed a supplement to Docket No. CP78-123 et al. requesting a Commission order approving the design specifications for a 48-inch diameter pipeline with a maximum working pressure of 1,260 psig and initial compression capacity of 2.4 billion cubic feet of gas. Since this docket treats overall issues associated with the Alaskan Natural Gas Transportation System, it will be the lead docket for this environmental impact statement.

3. The proposed site for the sales gas conditioning facility (SGCF) is at Prudhoe Bay, Alaska. The facilities would consist of four processing trains using the SELEXOL process to condition the gas and refrigeration to separate the hydrocarbons. An operations/living center and construction camp would also be constructed. The environmental impacts from construction and operation of the proposed facility would include impacts to land use, soils and permafrost, water quantity and quality, air quality, noise levels, wildlife, and social and economic aspects of the human environment.

4. The alternative sites considered for the SGCF include the Yukon River near the TAPS bridge and Fairbanks (North Pole), Alaska. Pipeline pressure and process alternatives are also considered.

5. Copies of this DEIS are being made available to the public and all parties to the proceedings on or about July 27, 1979, and to the following:

A. Federal

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army
Department of Commerce
Department of Defense
Department of Energy
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Labor
Department of State
Department of Transportation
Environmental Protection Agency

A. Federal (cont.)

Federal Trade Commission
Honorable Mike Gravel
Honorable Ted Stevens
Honorable Dan Young
Interstate Commerce Commission
Marine Mammal Commission
Nuclear Regulatory Commission

B. State of Alaska

1. State

Alaska Energy Allocation Assistance Office
Alaska State Clearinghouse
Department of Community and Regional Affairs
Department of Economic Development
Department of Environmental Conservation
Department of Fish and Game
Department of Highways
Department of Labor
Department of Law
Department of Natural Resources
Department of Public Works
Department of Social and Health Services
Federal-State Land Use Planning Commission for Alaska
Office of the Governor
State Historic Preservation Officer
University of Alaska

2. Regional and Local

Alaska Federation of Natives
Arctic Slope Regional Corporation
City of Anchorage
City of Barrow
City of Fairbanks
City of Haines
City of North Pole
City of Tok
City of Valdez

2. Regional and Local (cont.)

Fairbanks North Star Borough
Greater Anchorage Area Borough
Greater Anchorage Chamber of Commerce
North Slope Borough
Village of Anaktuvuk Pass
Village of Eagle
Village of Kaktovik
Village of Northway
Village of Nuiqsut
Village of Rampart
Village of Stevens

3. Conservation and Citizen Groups

Alaska Center for the Environment
Alaska Conservation Society
Alaska Wildlife Federation and Sportsmen's Council, Inc.
Fairbanks Environmental Center
Green Peace
League of Women Voters of Alaska
Trout Unlimited
Trustees for Alaska
Wildlife Society, Alaska Chapter

C. National Citizens Groups

American Conservation Association, Inc.
Conservation and Research Foundation, Inc.
Conservation Foundation
Environmental Action
Environmental Defense Fund
Environmental Law Institute
Friends of the Earth
Iroquois Research Institute
National Association of Conservation Districts
National Audubon Society
National Resources Council of America
National Wildlife Federation
Natural Resources Defense Council, Inc.
North American Wildlife Foundation
Sierra Club
The Wilderness Society
Wildlife Society

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ABBREVIATIONS AND ACRONYMS

laska Administrative Code
\laska Gas Project Office
-Alcan Pipeline Company
-Alaska Natural Gas Transportation Act
-Alaska Natural Gas Transportation System
merican Petroleum Institute
.ir Quality Control Region
.tlantic Richfield Company
lest available control technology
.ological oxygen demand
.tish Petroleum Company
ka--BP Alaska, Inc.
rrels per day
illion cubic feet per day
itish thermal unit
rees Celsius
ean Air Act
ntral Compressor Plant
uncil on Environmental Quality
bic feet per second
ubic feet per second per square mile
timeters
bic meters per second
bon monoxide
rbon dioxide
ntral Power Plant
cibels on the A-weighted scale
artment of Environmental Conservation (Alaska)
fense Early Warning
. Department of Transportation
. Environmental Protection Agency
ergency shutdown system
xxon Company, USA
eral Aviation Administration
nal environmental impact statement
deral Energy Regulatory Commission
h and Wildlife Service
lons per day

gpm--gallons per minute
HC--hydrocarbons
HEL--higher explosive limit
HHV--higher heating value
H_2S--hydrogen sulfide
km--kilometers
LEL--lower explosive limit
mcfd--million cubic feet per day
mg/l--milligrams per liter
msl--mean sea level
MW--megawatt
NAAQS--National Ambient Air Quality Standards
NEPA--National Environmental Policy Act
NFPA--National Fire Protection Association
NGL's--natural gas liquids
NMFS--National Marine Fisheries Service
NO --nitrogen oxides
NOAA--National Oceanic and Atmospheric Administration
Northwest Alaskan--Northwest Alaskan Pipeline Company
NPDES--National Pollution Discharge Elimination System
NSPS--New Source Performance Standards
NWS--National Weather Station
OSHA--Occupational Safety and Health Act
PSD--prevention of significant deterioration
psig--pounds per square inch, gauge
Parsons--Ralph M. Parsons Company
ppm--parts per million
ppt--parts per thousand
SGCF--sales gas conditioning facility
SO_2--sulphur dioxide
SO_x--sulphur oxides
SOHIO--Sohio Petroleum Company
TAPS--Trans-Alaskan Pipeline System
TSP--total suspended particulates
TSS--total suspended solids
USGS--U.S. Geological Survey
WPCA--Water Pollution Control Act

A. DESCRIPTION OF THE PROPOSED ACTION [1/]

1. Purpose of the Proposed Facilities

The Prudhoe Bay field, as presently defined, is about 45 miles long and 18 miles wide and is estimated to contain 9.6 billion barrels of recoverable oil and in excess of 20 trillion cubic feet of saleable natural gas (partly in solution and partly in a free gas cap above the oil) in the sandstones of Perma-Triassic age. 2/ Currently, natural gas produced at the Prudhoe Bay field is reinjected into the oil-producing formation by compressors at the Central Compressor Plant (CCP). Before reinjection, water and a portion of the heavier hydrocarbons are removed by dehydration facilities. To meet the proposed pipeline quality specifications listed in table 1, all the natural gas will have to be conditioned before being transported into Canada and the lower 48 states. The proposed construction of a sales gas conditioning facility (SGCF) at Prudhoe Bay would accomplish this by using Allied Chemical's patented SELEXOL process to remove high concentrations of carbon dioxide (CO_2) and various molecular weight hydrocarbons entrained in the 2 billion cubic feet per day (Bcfd) feed gas stream.

See p. 21

The SGCF must be an operational and economic design which will be compatible with the specifications of the Canadian segment of the pipeline, which has already been determined. Hydrocarbon dewpoint control (removal of certain hydrocarbons) is required to avoid possible hydrocarbon condensation in the pipeline. This could cause operational problems and possible pipeline shutdown. The removed hydrocarbons (ethane and heavier fractions) are called natural gas liquids (NGL's). Once gas sales commence, 10 to 15 barrels of NGL's per million cubic feet of natural gas would be extracted at the SGCF to make the gas acceptable for delivery by the pipeline system. Removal of acidic gases (sweetening) becomes essential only if the hydrogen sulfide (H_2S) content of the gas exceeds values specified in pipeline contracts. These are often as low as 1 grain of H_2S per 100 cubic feet of natural gas. However, only if H_2S content is much higher than that does it become attractive to recover elemental sulfur from the SELEXOL solvent.

1/ The project as assessed in this EIS is assumed to be the project as proposed in the Ralph M. Parson's Inc. study conducted for the North Slope gas and oil producers.

2/ Additional information on oil reserves appears in appendix A.

TABLE 1

PIPELINE GAS COMPOSITIONS

Volume % Component	Pipeline Design Case	Plant Base Case
CO_2	1.002	0.486
N_2	0.597	0.603
C_1	85.342	90.991
C_2	8.087	4.425
C_3	4.353	1.728
iC_4	0.213	0.505
nC_4	0.331	1.209
iC_5	0.034	0.040
nC_5	0.031	0.012
C_6+	0.020	0.001
Total	100.00	100.00

2. Location of the Proposed Facilities

The SGCF would be located in Prudhoe Bay, Alaska (figure 1), an existing oil and gas industrial complex presently operated by Sohio Petroleum Company (SOHIO) and the Atlantic Richfield Company (Arco).

Ralph M. Parsons, Inc. (Parsons) presented two SGCF designs: a base case and an alternate case. The base case would utilize the existing inlet, separation, and dehydration facilities and the existing first stage compressors at the CCP. The alternate case assumes new inlet, separation, dehydration, and sales gas compression facilities.

For the base case, construction would be adjacent to the CCP. This site was chosen because of the necessity to maintain a minimum pressure drop in the interconnecting piping between the SGCF process trains and the CCP compressors. (See figure 2.) The site is also close to both gas and liquid injection wells. For the alternate case, the location of the SGCF would not be critical. However, the cost of additional gas transit and injection pipeline would be minimized by using the same location.

3. Proposed Facilities

a) Process Facilities

The process facilities recommended by Parsons include four parallel extraction trains capable of delivering about 665 million cubic feet of conditioned gas per day. Each train is composed of three units: a low temperature separator to remove entrained liquid hydrocarbons from the feed gas, a SELEXOL solvent gas treating unit to remove carbon dioxide, and mechanical refrigeration for proper control of the hydrocarbon dewpoint. A process flow diagram is shown in figure 3.

The solvent system selected for NGL extraction and CO_2 removal is Allied Chemical's patented SELEXOL physical solvent process, which uses the capacity of the dimethyl ether of polyethylene glycol to physically and selectively absorb such compounds as CO_2, H_2S, carbonal sulfide, NGL's,

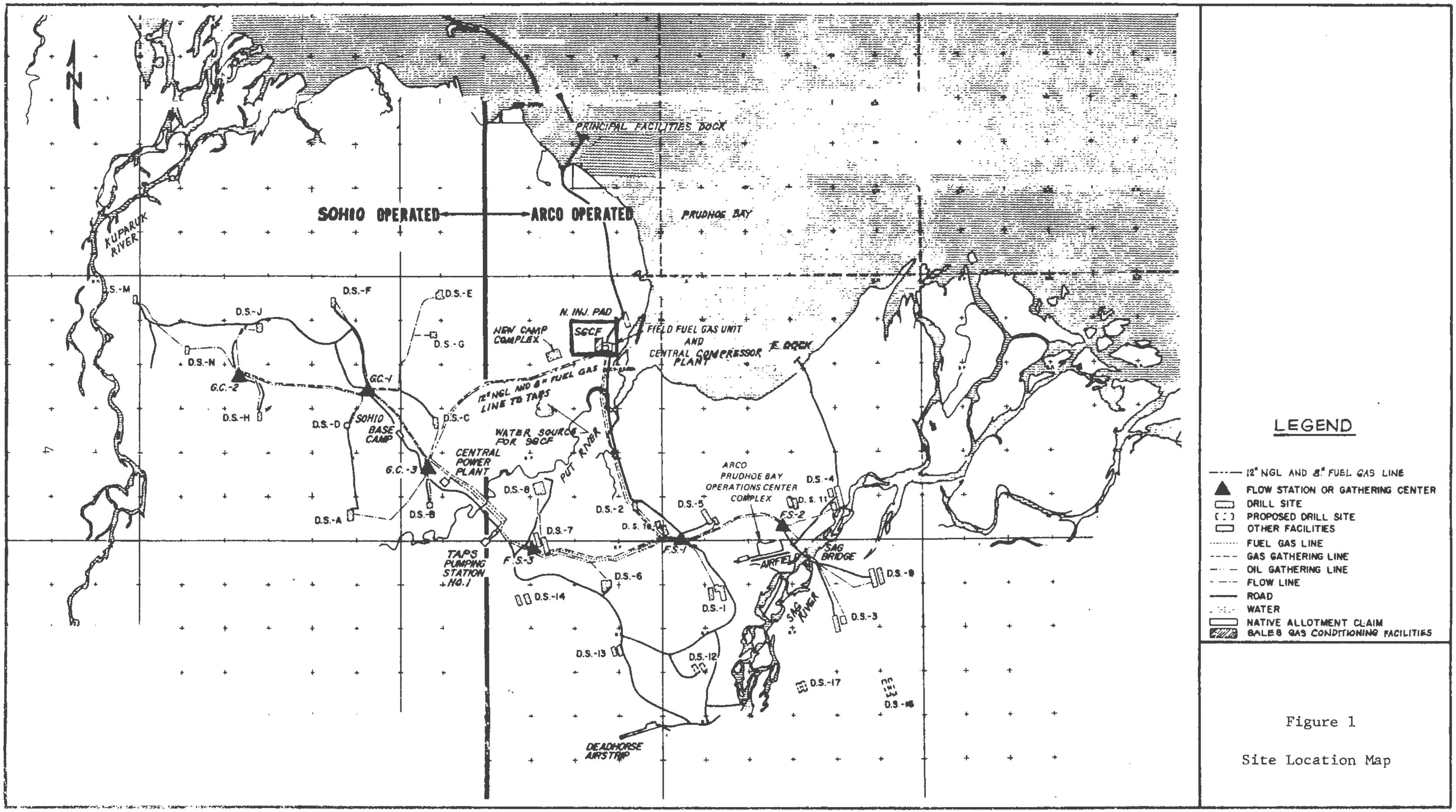

Figure 1

Site Location Map

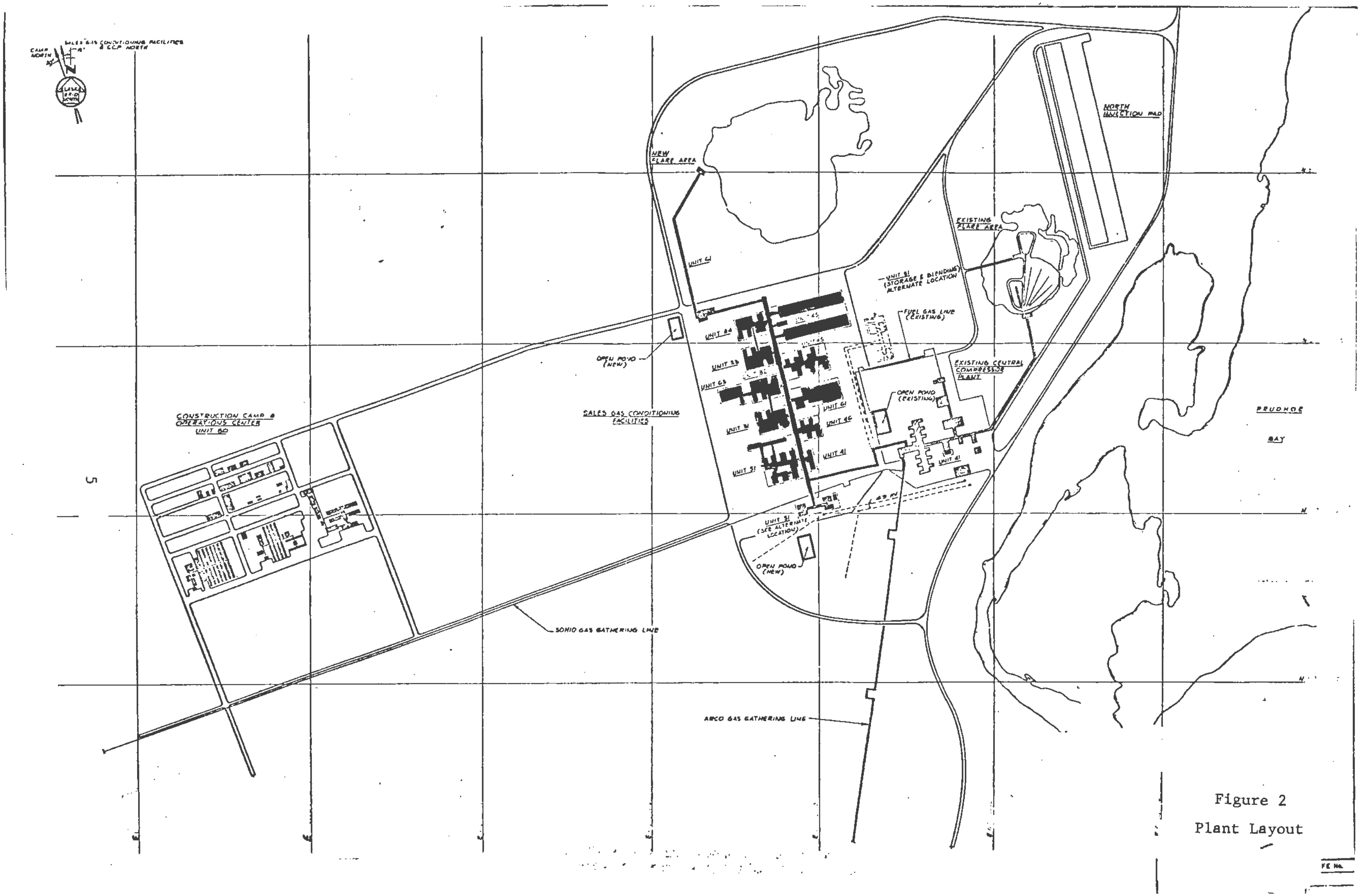

Figure 2

Plant Layout

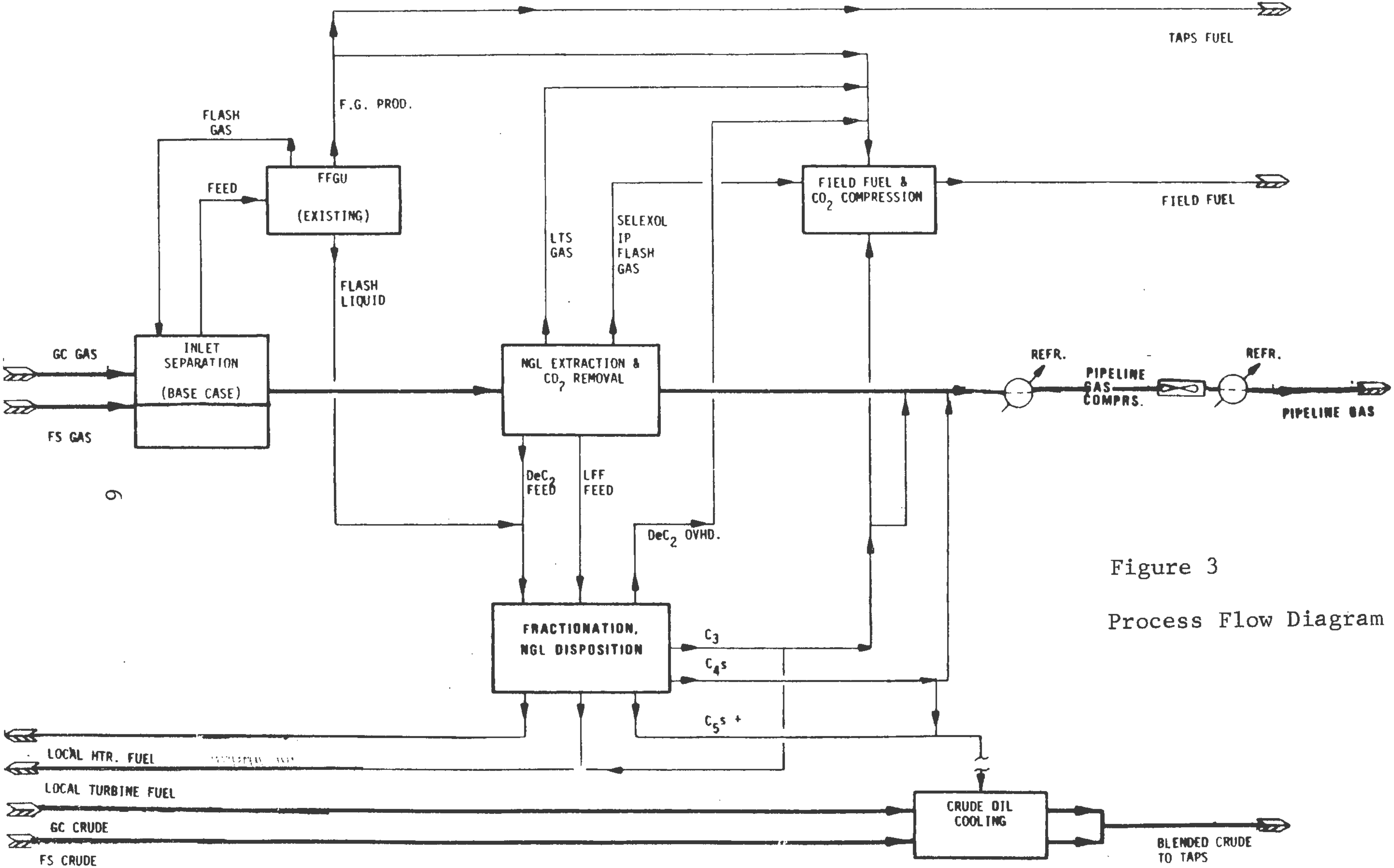

Figure 3

Process Flow Diagram

and mercaptans. (See figure 4.) This system is a simple recirculating loop which contains a SELEXOL absorption column (using selective physical absorption procedures to remove various molecular-weight hydrocarbons and CO_2, three differential pressure flash drums (to remove CO_2 and varying quantities of hydrocarbons from the SELEXOL column feed gas), and a SELEXOL stripper (used to regenerate SELEXOL solvent). (See figure 5.) Also included is one single train fractionating unit, which consists of a local fuel fractionator, a deethanizer, a depropanizer, and a debutanizer.

Removal of the CO_2 and NGL fractions in the feed gas takes place in a conventional countercurrent absorption column designed to accept recycled gas and semilean and lean solvents for maximum plant efficiency. The enriched SELEXOL solvent normally passes through four stages of equilibrium flashing and stripping prior to recirculation to the absorber. First, the high pressure flash produces carbon dioxide plus a smaller quantity of low molecular-weight hydrocarbons; this flashed gas is recycled with the feed gas to the absorber, while the solvent flows to the next flash vessel. In the intermediate flash stage, the flash gas usually has sufficient fuel value to drive some plant engines; in this stage, the liquid stream is fed to the low-pressure flash and final stripper. Next, semilean solvent from the low-pressure flash is pumped back to an intermediate tray in the absorber and flash gas is vented. Finally, the lean solvent passes from the stripper to the upper section of the absorber, and the gas is again either vented or processed to a sulfur unit. For some design conditions, the stripper and/or the intermediate flash vessel may be omitted. 1/ The SELEXOL process improves efficiency as the temperature is lowered and therefore takes maximum advantage of the cooling effect from gas depressuring through hydraulic turbines. The SELEXOL system inherently provides a complete heat balance with little or no external heating or cooling required. Additional details of the process description are identified in appendix C.

In addition to the 2 Bcfd of pipeline gas conditioned by the SGCF, a number of other products such as the high-CO_2 NGL would be separated. The flash gases would be used as fuel at the SGCF and the Prudhoe Bay industrial complex. The NGL's, which include separate propane and ethane,

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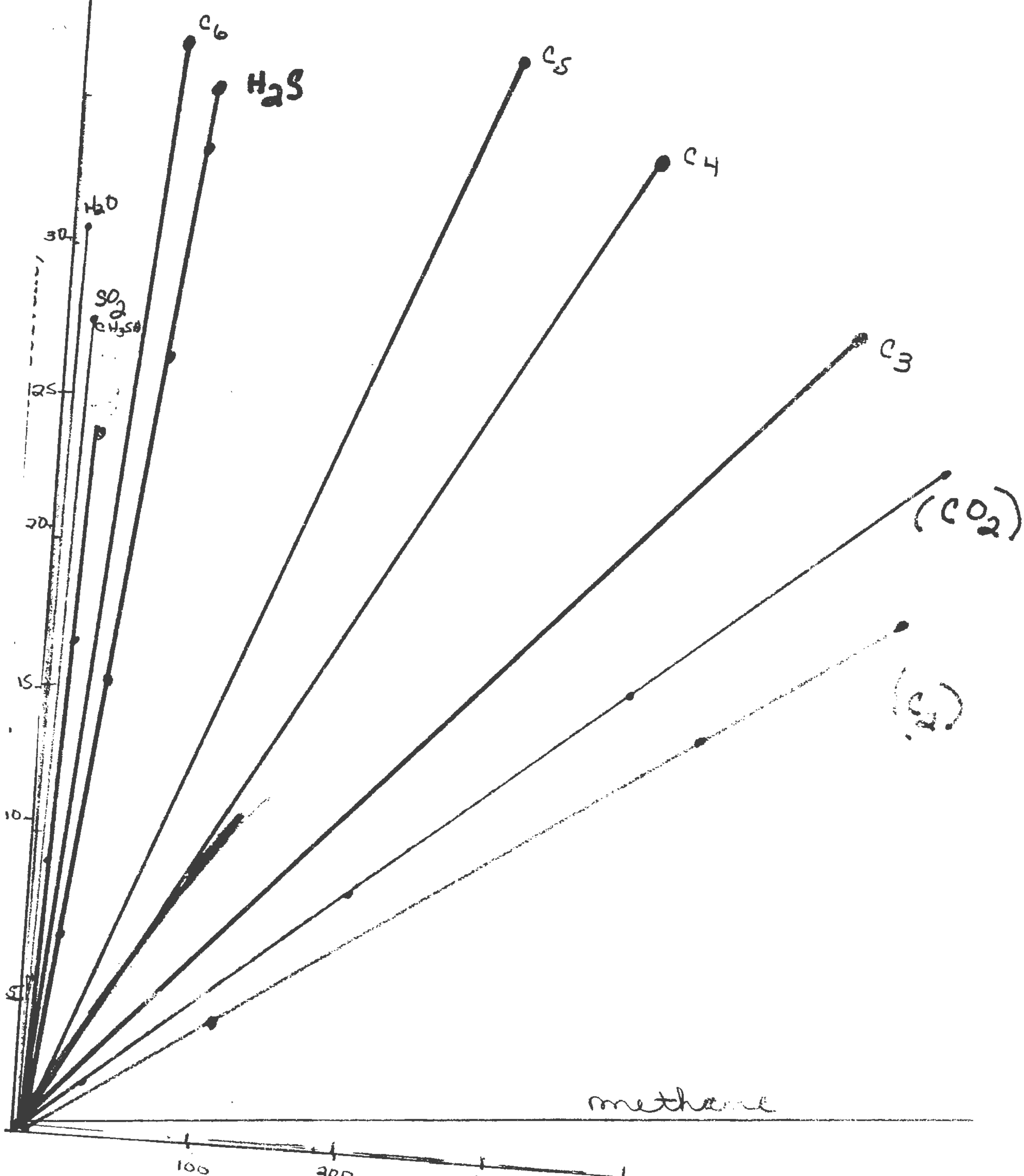
1/ See appendix B for a discussion of Plant and Process Economics.

Figure 4

Approximate SELEXOL Solubility Curve



(Partial Pressure-PSIA)

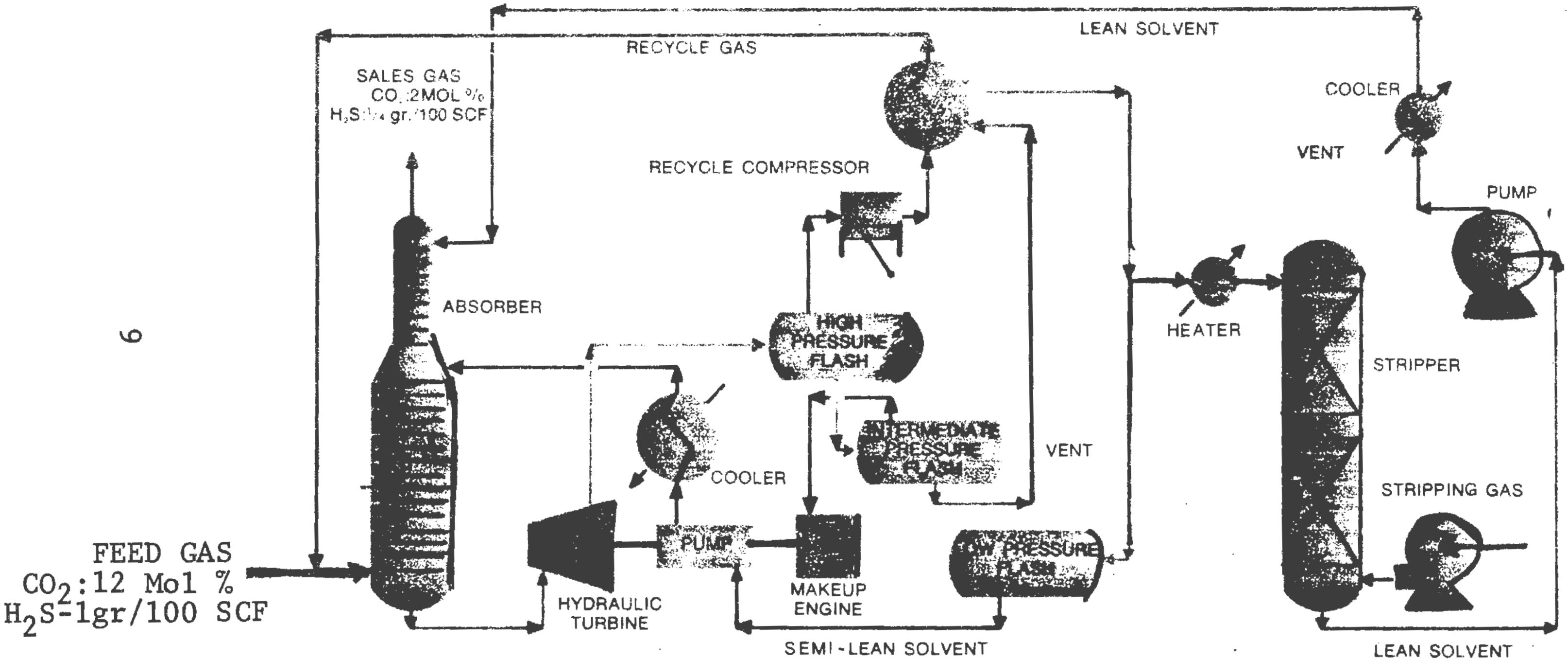


Figure 5: Typical SELEXOL Process For The Removal of CO_2 From Natural Gas

butane, and pentanes-plus streams, could be blended into the fuel streams (propane) to control heating value, into the pipeline gas to the hydrocarbon dewpoint limitation (propane or butane), or into the crude oil (butane or pentanes-plus) as limited by the vapor pressure specification.

The design anticipates that there would be a significant variation in the summer and winter fuel requirements at the SGCF. The demand for fuel by the industrial complex would vary both as a function of season and time as well as oil production rates. Blending of butanes into either pipeline gas or crude is controlled by the pipeline hydrocarbon dewpoint limitation or by economics. These variations have been incorporated in the design.

The SELEXOL process was screened by Parsons along with various other processes to remove CO_2 from the natural gas being produced at Prudhoe Bay. The other processes evaluated were: Fluor's Propylene Carbonate, Shell's Sufinol, Union Oil's Sorbco-2, Latepro's Rectisol, Lurgi's Purisol, and Open-art DEA. Initially, Parsons determined that Latepro, Lurgi, and Open-art DEA did not have adequate commercial experience. The primary design criteria were proven reliability and capability of integration with existing facilities at low cost. The SELEXOL process was selected because of its proven commercial experience and its ability to meet hydrocarbon dewpoint specifications for the Prudhoe Bay gas. The environmental impacts of these process alternatives are addressed in section H of this EIS. The SELEXOL process has no liquid or solid waste streams.

b) Support Facilities

The proposed docking facilities at Prudhoe Bay would have the capability of loading and unloading two barges simultaneously. A general cargo storage and modular staging area would be provided with appropriate lighting facilities. The proposed docking facilities considered in this EIS are the existing dock facilities owned by Arco/Exxon/SOHIO, widened to accommodate two-way modular traffic. An alternative to this would be a new separate causeway and dock that could be constructed independent of existing dock facilities.

Process support facilities would include gas turbine-driven electric power generators, an emergency diesel-driven power generator, four 1,000-barrel NGL storage tanks, a waste product disposal system, a fire protection system, and a high-low pressure flare system to provide safe disposal of vapors generated during possible emergency conditions. Buildings required for plant administration and operation include an administration building, dormitory modules, an office and dining building, an elevator tower, a multistory shop complex, vehicle storage building, a warehouse, and an incinerator building. Access to the proposed SGCF and camp facilities would be provided by a new road network integrated with existing Prudhoe Bay roads.

i. Water Reservoir and Treatment Facilities

The proposed SGCF would extract water from the Putuligayuk (Put) River for immediate summer use and for storage in the proposed reservoir for use during the winter. A river intake structure, consisting of a small house on pilings from which two slotted casings would be hung, would be constructed on the main channel. The casings would have submersible pumps and discharge piping. Each pump would have a capacity of 200 gallons per minute (gpm), and they could be run simultaneously. The maximum extraction rate, therefore, would be 400 gpm, or slightly less than 1 cubic foot per second. The pump(s) would be stopped automatically during periods of low flow by a float attached to a shut-off valve. This would avoid removing all water from the river and would prevent damage to the pumping apparatus.

The water withdrawn from the river would be conveyed to a water heater that would heat the water to between 4.4°C. and 7.2°C. (40°F. to 45°F.). A 15.2 centimeters (cm.)(6-inch) diameter pipeline would convey the water directly to the operations center or to the water storage reservoir. The pipeline would be insulated by 10.1 cm. (4 inches) of polyurethane and warmed by electrical impedance heaters.

The water storage reservoir would be constructed midway between the river and the operations center. Two existing lakes averaging 0.61 meter deep would be thawed and deepened to provide a working capacity of 63 million gallons. The reservoir would have a maximum depth of 7.6 meters (25 feet), and the surface area would be about 19 acres. Approximately 305,824 cubic meters (400,000 cubic yards) of excavation would be necessary to provide that capacity; this includes an allowance for 1.8 meters of ice cover throughout the winter and for the possibility of annual precipitation in excess of the average of 12.7 cm. per year. 1/

The intake arrangement in the reservoir would be similar to the one proposed on the Put River. Two pumps, each with a 200-gpm capacity, would lift water to the operations center. The water would then be treated and distributed to the facilities in the operations center and to the temporary construction camp.

Detailed information about the proposed water injection facilities is not available. Presumably, 43,750 to 72,000 gpm of Beaufort Sea water would be withdrawn and injected into wells. The multiple seawater intakes would be located either at the end of West Dock or at the 6.1-meter isobath about 3.2 kilometers (km.) to 4.8 km. from shore. The multiple intake design would result in lower intake velocities than a single intake. It is expected that the intakes would be screened and the intake structures would be 0.9 meter to 1.5 meters above the ocean floor. If the intakes were constructed at the 6.1-meter isobath, they would reportedly be positioned to take advantage of a summer ice-floe "shadow" provided by the outer barrier islands north of Prudhoe Bay. Also, during winter the 6.1-meter isobath is seaward of the inshore bottom-fast ice and landward of the grounded ice of the shear zone. Consequently, the intakes would lie in an ice-covered "pool." Intake conduits would be laid in dredged and backfilled trenches to the end of West Dock.

The pump station and treatment plant would be located at the end of West Dock. They would be placed on a gravel protection pad and would be connected to shore by a gravel causeway. Filter backwash from the treatment plant would be discharged into Prudhoe Bay at the approximate rate of 875 gpm. It is anticipated that this backwash would carry an average 1 ton per day of solids. However, during peak runoff during the summer, 60 tons per day of solids could be discharged with the backwash.

1/ Factors for converting English units to metric units are presented in table 2.

TABLE 2

FACTORS FOR CONVERTING ENGLISH UNITS TO METRIC UNITS

Multiply English Units	By	To Obtain Metric Units
	Length	
inches (in)	25.4	millimeters (mm)
	.0254	meters (m)
feet (ft)	.3048	meters (m)
yards (yd)	.9144	meters (m)
rods	5.0292	meters (m)
miles (mi)	1.609	kilometers (km)
	Area	
acres	4047	square meters (m^2)
	.4047	hectares (ha)
	.004047	square kilometers (km^2)
square miles	2.590	square kilometers (km^2)
	Volume	
fluid ounces	29.6	milliliters (ml)
gallons (gal)	3.785	liters (l)
	3.785×10^3	cubic meters (m^3)
million gallons (10^6 gal)	3785	cubic meters (m^3)
barrels (bbls)	.159	cubic meters (m^3)
cubic feet (ft^3)	.02832	cubic meters (m^3)
cfs-day (ft^3/s-day)	2447	cubic meters (m^3)
acre-feet (acre-ft)	1233	cubic meters (m^3)
	1.233×10^6	cubic kilometers (km^3)
	Flow	
cubic feet per second (ft^3/s)	28.32	liters per second (l/s)
	.02832	cubic meters per second (m^3/s)
gallons per minute (gpm)	.06309	liters per second (l/s)
	6.309×10^5	cubic meters per second (m^3/s)
	Weight	
grains	64.8	milligrams (mg)
ounces (oz)	28.35	grams (gr)
pounds (lb)	.4536	kilograms (kg)
tons (short)	.9072	tons (metric)

The water treatment system for the SGCF would be similar to that of the existing water treatment system in the Arco Operations Center. The design was selected because of its proven capability at the existing facilities. Water for treatment is proposed to be pumped from the Put River in the summer (late June through September) and from the water storage reservoir during the remainder of the year. The plant would contain the following equipment: flocculant feed equipment, sand filters, softeners, chlorinators, storage tanks, high-service pumps, and ancillary equipment. The usual treatment consists of sand filtration, softening, and chlorination. If the water were unusually turbid, flocculation equipment would be available. If the river were turbid, however, water generally would be taken from the reasonably clear reservoir. The water treatment facilities would have the capacity to treat 150,000 gallons per day (gpd) and to store 90,000 gallons in three equally sized tanks. Minor amounts of filter backwash and sediment, the direct byproducts of the water treatment facilities, would be conveyed to the sewage treatment facilities.

The anticipated peak daily water use is estimated to be 100 gallons per capita. Actual data for similar facilities indicate averages of 70 to 80 gallons per capita. An average camp with a population of 1,176 would use from 94,080 to 117,600 gpd during construction. 1/ The permanent operations center would have a population of 200 and a daily water use of from 16,000 to 20,000 gallons. During construction, the water storage requirement for an assumed 8.5-month period would be from 23,990,000 to 29,988,000 gallons. The remaining capacity of the lake would be usurped by ice. During operation, the storage requirement would be only 5,100,000 gallons, or about 17 percent of the construction capacity.

The rate of pumping from the Put River during the 3.5 months of flow would be determined by the quantity required to replenish the reservoir and to provide the operations center and the construction camp with water. Assuming 101 pumping days (i.e., continuous pumping during June, July, August, and half of September), the daily pumping rate would be 414,500 gpd (287 gpm or 0.64 cubic feet per second (cfs)) during construction and 70,500 gpd (49 gpm or 0.1 cfs) during operation. It is more likely, however, because of low flow

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1/ The camp population is estimated to include 1,000 craft personnel, 130 subcontractor staff, and 46 Alaskan managing contractor staff.

conditions in the Put River, that pumping would occur on 75 or fewer days during June, July, and August. Therefore, a more realistic pumping rate would be 517,400 gpd (359 gpm or 0.8 cfs) during construction and 88,000 gpd (61 gpm or 0.14 cfs) during operation.

The wastewater treatment facilities for the proposed SGCF would be similar in design to the existing Arco wastewater treatment facilities. Wastewater from the proposed construction camp and operations center would be pumped to two 30,000-gallon surge tanks. Together the tanks would hold 50 percent of the maximum daily flow from a maximum camp population of 1,176. The flows from the conditioning plant would be stored in a holding tank in the plant and then would be trucked to the wastewater treatment plant.

The proposed treatment involves secondary wastewater treatment and sludge incineration. Wastewater would flow from the surge tanks at a controlled rate through a comminutor into a primary settling tank and then to an aerobic biological filter treatment unit. The effluent from the secondary clarification of the wastewater would be passed through a multimedia filter and would be disinfected with liquid chlorine, using a 45-minute to 60-minute contact period. The chlorinated wastewater would be discharged to a stabilization pond that would be constructed by diking a tundra lake located on the north side of the housing area. (The total size of the tundra lake is unknown.) The dike would be earthen. The effluent would be discharged into the pond through a pipe approximately 0.61 meter (2 feet) below the surface. Water from the pond then would flow over a wier to the main part of the lake or onto the tundra. The path of the treated wastewater after leaving the stabilization pond is unknown.

At the existing Arco wastewater lake, which has a surface area of about 195 acres, wastewater flows of from 33 to 55 million gallons per year are disposed of. Based on a net evaporation rate of from 12.4 to 15.1 cm.of water from June through September, from 24 to 31 million gallons could evaporate from the lake. Therefore, from 9 to 24 million gallons of water per year either flow through or across the tundra or are removed via evapotranspiration by the tundra. It is estimated that between 39 and 105 acres of tundra would be required to evaporate that quantity of water.

At the proposed SGCF wastewater pond (surface area of 19 acres), about 2.5 to 3 million gallons of water would evaporate during the summer. The net outflow to the tundra, therefore, would be about 40 million gallons. The area of tundra necessary to evaporate this water would be approximately 175 acres. Because of the saturated condition of the active layer during the summer, it is unlikely that significant volumes of wastewater would be transported for any distance through the active layer.

The sludge from the primary and secondary clarifiers would be settled, thickened, and centrifuged. About 613 pounds of sludge would require incineration daily.

The National Pollution Discharge Elimination System (NPDES) permit for the effluent discharge of waste to the existing Arco lake requires a monthly average 5-day biochemical oxygen demand (BOD5) of 30 milligrams per liter (mg/1) or less and a monthly maximum of 45 mg/1. The permit requirements for total suspended solids (TSS) are the same as those for BOD_5. It is anticipated that the NPDES requirements would be similar at the new facility. The expected ranges of wastewater BOD_5 and TSS are 10 to 20 mg/1 and 5 to 10 mg/1, respectively. Wastewater flows of up to about 120,000 gpd are anticipated, based on the assumption that 100 gallons per capita per day would be produced. The plant would have the capacity to treat flows of up to 150,000 gallons per day.

ii. Solid Waste Disposal Facilities

The solid waste disposal system would consist of an incinerator facility and a landfill to dispose of noncombustibles and ashes. The incinerator would be housed in a 9.1 by 18.3 meter building where refuse collection trucks could dump the trash without scattering it indiscriminately. The incinerator could accommodate wastes from a 1,500-person construction force that produces 8.5 pounds per capita per day of wastes requiring incineration, or an estimated total of 12,750 pounds (6.4 tons) per day. During operation, the 200-person camp is expected to produce a total of 1,700 pounds (0.85 ton) of waste per day. Sludge from the wastewater treatment plant, containing 30-percent solids, would be incinerated at the same facility. About 613 pounds of sludge would require incineration each day.

Presently, solid wastes and sludge from all of the Arco facilities and from the Parsons construction camp are incinerated at the Arco operation center. A 1979 study done for the proposed Kuparuk Field Facilities determined that the solid waste production rate for the existing facilities was from 18 to 20 pounds per capita per day, although much of the waste (10 to 11 pounds per capita per day) was noncombustible construction debris that was placed directly in the landfill. The capacity of the existing Arco incinerator is 2,000 pounds per hour, or a maximum capacity of 24 tons per day.

The North Slope Borough has finished constructing an incinerator facility at Deadhorse that contains two units: one with a 4,000 pounds per hour capacity (48 tons per day) and the other with a 2,000 pounds per hour capacity (24 tons per day). The system consists of a refuse collection truck receiving area, a shredder, a magnetic separator, and the incinerators. An air classifier system has been proposed to remove light materials. Construction debris, large noncombustibles, and ashes would be trucked to a landfill.

4. Construction Procedures

The Parsons report estimates that approximately 4.5 years would be required for a workforce of 1,000 to complete the proposed gas conditioning facility. The general construction plan assumes that three phases of work would take place. First, a small sealift of basic equipment would be scheduled for 1980 and would be supplemented by truck hauling. Two major sealifts would be planned for 1981 and 1982. To meet this schedule, work must begin in 1980 both at fabrication sites in the lower 48 states and at Prudhoe Bay.

The lower 48 fabrication site(s) would be located adjacent to major deep-draft waterways, probably on the west coast of the United States, which provides favorable weather conditions, adequate labor force, and the shortest shipping route to Prudhoe Bay. Fabrication sites would require about 200 acres for 1981 and 80 acres for 1982. Because of the magnitude of this project, at least two or three sites would be needed. All possible sites would require grading, compacting, and construction of module assembly pads, offices, warehouses, utility distribution system, fencing, and barge loading facilities. Docking facilities at the fabrication sites would be capable of deadloading--loading a barge that is flooded and bottomed, thus providing a stable loading platform. The difference in elevation of the dockhead and waterway bottom must match barge side shell heights; in addition, water depth must be sufficient to allow flotation of the loaded barges after deballasting. The load line draft of the largest barge is 4.3 to 4.6 meters; it is not anticipated that loaded barge drafts would exceed 3.4 meters, so that a high tide water depth of 4 meters would be sufficient for the loading/unloading operation.

Recommendations call for shipping widths of modules to be limited to 14.6 meters, allowing for side-by-side storage of modules on the 122 meter by 30.3 meter barges. Shipment of heavy, high center-of-gravity modules such as those containing the CO_2 absorber, SELEXOL strippers, and other columns would require strengthened barges.

The size and quantity of cargo barges available for the project, as well as the projected requirements, are shown in table 3. Both the phased and full startup cases would require approximately the same footage of barge space. Phased startup would require larger but fewer barges. At Prudhoe Bay, crawler transporters and transporting vehicles with pneumatic tires would be required to offload the modules from the barges. However, present crawler transporters do not have the overland speed necessary to complete extensive offloading programs. Modifications would be necessary to increase their overland speed.

Further discussion of the impact of modular construction is presented in appendix D.

Construction at Prudhoe Bay must allow for remote location, long periods of darkness, extreme ranges of temperatures, and congested packed ice conditions in the ocean access routes. The low temperatures and high winds prevalent at Prudhoe Bay dictate that all equipment be totally enclosed. By controlling the environment in which the equipment operates, it is possible to design efficient, low-maintenance process systems. Construction on the permafrost of Prudhoe Bay requires that all facilities and all accessways to facilities be on gravel pad, which distributes loads and provides an insulating blanket to prevent melting of the permafrost. A gravel pad thicker than the thaw depth is required to keep the permafrost under the pad frozen. Gravel pads would be laid in place before modular construction began.

TABLE 3
OCEAN-GOING BARGES FOR MODULE MOVEMENT

Primary Barge Sizes (LxWxH)	Quantity Available	Estimated Quantity Required					
		1983 Full Capacity Start			1982/3 Phased Start		
		1980	1981	1982	1980	1981	1982
400ft X 99.5ft. X 20ft (or 25ft.)	20	--	12	13	--	17	10
400ft. X 76ft X 20ft.	10	--	8	2	--	6	--
312ft. X 68ft. X 17ft.	3	--	--	--	--	--	--
250ft. X 76ft. X 16.7ft.	10	2	4	1	2	2	1

Source: "Sales Gas Conditioning Facilities, Prudhoe Bay, Alaska," September 1978 Study Report, Volume III - Implementation Plan and Cost Estimate Summary, The Ralph M. Parsons Company.

All equipment, interconnecting systems, and accessways would be designed for preassembly in the lower 48 states. These units would be further assembled into larger modular units in Alaska. Modular construction is designed to minimize the impact of the process plant on the permafrost, to minimize the plant's acreage layout, and to facilitate the ease of construction at the construction site.

5. Operation, Maintenance and Emergency Procedures

Access to the SGCF would be limited to authorized personnel. Fire protection measures would be taken to prevent loss of life and to protect the process equipment. Fire, smoke, and gas detection alarm systems, a Halon inerting/extinguishing system, foam and dry chemical firefighting carts, fire-control water hose stations, self-contained breathing apparatus, and protective/evacuation equipment would be installed. The modular design would provide multiple exits to the outside and to other protected areas.

Under normal conditions, the gas conditioning facilities would be operated by a permanent crew of 200. All operations would be controlled from a central control room. Local satellite control rooms would operate equipment in localized operational areas during startup and shutdown. The SGCF central control room would be equipped with safety alarm and control systems which would continuously monitor significant plant operations and allow the control room operators to make adjustments or notify local operators of required adjustments.

Microwaves are the primary communication between all major facilities at Prudhoe Bay. The systems would be integrated with transmitters and receivers at each location which provides both telephone and data communications with Arco, SOHIO, Alyeska, and gas pipeline compressor stations. The RCA satellite would link this system to direct dial telephone systems outside Prudhoe Bay.

The fire protection system of the proposed facility would consist of process and utility units subdivided into separate fire zones. It would comply with the provisions of the National Fire Protection Association (NFPA) Standard 70 National electric code. Fire zones are protected by two types of detection systems: a hydrocarbon gas detection system employing primary gas detectors calibrated for methane and supplemental detectors that are calibrated for propane and heavier hydrocarbon gases, and a fire detection system employing either thermal or ionization detectors. In addition, each fire zone would be protected by an independently controlled ventilation system and an independently controlled Halon 1301 (inert gas) inerting/extinguishing fire protection systems. The Halon system in any one or all of these fire zones could be activated either manually or automatically by a signal from either a gas or thermal detector.

The facilities and process equipment would be protected from overpressurization and be capable of depressurizing in any emergency. Venting systems would be collected by flare headers at two pressure levels. A high-pressure flare system would be designed to depressurize the SGCF to 200 psig in 10 minutes, and a low-pressure flare system would be sized to depressurize the SGCF to 5 psig in 10 minutes. All systems operating at or below 200 psig would be connected to a low-pressure flare. The emergency shutdown vent system would also be capable of relieving the entire facility within 10 minutes, with special attention given to the chilling effect caused by expansion during depressurizing in order to minimize metallurgical failure at reduced temperatures caused by thermal shock. The unenclosed flare headers would be heat traced and insulated downstream of the knockout drum to minimize condensation and possible pipeline freezeup.

6. Future Plans and Abandonment 1/

a) General Plans

A definite design for future expansion has not been established. However, the SGCF could increase its output by 50 percent without any major modifications to the proposed plant's process equipment. Piping, headers, and major manifolds in the proposed facilities are designed to accommodate

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1/ With the exception of occasional references, it is not the purpose of this EIS to discuss environmental impacts that would result from construction and operation of possible future facilities (e.g., water injection facilities) which are not now the subject of a FERC application.

an eventual expansion of 50 percent. Space adjacent to the proposed SGCF has been allotted for future additions to the facilities.

b) Water Injection Facilities

When gas now being reinjected in the reservoir is sold, the reservoir pressure will decline rapidly. To minimize pressure decline and increase recovery in portions of the reservoir, water would be injected. Water injection (or water flooding) is a commonly used secondary recovery or pressure maintenance method. Water would be injected under pressure into the producing reservoir rocks via injection wells located along the western portion of the field.

In water flooding operations, the injection water must be free from suspended particles which might partially or completely block the pores in the reservoir rock. Efficient filtering facilities would be needed. Makeup, or source water, must be compatible with any produced water with which it is mixed to avoid precipitates that could block the pores. When the water contains oxygen, such as seawater, deaeration may be required. Other chemical treatments include additions for flocculators, anti-bacteria materials, or corrosion inhibitors. The treating method chosen primarily depends on the nature of the water and, to a lesser extent, on the physical and chemical properties of the reservoir rock and fluids.

Adverse environmental effects from water injection could arise from withdrawals from subterranean reservoirs, withdrawal from rivers, spills, seawater if utilized, and from leaks to different formations in water-producing wells or injection wells. If seawater is utilized, intake facilities must be designed to prevent any damage to marine life.

The presently planned source of water for water-injection is the Beaufort Sea. Location of a large aquifer in the vicinity of Prudhoe Bay could change this decision. Water injection is not planned for several years after initiation of gas sales. At that time, appropriate permits would be required from the U.S. Army Corps of Engineers, EPA, and perhaps others. A separate EIS may be required at that time.

Since the Prudhoe Bay field could produce for more than 25 years and since there is a high potential for discovering other reserves in the area, the proposed SGCF should be operational for many years; therefore, exact abandonment procedures have not been formulated.

3. DESCRIPTION OF THE EXISTING ENVIRONMENT

. Climate

Climatological data for the arctic coast of Alaska are carce. The US National Weather Service (NWS) station closest o the project site is Barter Island, approximately 190 m. to the east. This station has 27 years urface weather data taken eight times per day. In the Prudhoe ay area, there are two non-NWS airport weather stations: at he Prudhoe Bay Airport and at the Deadhorse Airport. The rudhoe Bay Airport weather station is operated 12 hours per ay by Alaska Airlines, and the Deadhorse Airport weather tation is operated 24 hours per day by the Federal Aviation dministration (FAA). At the latter station, temperature bservations are taken infrequently because the FAA controller ust leave the control tower to read the thermometers. Normal AA operations prevent this most of the time. The data eported in this section are from the Barter Island station, xcept where otherwise noted. The data from Barter Island re similar to the data from Prudhoe Bay, except where noted.

a) Temperature

The Arctic Slope of Alaska has long, cold winters and hort, cool summers. At Barter Island, temperatures range etween 4°C. and 24°C. during the summer months and between 29°C. and -51°C. in the winter. Annual mean temperatures range rom -15.4°C. to -9°C. (See table 4.) Minimum ambient air emperatures during December, January, and February for the eriod of record show that at Barter Island temperatures will e -31.6°C. or lower for 15 days in December, 14 days in January, nd 23 days in February.

b) Precipitation

The Prudhoe Bay area is semiarid, with annual precipitation anging between 10.2 and 25.4 cm. Storm paths are resent only during summer months and are generally infrequent. recipitation is highest in July and August, when it generally alls as rain. Snow, however, appears in every month and sually predominates from September to May. The highest

Month	Avg. Temp. (°F.) Daily Max.	Avg. Temp. (°F.) Daily Min.	Avg. Temp. (°F.) Monthly Mean	Temperature Extremes (°F) Record highest	Temperature Extremes (°F) Record lowest	Temperatures (°F) Number of Days (Max) 90° and above	Temperatures (°F) Number of Days (Max) 32° and below	Temperatures (°F) Number of Days (Min) 32° and below	Temperatures (°F) Number of Days (Min) 0° and below	Relative Humidity (%) vs. Time 2 am	Relative Humidity (%) vs. Time 8 am	Relative Humidity (%) vs. Time 2 pm	Relative Humidity (%) vs. Time 8 pm
(a)				25	27	27	27	27	27	27	27	27	27
January	-8.5	-21.9	-15.2	39	-51	0	31	31	29	69	69	68	68
February	-13.1	-25.8	-19.5	34	-59	0	28	28	28	67	68	67	68
March	-7.5	-21.9	-14.7	36	-51	0	31	31	30	67	67	68	68
April	8.2	-8.1	0.1	43	-38	0	29	30	23	74	74	75	75
May	26.5	15.7	21.1	52	-16	0	24	31	3	87	87	85	87
June	38.2	29.9	34.1	67	13	0	4	23	0	92	90	88	90
July	45.5	34.5	40.0	78	24	<0.5	<0.5	9	0	93	89	86	89
August	43.5	34.3	38.9	72	24	<0.5	1	11	0	95	92	88	92
September	35.0	28.1	31.6	64	4	0	11	25	0	92	91	88	91
October	21.5	11.2	16.4	46	-23	0	29	31	7	84	84	84	84
November	6.3	-5.9	0.2	37	-51	0	30	30	20	75	75	75	74
December	-6.4	-18.3	-12.4	37	-51	0	31	31	29	69	69	69	69
ANNUAL AVERAGE	15.8	4.3	10.1	78	-59	<0.5	249	312	168	80	79	78	80

(a) length of record, (years) through the current year unless otherwise noted, based on January data.

NORMALS - based on records for the 1941-1970 period.

Source: NOAA,1977

Month	Water Equivelent				Snow Ice Pellets		Precipitation 0.01 in. or m	Snow, ice pel lets, 1.0 in. or more	Thunderstorms	Heavy fog, vi ibility 0.25 or less
	Normal	Maximum Monthly	Minimum Monthly	Maximum in 24 hr.	Maximum Monthly	Maximum in 24 hr.				
(a)		26	26	26	26	26	25	26	25	26
January	0.55	4.08	0.01	2.25	35.0	14.8	6	1	0	1
February	0.33	2.53	T	1.22	15.3	3.8	5	1	0	1
March	0.26	1.44	T	0.55	15.0	5.5	5	1	0	1
April	0.23	1.22	T	0.44	12.2	4.4	6	1	0	3
May	0.31	1.51	T	0.76	11.1	7.6	7	1	<0.5	8
June	0.53	2.09	0.06	1.15	9.4	6.7	6	1	<0.5	12
July	1.12	3.01	0.15	1.64	3.0	2.8	9	<0.5	<0.5	15
August	1.28	3.40	0.16	1.11	7.4	3.4	11	1	0	16
September	0.89	4.91	0.07	2.23	35.8	17.0	10	2	0	10
October	0.81	3.62	0.12	1.98	32.1	16.0	13	3	0	4
November	0.45	1.50	0.04	0.43	14.9	5.0	8	2	0	3
December	0.29	1.17	T	0.55	12.9	5.2	6	1	0	1
ANNUAL AVG.	7.05	4.91	T	2.25	35.8	17.0	91	13	<0.5	75

(a) -period of record (years) through the current year, unless otherwise noted, based on January data

T - Trace

Normal - Based on record for the 1941-1970 period.

Source: NOAA, 1977.

TABLE 6 WIND DIRECTION, WIND VELOCITY, AND OTHER METEOROLOGICAL DATA AT BARTER ISLAND, ALASKA, 1941-1970

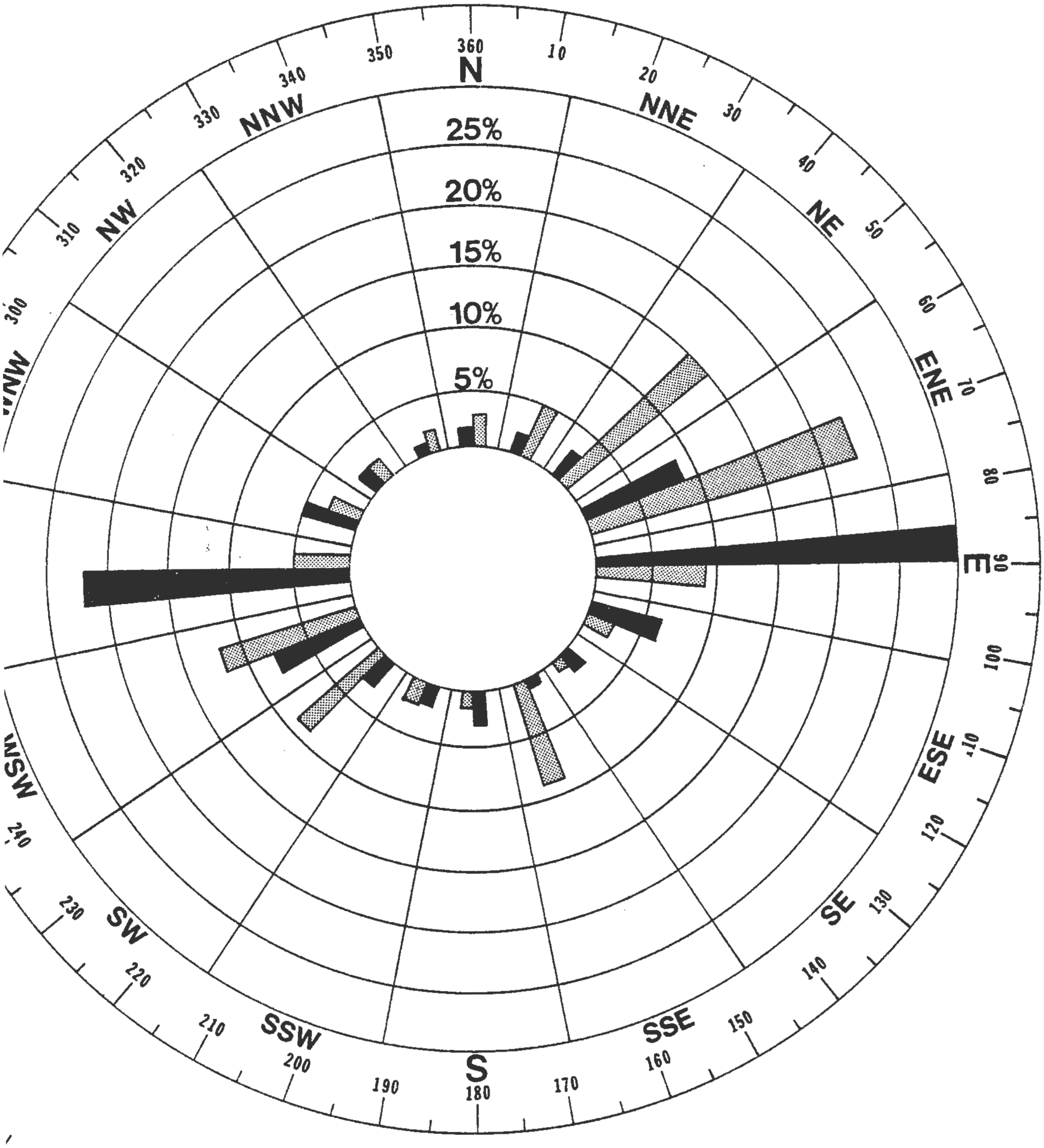
Month	Wind		Wind: Fastest Mile			Mean Number of Days Sunrise to Sunset			
	Mean speed m.p.h.	Prevailing direction	Velocity m.p.h.	Direction	Year	Clear	Partly Cloudy	Cloudy	Mean sky cover, tenths, sunrise to sunset
(a)	25	15	18	18		26	26	26	26
January	14.7	W	81	27	1974	4	2	8	#
February	14.0	W	62	27	1962	10	6	12	5.3
March	13.5	W	77	28	1969	11	8	12	5.5
April	12.0	W	52	27	1963	8	8	14	6.0
May	12.2	E	55	26	1968	3	6	22	8.2
June	11.4	ENE	38	27	1970	3	7	20	7.8
July	10.5	ENE	40	25	1963	3	9	19	7.8
August	11.6	E	44	27	1969	1	7	23	8.5
September	13.2	E	78	27	1957	2	5	23	8.5
October	14.5	E	58	27	1963	2	5	24	8.3
November	15.0	E	81	26	1970	4	4	15	#
December	13.9	E	72	27	1961	0	0	0	#
ANNUAL AVERAGE	13.0	E	81	27	JAN. 1974	51	67	192	

(a) Period of record (years) through the current year, unless otherwise noted, based on January data.

\# Sun below continuously horizon, November 24 to January 17.

Prevailing Wind Direction - Record through 1963.
Wind Direction - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
Fastest Mile Wind - Velocity is fastest observed 1-minute value when the direction is in tens of degrees.

Source: NOAA,1977



BARTER ISLAND 1968-77, CALM 1.2%

DEADHORSE AIRPORT 1976, CALM 4.5%

ure 6: Annual Wind Frequency Distribution

rce: Arco, 1978

2. <u>Topography, Geology, and Soils</u>

The proposed SGCF would be constructed within the Arctic Coastal Plain. This relatively flat region extends north from the Arctic Foothills to the Arctic Ocean with few variations in its overall gentle slope to the sea. It is an area of very low relief; this fact, coupled with the presence of widespread shallow permafrost, has led to the formation of thousands of shallow lakes and extensive marshy or boggy areas. The skyline is sometimes flat but is commonly gently undulatory because of pingos, patterned ground , old drainage channels and other depositional, erosional, or permafrost related features.

Pingos are ice-cored hills, and they tend to grow because water migrates toward ice, freezes, and accumulates. They are not of substantial size in the vicinity of the site. Areas where vertical ice-wedges within the soil have connected to form ice-wedge polygons are commonly referred to as patterned ground. The polygons frequently take the shape of hexagons--six-sided figures--but four- and five-sided figures are common. The interior of the polygons may be higher or lower than the surface of the ground adjacent to the bounding wedge of ice depending on the soil properties and whether the ice-wedges are still growing. Patterned ground indicates shallow permafrost, generally in five-grained soils.

The shoreline of the Beaufort Sea is only infrequently marked by vertical relief in excess of 15 meters. Generally there is less than 3 meters difference between the level of the land and the adjacent sea floor as a result of the youthfulness of the coast, its depositional nature, and the lack of appreciable wave action. Immediately adjacent to the proposed plant, the shoreline of Prudhoe Bay is marked by a short broad ridge about 8 meters high.

While the elevation of the Arctic Coastal Plain may reach 180 meters at its southern Brooks Range edge, some 80 km south of the project area, there is no place within 16 km. of the proposed facilities where the natural elevation is as great as 30 meters above mean sea level. The immediate vicinity of the proposed construction camp and the separate conditioning facilities ranges from about 3 to 10 meters in elevation. It includes much marshy area and several lakes and ponds.

Within the proposed project area, the bedrock is overlain by hundreds of meters of unconsolidated marine sediments and local deposits of terrestrial origin. The proposed conditioning plant and the associated construction camp would be located on upland tundra no more than 8 meters higher than the various lacustrine deposits which occupy the numerous shallow depressions on the adjacent coastal plain. The Tertiary mudstones and siltstones which form the underlying bedrock surface are generally

The upland tundra deposits covering the proposed sites generally consist of over 400 meters of stratified sandy gravels with interbedded lenses of gravelly sand, sand, and silty sand. Individual lenses are up to 3 meters thick. Poorly stratified sandy silt 0.5 to 3.5 meters thick and often rich in organic material overlies the gravels and is in turn overlain by an organic silt-tundra mat up to 15 cm. thick.

Near shore, submarine sediments are generally poorly sorted mixtures of sand, silt, clay, and gravel. Adjacent to the proposed site are the silts of Prudhoe Bay and sands which extend eastward in a band intersecting the shoreline at Point McIntyre on the north and the mouth of Prudhoe Bay on the south.

Permafrost is, as its name implies, permanently frozen material. It may include soil, unconsolidated geologic deposits beneath the soil, and bedrock. It need not include any water, frozen or otherwise, since the definition is based only on temperature. Because of seasonal variations in the air temperature over the ground, there is generally an active layer above the permafrost which thaws during the summer and freezes in winter. Therefore, the vertical extent of the permafrost is defined by (1) the maximum depth of the active layer (top of the permafrost) and (2) the bottom of the permafrost, which is a function of the equilibrium between regional heat flow from the interior of the earth and present climatic conditions as well as those which have existed within the past 10,000 years.

Local variations in the thickness of the active layer depend on several factors including the properties of the surficial materials, the extent to which those materials are shaded from the sun, and the presence of surface water. For instance, the active layer is thinner on north-facing slopes and thicker under bodies of water. Where rivers or lakes (or the ocean) do not freeze to the bottom, the permafrost, if it exists, will be overlain by permanently thawed material or talik.

Permafrost is continuous throughout this part of Alaska and generally extends to depths on the order of 650 meters. The active layer is generally less than 0.3 meter thick. The permafrost is commonly ice-rich, containing observable free ice.

Within the onsite tundra deposits, the active layer may be as much as 2.5 meters thick, but more typically it ranges from 0.5 to 1.5 meters. Water content of the active layer, represented as a percent of the volume of solids present, may range from 50 to 200 percent in silts and sands and from 5 to 20 percent in sandy gravels. The bearing capacity of the onsite deposits, which remains moderate if only the active layer is allowed to thaw, becomes poor to very poor if the permafrost itself thaws. The deposits fail in direct proportion to the intensity and duration of loading.

Only two geologic resources are known to exist in the project area: hydrocarbons and gravel. The latter is found primarily along and within river channels, the nearest being those of the Put and Sagavanirktok (Sag) Rivers. Gravel may also be found under some larger thaw lakes. Hydrocarbons, of course, are found at depth beneath this area as natural gas and crude oil.

The project area is within Seismic Risk Zone 1 of the Uniform Building Code (UBC), and the projected maximum Modified Mercalli Intensity for this area is III. Therefore, seismicity would not be a significant hazard to the proposed facility.

Because of the low relief of the area and the lack of major fast-moving streams, hazards resulting from landslides and erosion from swift currents are nonexistent. However, other type mass wasting phenomena--solifluction, thaw compaction, deep seated flow, and frost heave--resulting from the existence of permafrost could create hazards at this site, or lead to construction difficulties.

Soils of the coastal plain are generally nearly level and poorly drained. The only soils exhibiting good drainage are associated with floodplains near either active or abandoned stream channels, coastal deposits, or sand dunes. Well-drained soils do not appear in the immediate area of the proposed project. Those few areas of well-drained soils which occur nearby are generally subject to flooding.

A vegetation mat which is occasionally greater than 40 cm. thick but is generally 20 cm. thick or less covers most of the soils in the area. Beneath this mat may be a layer of black mucky silt loam, with a dark gray to dark gray brown frost-churned silt loam invariably underneath either the muck or the mat. In terms of Unified Group Symbols, the soils are primarily ML (silts and very fine sands-silty, clayey fine sands or clayey silts), are non-acid to calcareous, have moderate permeability, and have a high susceptibility to frost.

These soils are too cold to allow cultivation and offer severe construction problems.

3. Hydrology

a. Arctic Coastal Plain

i General Hydrology

There are three major watersheds in the Prudhoe Bay region. The smallest watershed, the Put River basin, lies entirely within the Arctic Coastal Plain. (See figure 7.) The elevation of the watershed ranges from sea level at Prudhoe Bay to 79.2 meters above mean sea level (msl) in the headwaters area. The basin is approximately 55.7 km. long and generally has very little relief, with an overall stream gradient of 1.4 meters per km. The drainage area is 473 square km.

Two larger watersheds flank the Put River basin, the Kuparuk River basin to the west and the Sag River basin to the east. Both of these watersheds extend to the divine caps of the Brooks Range. The Arctic Mountain physiographic province and the Arctic Foothills physiographic province constitute the major parts of the Kuparuk River basin and Sag River basin, respectively. In contrast to the Put River basin, limited areas of the larger basins lie within the Arctic Coastal Plain. The Sag drains 14,898 square km. and is about 272 km. long; the Kuparuk drains 9,802 square km. and is about 300 km. long.

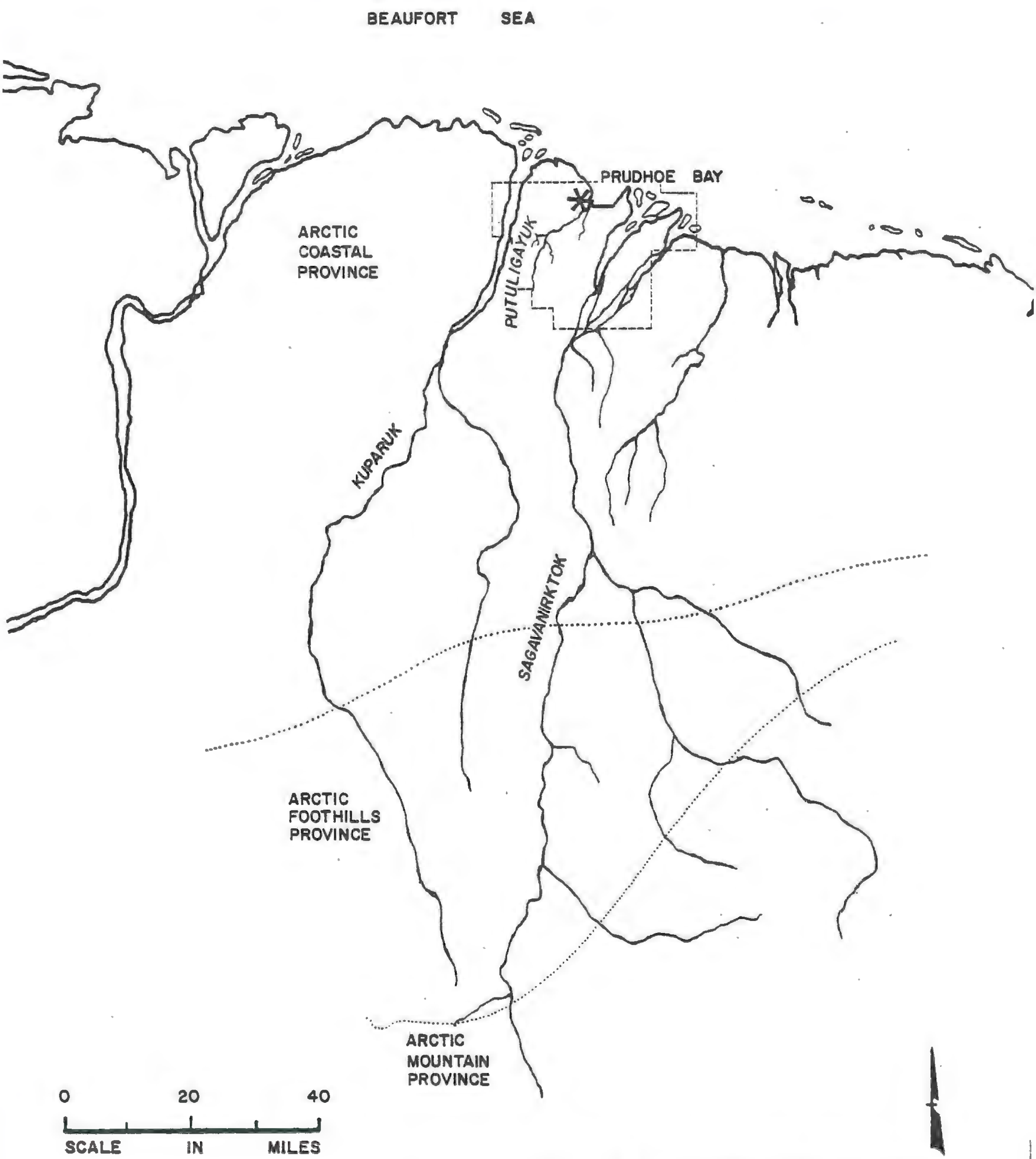


Figure 7: Prudhoe Bay Region

---------- EXISTING PRUDHOE BAY SITE BOUNDARIES

* PROPOSED SALES GAS CONDITIONING FACILITY

The Arctic Coastal Plain contains hundreds of thousands of shallow lakes and ponds, a number of wide, braided rivers, and many small streams that meander extensively. Coastal lakes are near or open to the ocean. The dissolved solid concentration and composition of fresh water coastal lakes may be influenced by salt spray carried inland by storms. In some areas, coastal lakes account for 80 percent of the total surface area. These lakes generally range from 0.6 to 6 meters deep and are normally rectangular or oval. Lakes and ponds on the North Slope usually freeze over by mid to late September, remaining frozen until late June or July.

Precipitation and existing surface bodies of water are the primary sources for groundwater recharge. Water reaches aquifers at depth only through unfrozen areas that perforate the permafrost. Suprapermafrost water (groundwater which flows between the vegetative mat and the permafrost) migrates along the permafrost table until it discharges at the surface or reaches an unfrozen zone. Where drainage is impeded by slope and soil conditions during the summer, a perched water table may be created at or near the ground surface if the permafrost is close to the ground surface. This would create marshy or swampy conditions such as those found on the Arctic Coastal Plain. Along the plain, permafrost is continuous and thick, and subpermafrost water is predominantly brackish or saline. This is because the permafrost tends to be impermeable and prevents freshwater from percolating downward. Only scant information exists on the movement of soil moisture through the active layer. However, the available information suggests that water movement and the contribution of water to surface drainages are minimal. The 487 meters of permafrost below the active permafrost layer virtually eliminate deep groundwater recharge, storage, and outflow.

ii. River Systems

The Put River is classified as a tundra stream. The Sag and Kuparuk Rivers are classified as mountain streams that have spring-fed and tundra-stream tributaries. Most arctic mountain streams are wide, braided streams that deposit extensive deltas of coarse-textured material in the Beaufort Sea. By contrast, tundra streams carry much less material, tend to have more stable channels, and do not form extensive deltas. A comparison of a typical mountain and tundra stream is presented in figure 8.

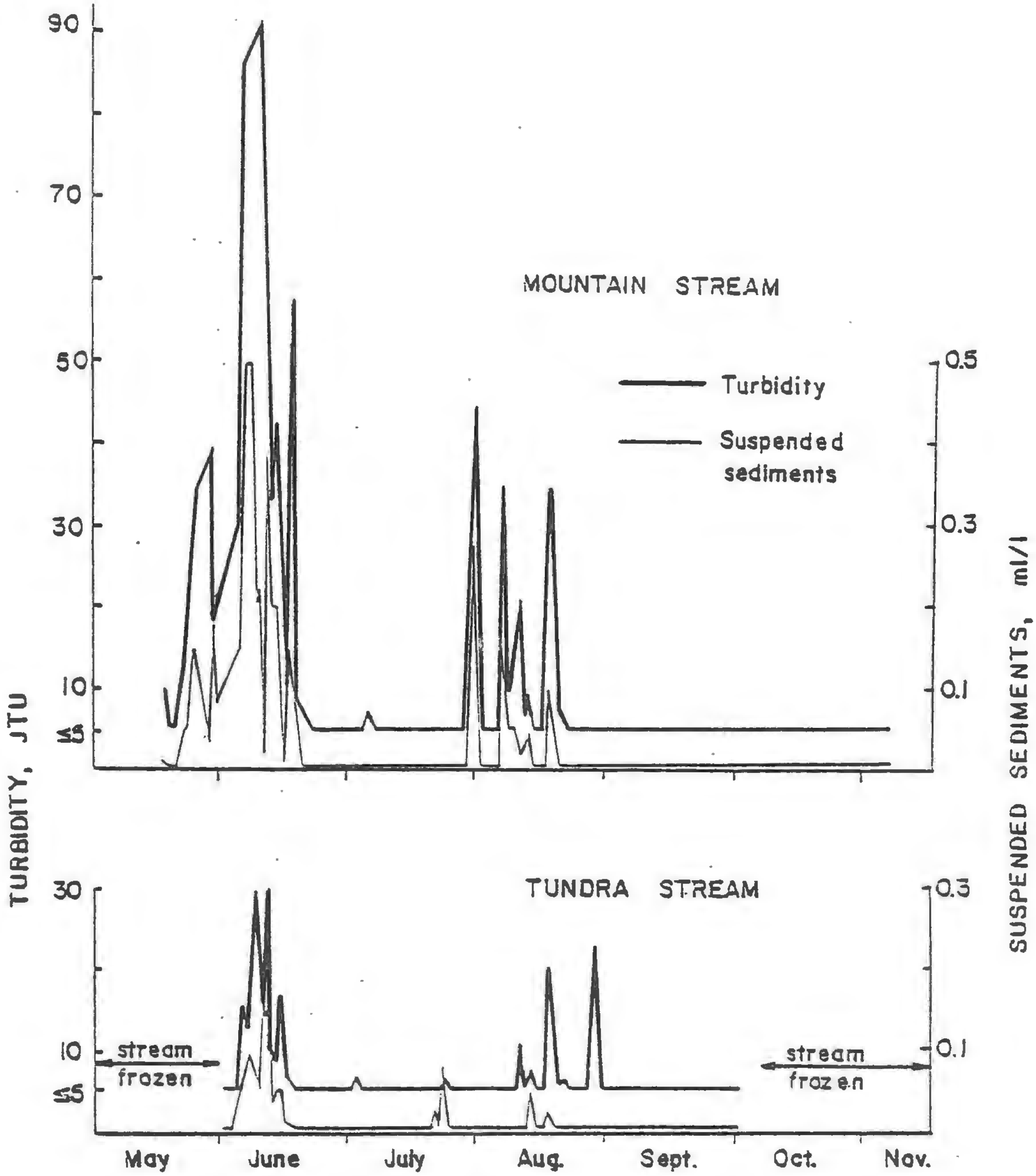


Figure 8: Comparison of Seasonal Fluctuations in Turbidity and Suspended Sediments in a Mountain Stream (Canning River) and a Tundra Stream (Wier Creek) During 1973

Source: Craig and McCart, 1975.

The complexity of the drainage of the Put River and of the two adjacent rivers is presented in table 7. The number of tributary streams in each order was determined from US. Geological Survey (USGS) quadrangle sheet. The ordering of streams is based on their hydrologic characteristics. The streams in the area vary from major rivers (stream order 6) to intermittent streams (stream order 1).

TABLE 7 DISTRIBUTION OF STREAM ORDERS IN THE PUT, KUPARUK, AND SAG RIVERS

Stream Order	1	2	3	4	5	6
River Basin	(Intermittent Streams)					(Major Rivers)
Put	4	1				
Kuparuk	185	62	12	3	1	
Sag	503	103	18	5	2	1

Source: Kane and Carlson, 1973

Although the Put River has a well-defined channel in the Prudhoe Bay area, meandering of this low gradient river is evidenced by the occurrence of oxbows. The channel is about 91.4 meters wide and the channel bottom is about 6.1 meters below the prevailing ground level.

Two roads cross the Put River in the Prudhoe Bay area. One crossing is located near the mouth of the river in the area operated by Arco and the other is located about 11.5 km. upstream from the mouth in the area operated by the British Petroleum Company (BP). A USGS gauging station is located at mid-channel about 61 meters upstream from the BP road crossing. Both crossings are constructed of multiple corrugated metal culverts and can handle the entire anticipated flood flow. The State of Alaska allowed culvert crossings on the Put River because there were no game fish that require a natural bottom in the river. Clear-span bridges over natural bottoms are required by the state on the two adjacent rivers, the Sag and the Kuparuk, because of significant runs of Arctic char and grayling. Sticklebacks have been observed in the Put River on one occasion.

Gravel removal operations are conducted by Arco and the SOHIO/BP companies along the Put River between the road crossings. The operations take place in old oxbows of the river that have been bermed to prevent inundation. Both of these oxbows have been excavated to approximately 6.1 meters below the ground surface. Arco has removed about 2.3 million cubic meters of material from the oxbow area proposed as the landfill site.

Stream Flow

The seasonal flows in the Put River depend on runoff from snowmelt and rainfall. The mean daily hydrograph for the river is shown in figure 9. The flow began between May 27 and June 9 for each of the 8 years of record. The peak flow, which results from snowmelt, usually occurs between June 6 and June 18. Subsequent peak flows resulting from rainfall were smaller. Freezing conditions ended stream flow between September 29 and October 10 during each of the 8 years of record.

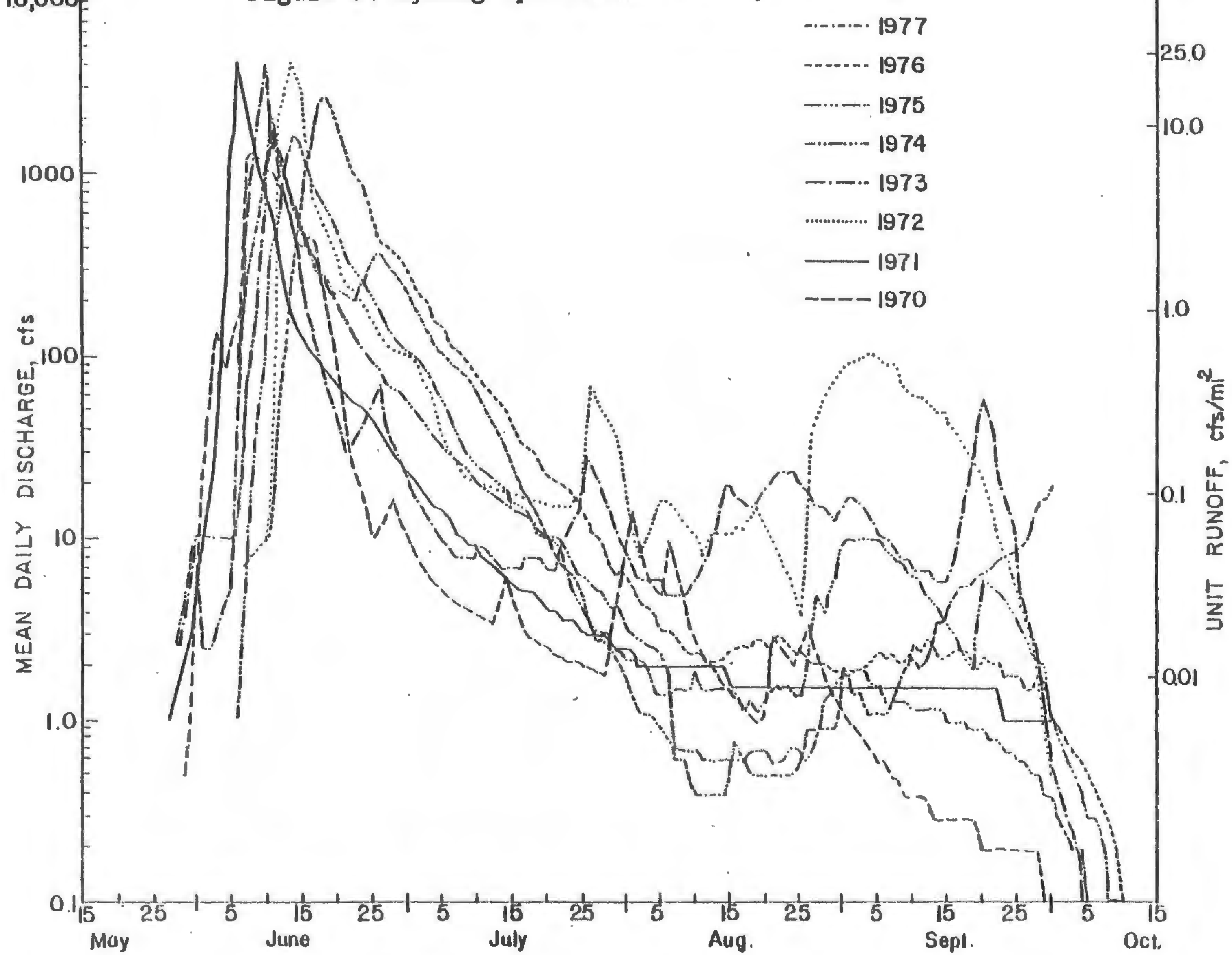
The two adjacent rivers, the Sag and the Kuparuk, have minimal flows beneath thick ice covers throughout the winter. Data gathered for water year 1974 indicate that the total annual discharge of the Kuparuk River (476,400 acre-feet or 155 x 10^9 gallons) is about 25 times the discharge of the Put River (19,490 acre-feet or 6.35 x 10^9 gallons), and the Sag River (1,336,000 acre-feet or 435 x 10^9 gallons) is much larger than the Kuparuk River.

The importance of the June snowmelt runoff for peak flows is shown in the hydrograph for the Put River (figure 9.) Data for 1976 indicate that the peak discharge (2,670 cfs) from snowmelt runoff was about 30 times larger than late summer peaks caused by rainfall runoff. The snowmelt runoff is important for the peak flows in all of the rivers in the study area.

After snowmelt, flows in the Put River decline to very low levels. August 1976 minimum flows averaged 1.9 cubic feet per second (cfs); August 1974, 0.6 cfs. These low flows are maintained by drainage from lakes and suprapermafrost waters. The average flow for the months of July, August, and September 1974 were 17.2 cfs, 1.13 cfs, and 1.06 cfs, respectively.

Pnt River

Figure 9: Hydrograph and Mean Daily Discharge



Source: US Geological Survey

Rainfall from June through September replenishes the flow in the Put River somewhat. Approximately one half of the annual precipitation--7.6 cm. of rainfall--occurs during this time. This precipitation is generally not attributable to large individual storms; rather, it is distributed evenly.

The adjacent large rivers continue to have higher flows into the summer because of the contributions from the deeper and more variable snowpacks in their drainage basins, the glaciers, and the springs in the Brooks Range. For example, mean flows in the Sag River near Sagwon for July, August, and September 1974 were 4,006 cfs, 6,731 cfs, and 1,624 cfs, respectively.

The average annual discharge for the Put River was 28,260 acre-feet (1.23×10^9 cubic feet or 9.2×10^9 gallons) for the 8 years of record. The minimum flow **was 19,490 acre-feet 18.5 x** 10^8 cubic feet or 6.35×10^9 gallons) in 1974, and the maximum was 41,170 acre feet (1.8 x 109 cubic feet or 13.4×10^9 gallons). Approximately 90 percent of the total flow occurs during June; the range was from 84 to 97 percent during the period of record. The variability of flow in June probably results from differences in the intensity of rainfall during the summer.

Water Quality in the Put River

Water quality data for the Put River are sparse. However the USGS has published some data in its annual publication, Water Resources Data for Alaska. On the basis of these data, the water quality generally is considered good. Although the level of suspended sediment is high during snowmelt runoff, the level quickly declines to minimal amounts after the peak flow. The Put, a tundra stream, does not move large particles of sediment as do the Sag and the Kuparuk, which are mountain streams.

The USGS has measured the values of selected water quality parameters for the Put River. **These values are listed** in table 8. A water temperature recorder installed at the gauging station on the Put River during 1976 measured a maximum water temperature of 19°C. (66.2°F.) on August 1, 1976.

Water Use

The present water supply in Prudhoe Bay is derived from four major sources. These sources, and the major user for each source, are:

TABLE 8

SELECTED FLOW AND WATER QUALITY PARAMETERS FOR THE PUTULIGAYUK RIVER (°F=9/5 °C + 32)

Date	Time	Discharge (cfs)	Specific Conductance (umhos)	Suspended Sediment (mg/l)	Temperature (°C)	pH
3 June 1971	1415	58	144	46	0.5	--
6 June 1971	1445	4,700	131	46	--	--
23 June 1971	--	53	206	6	13.5	--
11 June 1975	1700	434	148	12	0.0	--
14 June 1975	1000	1,870	150	45	0.0	--
8 July 1975	2210	25	240	--	15.0	7.7
31 July 1975	800	2.2	--	--	5.0	8.0
13 Aug 1975	1600	14	--	--	13.0	--
20 Sept 1975	800	6.3	290	--	0.0	--
10 June 1976	1130	15	--	1	--	--
23 Aug 1976	1400	2.6	250	--	9.5	7.9

Source: USGS, 1971, 1975, 1976

Kuparuk River - SOHIO/BP construction camp

Big Lake - SOHIO/BP operations center

Colleen Lake - NANA distribution to service companies

Sag River - Arco operations center and construction camp

Arco presently has the water rights (permits) to pump 294,000 gpd from the Sag River and 300,000 gpd from the Put River. (Arco does not currently withdraw water from the Put River.) An excavated reservoir with a 138 million gallon capacity that is filled from the summer flows of the Sag River provides a winter water supply for the Arco facilities. SOHIO/BP has two reservoirs on the Kuparuk River with a combined storage capacity of 42 million gallons and a small reservoir on Big Lake with a 3 million gallon capacity. The reservoir on Big Lake is capped with 6 inches of styrofoam following the formation of ice in the autumn to limit the ice cover to 0.61 to 0.91 meter. NANA Environmental Services maintains a hole in the ice of Colleen Lake for winter access. The various service companies and NANA Oilfield Services truck water from this source.

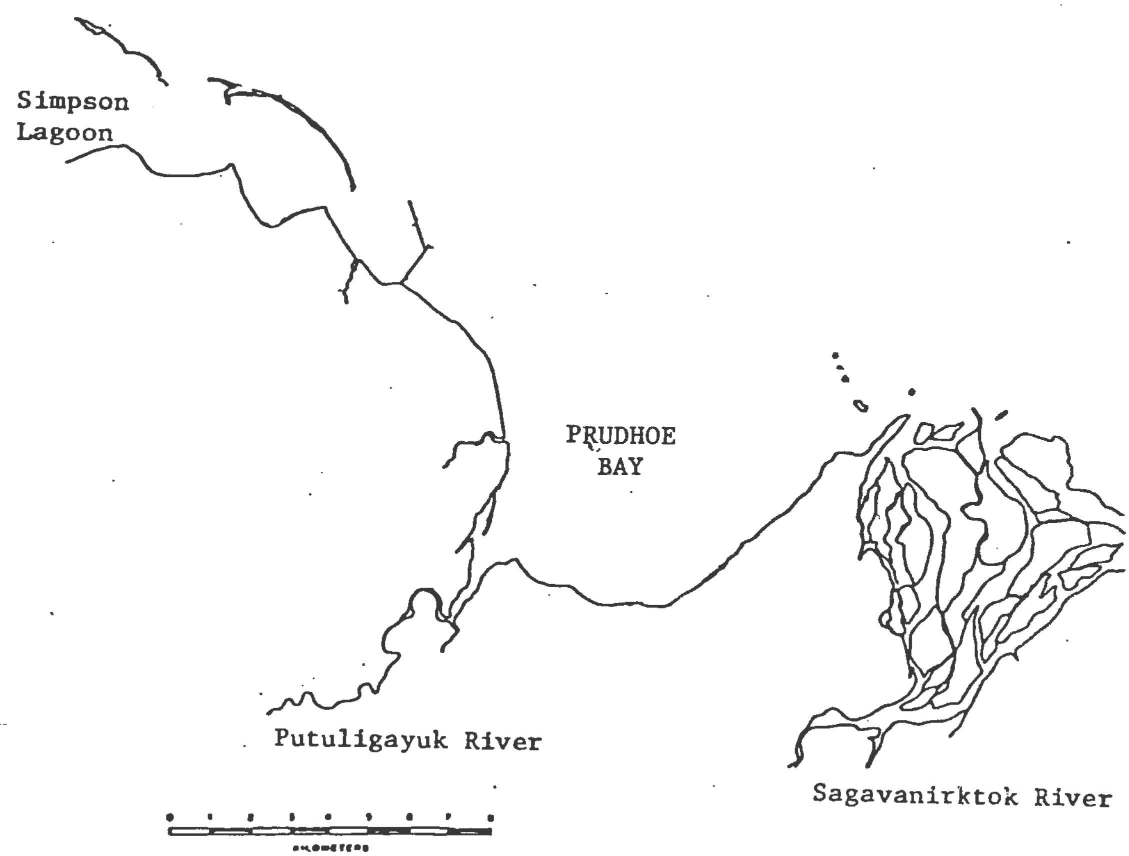
b. Prudhoe Bay

i. General Conditions

Prudhoe Bay, a shallow embayment in the Beaufort Sea, is located at the mouth of the Put River. The bay is flanked by the Simpson Lagoon and Kuparuk River to the west and the Sag River to the east. (See figure 10.) Prudhoe Bay exceeds 2 meters in depth only at its center, where it reaches approximately 2.7 meters.

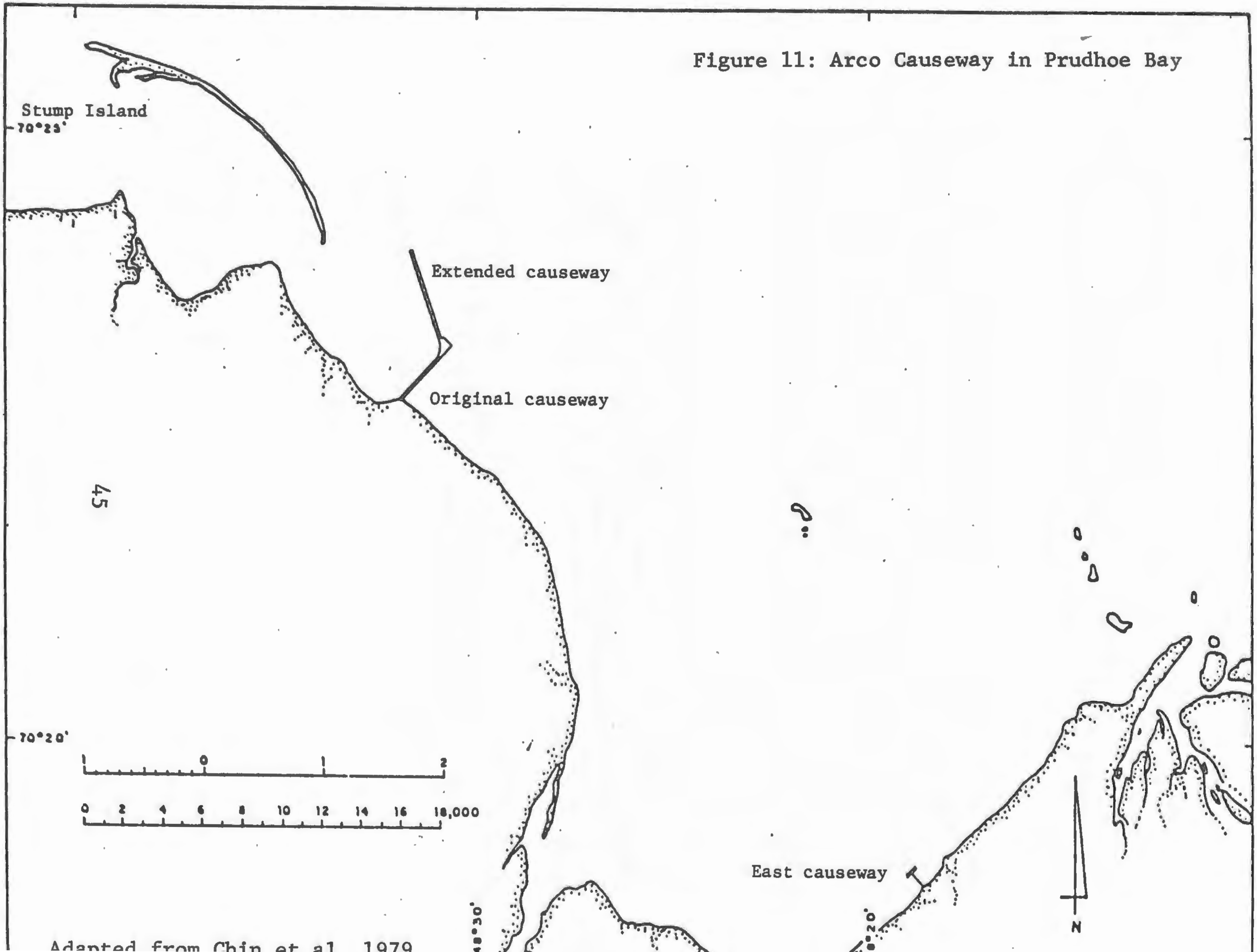
A compacted gravel causeway, 2864 meters long, is located on the western side of Prudhoe Bay, just east of Simpson Lagoon. (See figure 11.) The Arco causeway was constructed in two sections. The original causeway and dock were completed in July 1975 (1340 meters), and an extension was completed in August 1976 (1524 meters). The causeway extension places the furthest offshore dockhead in water of a depth of 2 meters. A smaller, infrequently used causeway is located on the east side of the bay.

Figure 10: Location of Rivers at Prudhoe Bay



Adapted from Chin et al.,1979

Figure 11: Arco Causeway in Prudhoe Bay



Adapted from Chin et al. 1979

ii. Physical Oceanography

The astronomic tides in the Beaufort Sea are considerably smaller than the meteorologic tides and are generally mixed semidiurnal with mean ranges from 10 to 30 cm. The tide appears to approach the shelf from the north. The average lunar tidal range in Prudhoe Bay is 15 cm., and the maximum recorded tidal range is 21 cm. The tides of Prudhoe Bay are characterized by two unequal highs and lows per 25-hour cycle.

From November to May, there is no significant wave activity along the Beaufort Sea coast because the sea is frozen. As the ice begins to break up in June, the predominately northeastern winds generate waves of less than 1 meter. The highly variable winds occurring in July and August generate waves in the Beaufort Sea typically less than 50 cm. in height, although some waves have been recorded as high as 1-3 meters during severe storms. Wave activity declines in October, and virtually all waves are less than 1 meter. The average wave heights in the Beaufort Sea are small because the fetch is limited by islands and nearshore ice. Information on the direction of waves along the Beaufort Sea coast east of Point Barrow during July, August, and September is presented in table 9.

The maximum recorded wave height for Prudhoe Bay is 0.3 meter. This measurement was taken on the east side of the extended causeway when east-northeast winds on the order of 10 to 20 knots hampered safe boating operations. Chin calculated the water elevation resulting from the wave setup created by a theoretical 10-knot onshore wind from 040^{0}T (true north) to be 0.006 meter and the average wave heights to be less than 0.3 meter.

TABLE 9 DIRECTIONS (%) OF WAVES ALONG THE COAST OF THE BEAUFORT SEA EAST OF POINT BARROW DURING JULY, AUGUST, AND SEPTEMBER

Direction	July	August	September
N	1	2	3
NE	7	10	11
E	14	20	19
SE	1	5	6
S	1	1	1
SW	1	2	4
W	4	8	13
NW	9	6	14
calm or indeterminate	61	45	29

Source: Brower and others, 1977

Throughout the nearshore Beaufort Sea, currents are caused primarily by the wind. Observation of sea ice flows and modeling of the currents of the Beaufort Sea confirm that circulation during the summer is related closely to local wind patterns. In the Beaufort Sea, westerly winds generally produce easterly currents and easterly winds produce westerly currents, while winds from the north generally drive surface currents easterly and south winds produce westerly currents. Current velocities in the Beaufort Sea vary from 2 cubic meters per second (cms) to 5 cms for westerly currents, and from 18 cms to 23 cms for easterly flowing currents. The current velocities decrease as the depth of water decreases, which results in slower nearshore currents.

The currents and circulation patterns of Prudhoe Bay are very complex because of the variability of the bottom topography and absence of barrier islands. Gyres, counter currents, and null areas occur frequently within the bay and are influenced markedly by wind direction and velocity. The Arco causeway influences the circulation of the western part of the bay to some extent. Computer simulation of a variety of wind conditions demonstrated that the Arco causeway separated the bay into two different but related wind-responsive circulation patterns.

Circulation patterns and current velocities are determined principally by wind because of the relative weakness of tidal forces and small tidal amplitudes. Chin and others reported that mean current speed in August approximated 2.3 percent of the wind's speed. This result agrees well with observations reported by Barnes and others in 1978 for Simpson Lagoon (3 percent of the wind's speed). These wind-generated currents usually are strong enough to mix waters of different salinities or temperatures, preventing persistent stratification of water layers. The effect of the wind on currents appears to persist through a large portion of the water column. Direct, nearbottom current measurements at approximately 3- and 5-meter depths were also found to be well correlated with local winds.

The coast erodes at a rate of 1.4 meters per year. A slight erosion rate was evident on the mainland of Prudhoe Bay between August 1976 and August 1977. Measurements indicate that during the 12-month sampling period, the shoreline receded between 0.5 and 1.5 meters. Mildly severe windstorms, expected to occur every 5 to 6 years, will generate waves of 0.6 to 1.2 meters and will accelerate this "normal" erosion rate. Estimations have been made that 30 to 60 cm. of the Arco causeway embankment will erode during a storm of this magnitude over 2 or 3 days.

The character and depositional pattern of sediments in Prudhoe Bay are influenced primarily by the Sag and Put Rivers. Figure 12 illustrates the extent of mixing of the waters from the two rivers in Prudhoe Bay. The very fine materials are found in water deeper than 1.8 meters because of their movement offshore in response to nearshore wave energy. Gravel is present, although not prevalent, in a few areas west of the Arco causeway.

The sands, sandy silts, and silty sands contain little organic carbon (average 0.37 percent of weight). This is because of the relatively low biological productivity of the bay. Because of the greater amount of fine material sediments, deeper waters (1.8 meters) have higher values of total organic carbon. It has been reported that total organic carbon valves are 2.95 percent of weight from the deeper bottom samples of Prudhoe Bay.

Temperatures in Prudhoe Bay for July and August range from 2°C. to 9°C. In June, the temperature of the water under the ice was as low as -4°C. Winter temperatures in the trapped pockets of salt water may reach -5°C. to -12°C. Mid-August temperatures are 6°C. on the east side of the bay, 6.8°C. on the east side of the Arco causeway, and 2.3°C. on the west side of the causeway. These differences result from the warm water, sometimes as high as 12°C., entering from the Sag and Put Rivers. During calm weather, a temperature gradient of 6°C. can exist in the Simpson Lagoon, where the depth is similar to that of Prudhoe Bay. However, winds can mix the water so that there are only minor differences in temperature between the surface and the bottom.

Prudhoe Bay generally is frozen over from September to June. Ice begins to form in early September and thickens at the rate of approximately 1 cm. per day. The exact time of total freeze varies with the weather and the winds. Two weeks may pass between the first shoreline ice formation and the total freeze. The ice can reach 2 meters in thickness. Most of Prudhoe Bay is frozen to the bottom, except in the deepest

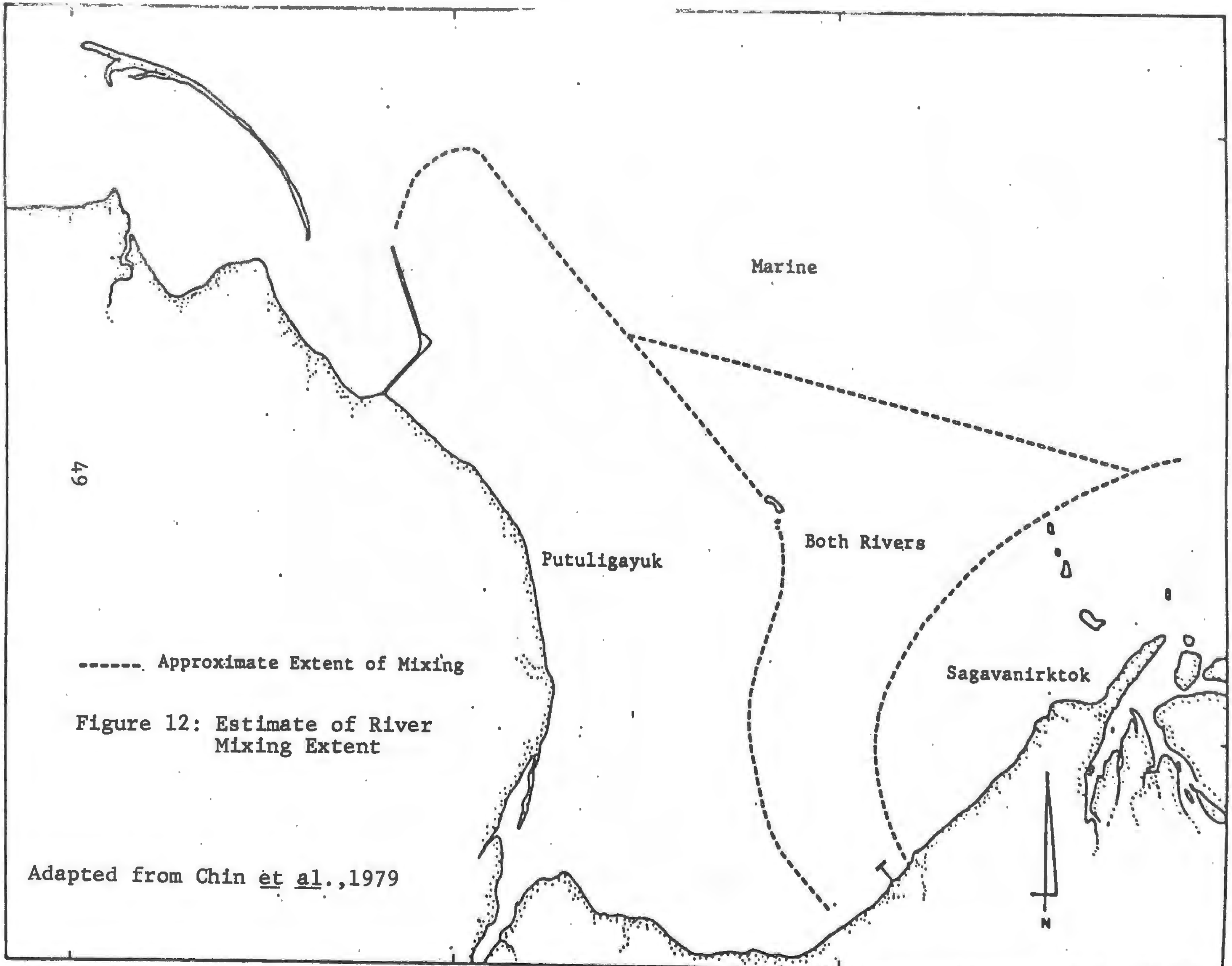


Figure 12: Estimate of River Mixing Extent

Adapted from Chin *et al.*,1979

part of the bay, where approximately 0.5 meter of water remains. During the winter, there is very little movement in the seashore ice, except for tidal and thermal tension cracks.

The ice begins to weaken and melt in May and breaks free of the beach in June, but the area is not clear of ice until July. During storms, drifting ice can move close to or onto the shore, often scouring the bottom in the process. In May and June, river water flows out onto shorefast ice. As channels melt in this ice, the river water drains through it and may scour the bottom sediments. This "strudel" scour can excavate depressions several meters deep. These depressions are filled with sediments entering from the rivers following break-up.

iii. Chemical Oceanography

The Beaufort Sea generally has a salinity of 30 parts per thousand (ppt). In Prudhoe Bay, recorded summer salinities range between 13 to 22 ppt, with the exception of a 6-ppt reading in late July. The low reading may have resulted from freshwater from the Sag and Put Rivers.

The Arco causeway affects the salinity of nearby waters, apparently by influencing the currents and the mixing patterns. Salinity measurements taken during several weeks in August on each side of the causeway are shown in figure 13. Lower salinities on the east side of the causeway probably reflect the presence of Sag and Put River waters that had not mixed the seawater to the west of the Arco causeway.

As the surface of the bay freezes in winter, a layer of dense, salty water forms just beneath the ice. This is caused by "freezing out" of 80 percent of the salt from seawater. This layer of high-salinity water sets up mixing currents that may cause an influx of low-salinity waters from offshore areas into high-salinity nearshore waters. Nevertheless, nearshore bottom waters rapidly become very salty as the ice thickens. Salinities of 72 ppt in Prudhoe Bay have been recorded. Salinities in isolated pools of under-ice brine have been measured at 182 ppt.

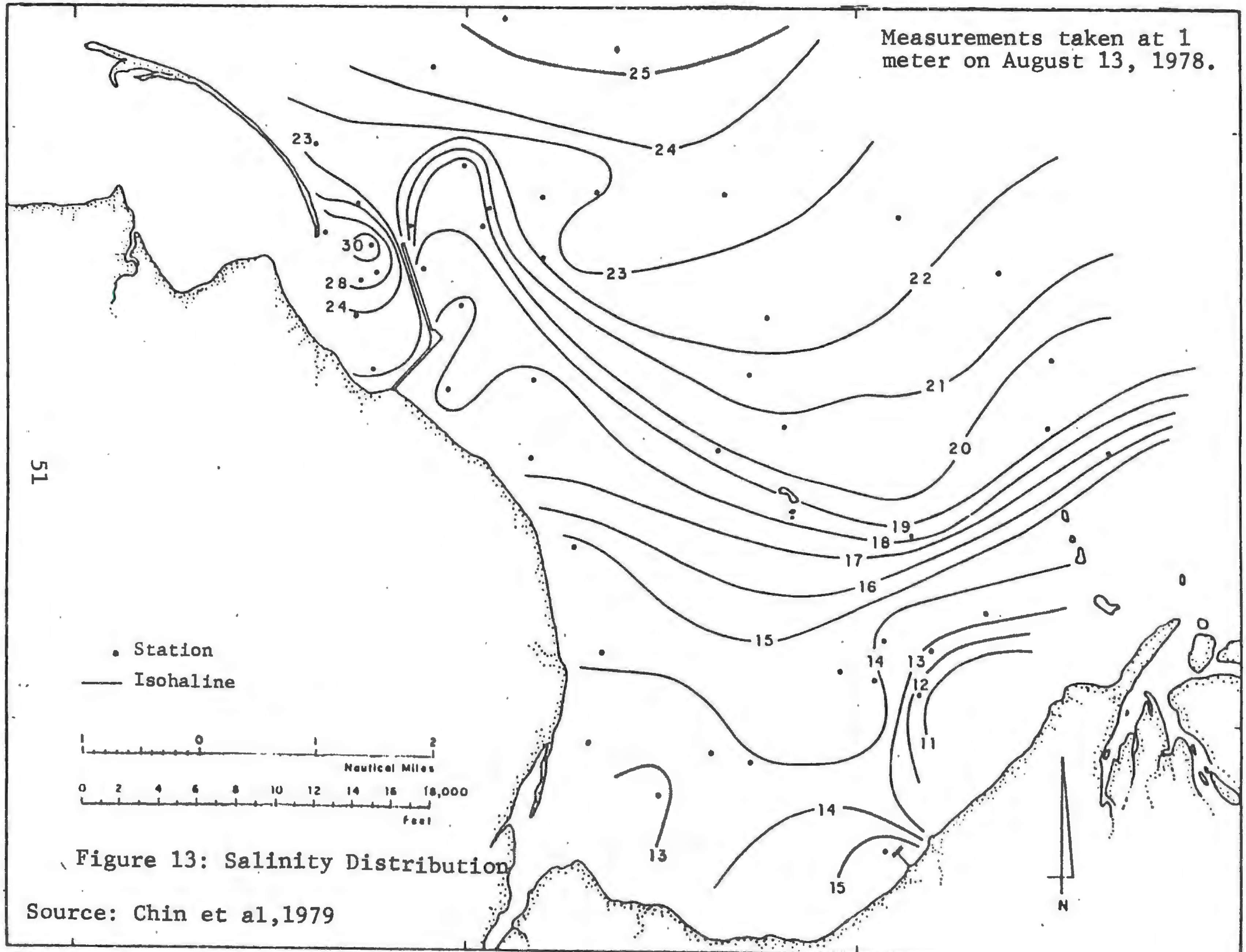


Figure 13: Salinity Distribution

Source: Chin et al,1979

Because the waters of Prudhoe Bay are well mixed by the wind, they are likely to have dissolved oxygen concentrations near the saturation level. Nearshore waters, although cut off from the atmosphere during the winter, apparently retain a significant oxygen content. Biological metabolism depletes the oxygen level during the winter, but this process occurs slowly because of the low temperatures. Dissolved oxygen is forced from the ice into the underlying water as the surface freezes to compensate for this depletion. Although oxygen concentrations of 4 to 5 parts per million (ppm) were recorded in the waters of Harrison Bay and Elson Lagoon during late April, oxygen levels may approach 0 ppm in pockets of seawater trapped below the ice.

Organic compounds in the water under the ice are broken down by bacterial action. This produces nitrates and ammonia that become available to plants. Mixing currents caused by salinity differences may carry some of the nitrogen compounds into offshore waters. The concentrations of nutrients reach an annual peak in the spring, which stimulates the growth of algae under the ice. During periods of open water, additional nitrogen compounds are added to the nearshore waters by river outflow and by shoreline erosion.

These sources apparently do not provide sufficient nitrogen to achieve maximum growth rates for algae, however. Growth of small floating algae (phytoplankton) generally requires 15 atoms of nitrogen for 1 atom of phosphorus to achieve maximum growth. In the nearshore Beaufort Sea, there are only five atoms of nitrogen for each atom of phosphorus; there are only three atoms of nitrogen to one atom of phosphorus in Prudhoe Bay during August. Phosphorus concentrations range from 0.3 $\mu g/l$ to 0.6 $\mu g/l$. Concentrations of silica in the nearshore waters, especially those close to river outflows, are high enough not to limit the growth of algae that require silica. Measured silica concentrations in Prudhoe Bay waters are up to 28 $\mu g/l$ in July but only 16 $\mu g/l$ in August. Consequently, the nearshore system of Prudhoe Bay apparently is nitrogen limited.

An unusual aspect of the nutrient supply in the nearshore Beaufort Sea is the significant input of carbon from eroded tundra peat. In most ecological systems, living plants maintain a supply of carbon by converting CO_2 into plant tissue through photosynthesis. In this arctic system, tundra peat (decomposed plant remains that have accumulated over many years) is being eroded and carried into the nearshore waters by the Put and Sag Rivers. This peat may supply 25 to 50 percent of the carbon entering the system. Detritus of tundra origin also may be important in the diets of some of the shallow water benthos of Prudhoe Bay.

4. Air Quality

There are no ambient air quality data for the Prudhoe Bay site that are suitable for analyses. The site is in an extremely rural area with little industry or population, except that which presently is at the site. It therefore can be assumed that the area is relatively pristine except for those air pollutants that are emitted from the Prudhoe Bay drilling site and the associated facilities and the arctic haze.

The staff analyzed air pollution dispersion to estimate the air pollutant levels from the operation of the existing facilities and Arco's EPA-approved prevention of significant deterioration (PSD) facilities at the Prudhoe Bay site. The analysis estimated maximum groundlevel concentrations by modeling "worst-case" meteorological and operational conditions (table 10). If it is assumed that background air contaminant concentrations from natural local sources and both natural and artificial distant sources are insignificant, the estimated pollutant levels from the operation of the existing facilities and Arco's PSD-approved facilities (table 10) are within the National Ambient Air Quality Standards (NAAQS).

Arctic haze is a turbid layer of air encountered in the arctic regions. Such layers have been found to be from 1 to 3 km. thick and hundreds to thousands of kilometers wide. The turbid layers can occur either individually or in multiple layers at different heights and can occur at nearly every level of the troposphere (the layer of the atmosphere extending from the surface of the earth to a height of 11.5 to 16.4 km. above the earth). The turbidity results from very fine aerosols (a suspension of liquid or solid particles in the air).

TABLE 10 MAXIMUM PREDICTED AMBIENT AIR QUALITY BACKROUND LEVELS AND NATIONAL AMBIENT AIR QUALITY STANDARDS
(Values are in $\mu g/m^3$)

Pollutant	Averaging Time	Background Level[a]	National Ambient Air Quality Standards[b]
TSP	Annual	0.6	75
	24-hour	21.8	260
	1-hour	37.4	-
SO_2	Annual	0.6	80
	24-hour	19.3	365
	3-hour	27.5	1,300
	1-hour	33.2	-
CO	8-hour	<1[d]	40,000
	1-hour	<1[d]	10,000
NO_2	Annual	24.0	100

[a] These levels represent groundlevel concentrations calculated using emissions from the major and approved existing sources in the area. Maximum levels were predicted to occur 1 km. downwind from the proposed facilities with the exception of NO_2, which was reported at 2 km. downwind.

[b] Source: 36 CFR 8996

[c] Turner's 0.17 power law equation was used to correct the 1-hour predicted values to 3-hour and 24-hour values.

[d] Based on the low CO emission rates from the major point sources and the small amount of vehicular traffic in the area.

Studies performed on arctic haze in Barrow by Rahn and others in 1977 and Rahn and Shaw in 1978 deal with the constituents, concentration fluctuations, and probable sources of arctic haze. Their findings indicate that arctic haze is prevalent in the winter and that it is a product of a long-range transport system rather than a product of local emission sources. The principal route of the aerosols and gases to the arctic currently is unknown.

Table 11 presents the constituents of arctic haze and their concentrations. Although sulfate represents only one-fourth of the aerosols by weight, its probable particle size approximates the wave length of light, giving the sulfate considerable haze-forming potential.

TABLE 11 COMPOSITION OF BARROW AEROSOL, DECEMBER 1976 - FEBRUARY 1977

Constituent	Concentration, $\mu g/m^3$
Sulfate (Nonmarine)	1.2
Soil	0.3
Sea salt	3.3
Nonsulfate pollutants	0.2
Total	5.0

Source: Rahn and Shaw, "Briefing on Arctic Haze and Arctic Aerosol," Washington, D.C., 1978.

5. Noise Quality

A noise measurement survey was conducted on February 14 and 15, 1979, to determine the existing sound levels at the Prudhoe Bay field. The ambient air temperature was -38°C. on February 14 and -29°C. on February 15. The wind speed on both days was less than 4.5 meters per second. (The measurements are typical of winter sound levels and may not be representative of summer levels.) Measurement locations were selected on both the SOHIO and Arco oil fields to determine the noise levels produced by equipment such as drilling rigs, compressors, and gas turbines. In addition, measurement locations at the perimeter of the Prudhoe Bay field were selected to determine the background ambient noise level from all the equipment noise sources. (See figure 14.) Noise levels were measured on the A-weighting network of a Burel & Kjaer 4426 Noise Analyzer set to read out the equivalent sound level. (See table 12.) Because of the very cold weather, levels were sampled for 5 minutes.

The major noise sources in the Prudhoe Bay field were the central compressor plant, the central power plant, and the drilling sites. Measurements obtained at the northern perimeter of the field, adjacent to the Beaufort Sea, indicate a background sound level of 32 dBA. This level is assumed to be the lowest sound level in the area at any distance from the oil fields. Closer to the fields, the sound level increases to the range of from 39 dBA to 44 dBA. The ambient sound level of 32 dBA can be assumed to be the sound level to which the wildlife in the area are accustomed.

6. Terrestrial Communities

The tundra which dominates the Arctic Coastal Plain is generally wet. The major influences upon this region, and on the arctic ecosystem in general, are the extremes of both the physical environment and the seasons. Both factors are important in causing annual population cycles in animals and plants.

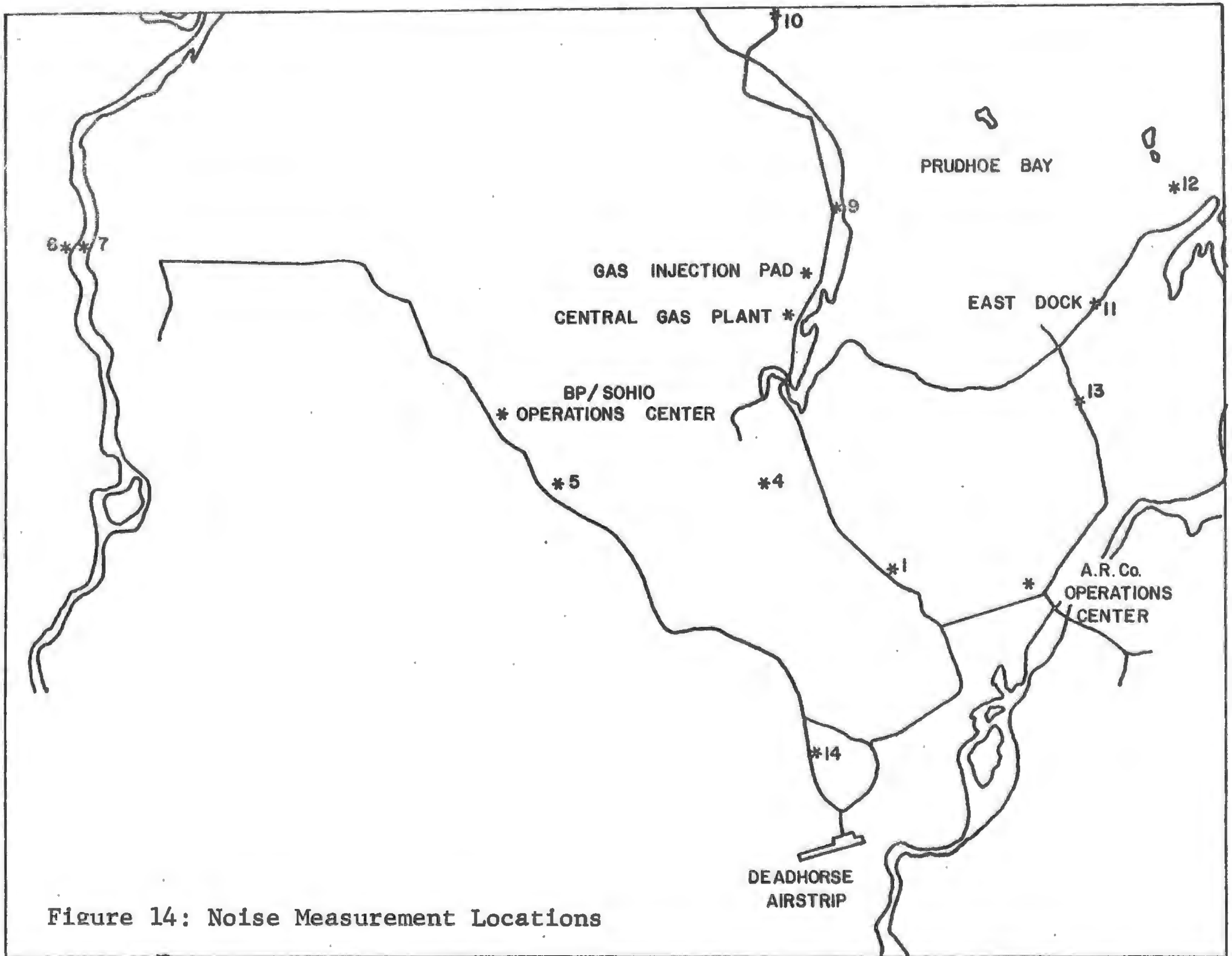


Figure 14: Noise Measurement Locations

TABLE 12

SOUND LEVELS (dBA) MEASURED IN THE PRUDHOE BAY AREA ON FEBRUARY 14-15, 1979

Measurement	Location 1/	Equivalent Sound Level (Leq)
1	300 m. from flow station #1	56
2	Central compressor plant - 15 m. from turbine air intake	74
3	Central compressor plant - 120 m. from flare operation	60
4	0.8 km. from central compressor plant	57
5	100 m. from SOHIO central power plant	67
6	600 m. from SOHIO drilling site	44
7	Bridge over Kuparuk River	39
8	1.2 km. from drilling site (DS) 7	44
9	1.7 km. from East Dock	44
10	10 km. north of gas injection pad	35
11	3.1 km. north of gas injection pad	32
12	Niakuk Island	32
13	1.8 km. south of East Dock	33
14	60 m. from drilling site #13	65

1/ Locations are illustrated in figure 14.

The wet tundra area is typically a mosaic of small lakes, ponds, and marshes. Sedges and moss are the predominant wet tundra species. Approximately 75 percent of the wet tundra vegetation is comprised of several species of sedges (especially Carex aquatilis). Many species of moss grow in the understory, but few lichens occur in the wet habitat. Secondary species include cottongrass, lousewort, and buttercup in the wetter sites and heather and purple mountain saxifrage in the raised drier habitats.

The arctic coastal beaches in the vicinity of Prudhoe Bay consist of mudflats, sandy shorelines, and coastal dunes. The dominant salt-tolerant vegetation found in this area is Dupontia, a medium-sized grass. Other grasses or sedges, willows, and mosses are found in association with Dupontia along the beaches.

The most common mammals in the wet tundra region are the brown and collared lemmings, the staple food for the arctic foxes and avian predators in the area. Wolves and, to a lesser extent, wolverines, are also observed in many of the drainages in the area. Wolves feed on ungulates, ground squirrels, lemmings, and other small animals. Grizzly bears may also be found, but usually only in the major river valleys, particularly after emerging from dens. The North Slope area is primarily the bears' summer range where they eat a variety of plants and animals. Caribou are scattered across the wide coastal and foothill regions, mostly between the Anaktuvik and Sag Rivers. They may migrate through the Prudhoe Bay area, utilizing this location as part of their summer range while feeding on grasses, sedges, and lichens. Figure 15 indicates some patterns of caribou movement through the Prudhoe Bay field during the summer of 1977.

The many ponds, lakes, and marshes of the area are important waterfowl habitat. The bird populations within this area are characterized by a pronounced seasonality, with the majority of birds present only from May to September. Many bird species feed and molt here, while some may come to nest and breed, and still others are only migrating through the region on their way to and from breeding grounds in other areas of the Alaskan, Canadian, and Soviet Arctic. Shorebirds found in the wet tundra include the long-billed dowitcher, dunlin, common snipe, and pectoral, Baird's, and semipalmated sandpiper. The red phalarope is especially abundant. Arctic

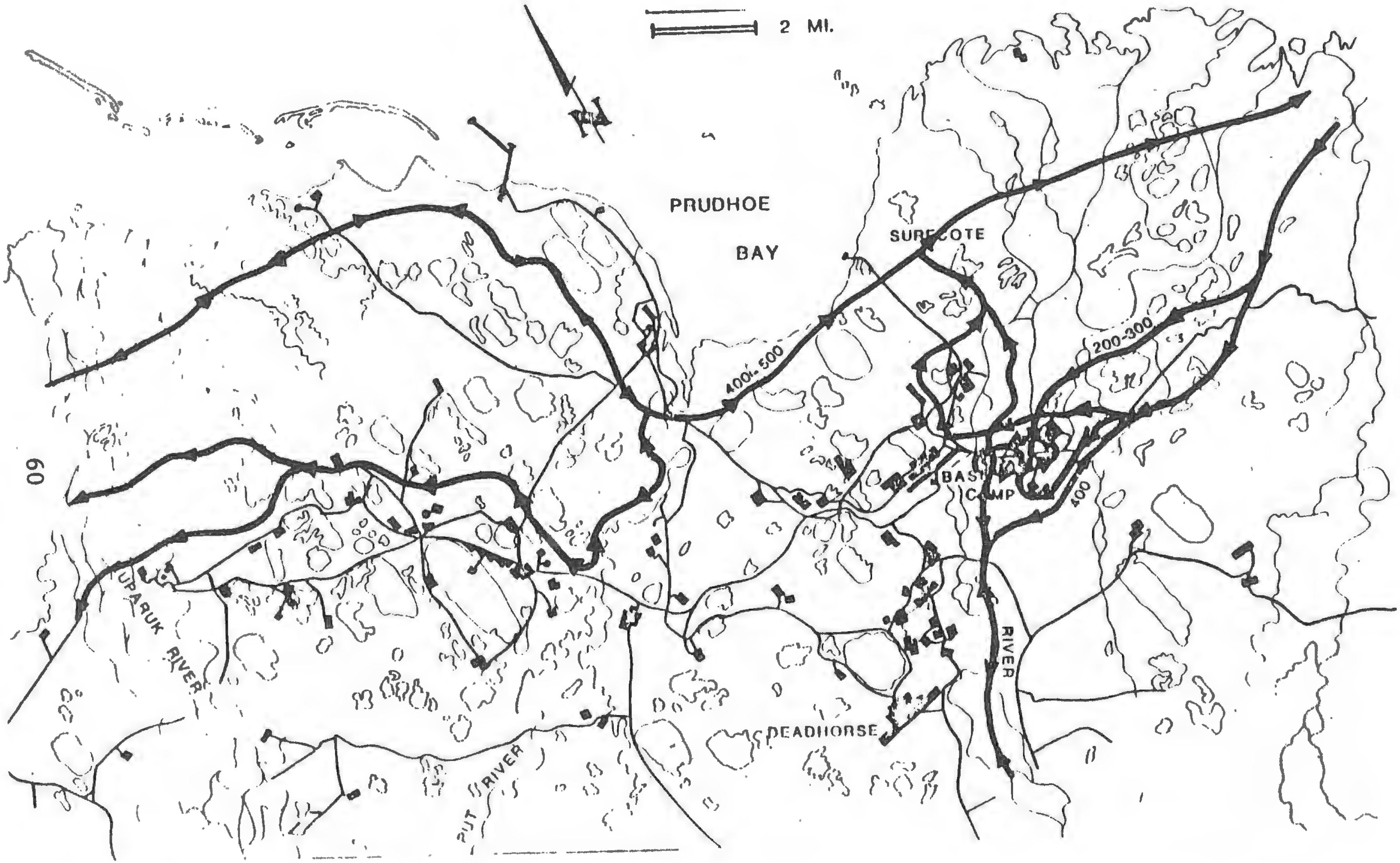


Figure 15: Some Patterns of Caribou Movement Through the Field During the Summer,1977. Some Movements Were Back and Forth Over the Same Routes.

Source: Caribou Migrations and Patterns, Prudhoe Bay Region, Alaska North Slope,1969-1977; Angus Gavin, Arco,1978.

terns, glaucous gulls, and all species of jaeger also prey on small birds and mammals of the wet tundra. Waterbirds that nest and feed in wet tundra include yellow-billed, arctic, and red-throated loons; whistling swans; pintails; oldsquaws; and Stellers, king, and spectacled eiders. Canadian geese commonly rest on dry sites such as well-drained streambank bluffs and pingos.

The endangered peregrine falcon (Falco peregrinus tundrius) may utilize the coastal area around Prudhoe Bay and the lower end of the Put River as hunting areas. However, there are no known peregrine nesting sites within the vicinity of the proposed project.

debated word. Arctic falcon may not be endangered

7. Aquatic Communities

Within the project area, the Put River empties into the southwest corner of Prudhoe Bay. (See figure 1.) It is a tundra drainage stream displaying intermittent flow during summer and no flow during winter, and it has been used for gravel operations since 1969. There is little available information on the existing aquatic flora and fauna of the Put River, but apparently it has little or no fishery value. There is some indication that the lower end of the river in the delta area of Prudhoe Bay may provide primary summer habitat for freshwater, anadromous, and some juvenile saltwater fish species.

A fisheries survey of the Beaufort Sea coastal area including Prudhoe Bay found that freshwater and anadromous species dominate the nearshore fish fauna during the open water season. Arctic char, arctic cisco, and least cisco were the most widespread and abundant anadromous fishes, while fourhorn sculpin and arctic cod were the two most abundant marine species surveyed. Table 13 lists the fish species captured in this study. Figure 16 shows the relative abundance of all species captured within the research area, and figure 17 indicates the seasonal distribution of all species captured in Prudhoe Bay. Generally, the species diversity and the number of fish within the Beaufort Sea-Prudhoe Bay coastal area are low compared with those in other areas.

Anadromous fish enter the Beaufort Sea at breakup and forage for variable distances along the coastline. Adults reenter freshwater systems to spawn and overwinter earlier than juveniles and nonspawning members of the same species. The movements of juvenile fish along the coastline are restricted to less saline, protected waters of major river deltas and lagoons. Anadromous whitefish and char spawn during the fall in a variety of river habitats ranging from perennial groundwater springs in headwater tributaries to isolated pockets of under-ice water in river deltas. Overwintering habitat has not been identified in the fast ice zone of the Beaufort Sea.

Primary production in the near-shore waters of the Beaufort Sea-Prudhoe Bay area consists of three types of primary producers: 1) planktonic algae (phytoplankton) floating in the water, 2) primary producers growing on the bottom (benthic microalgae and macroalgae), and 3) primary producers growing in the ice (epontic algae). The relative annual rates of production for these three types in Prudhoe Bay have been estimated in the following quantities: phyto plankton, 31 percent; benthic microalgae, 62 percent; epontic algae, 6 percent.

TABLE 13 NEAR-SHORE SPECIES CAPTURED BETWEEN HARRISON BAY AND BROWNLOW POINT

Scientific Name	Common Name	Species Abbreviation
Salmonidae		
Salvelinus alpinus	Arctic char	AC
Coregonus sardinella	Least cisco	LCI
C. autumnalis	Arctic cisco	ACI
C. nasus	Broad whitefish	BWF
C. pidschian	Humpback whitefish	HWF
Prosopium cylindraceum	Round whitefish	RWF
Thymallus arcticus	Arctic grayling	GR
Osmeridae		
Osmerus mordax	Boreal smelt	BSM
Mallotus villosus	Capelin	CAP
Gadidae		
Boreogadus saida	Arctic cod	ACD
Eleginus gracilis	Saffron cod	SCD
Cottidae		
Myoxocephalus quadricornis	Fourhorn sculpin	FSC
Pleuronectidae		
Liopsetta glacialis	Arctic flounder	AFL
Gasterosteidae		
Pungitius pungitius	Ninespine stickleback	NSB
Liparidae		
Liparus sp.	Snailfish	Lip

Source: T. Bendock, Beaufort Sea Estuarine Fishery Study, 1977.

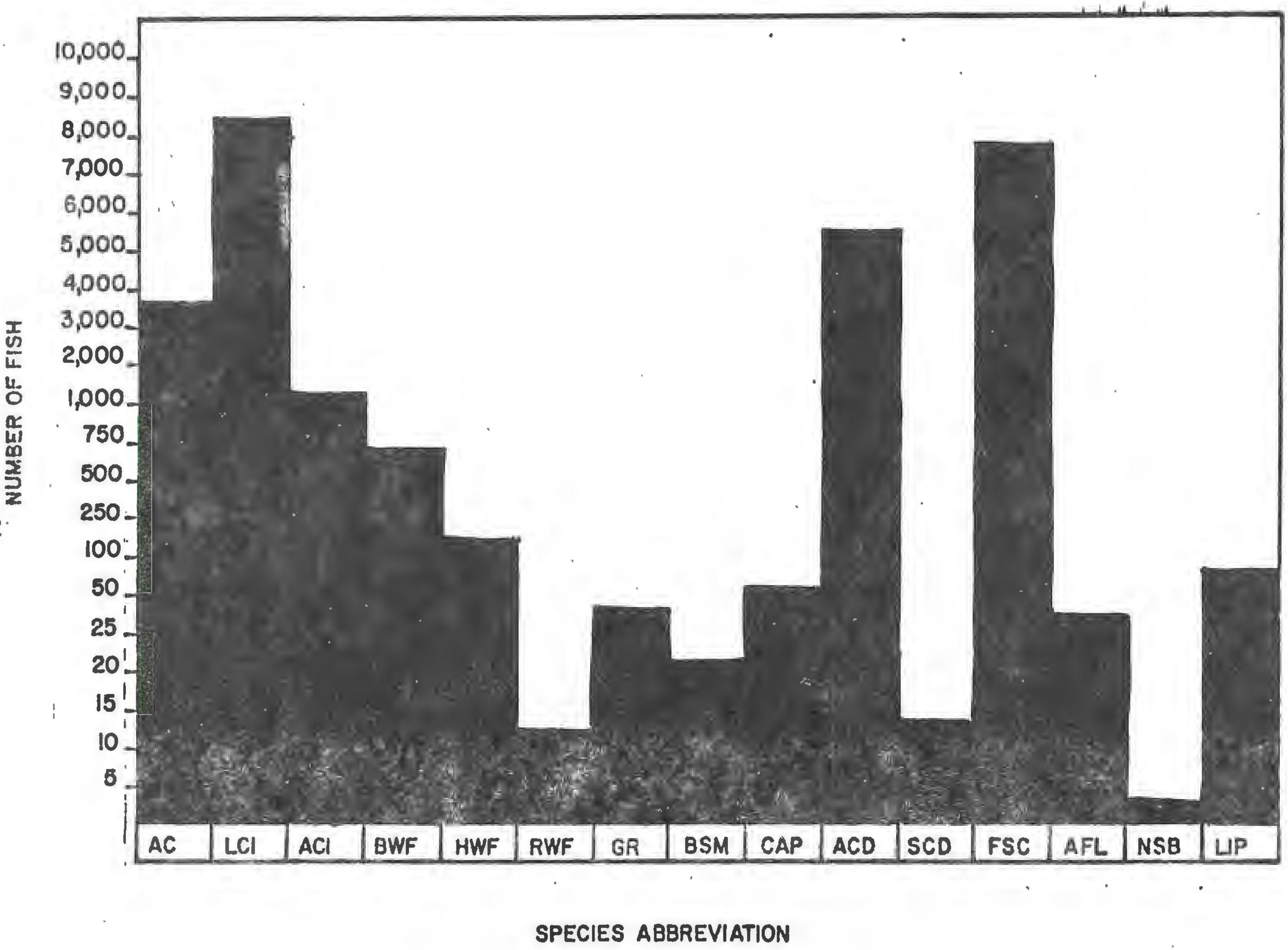


Figure 16: Relative Abundance of Freshwater, Anadromous, & Marine Fish at Prudhoe Bay

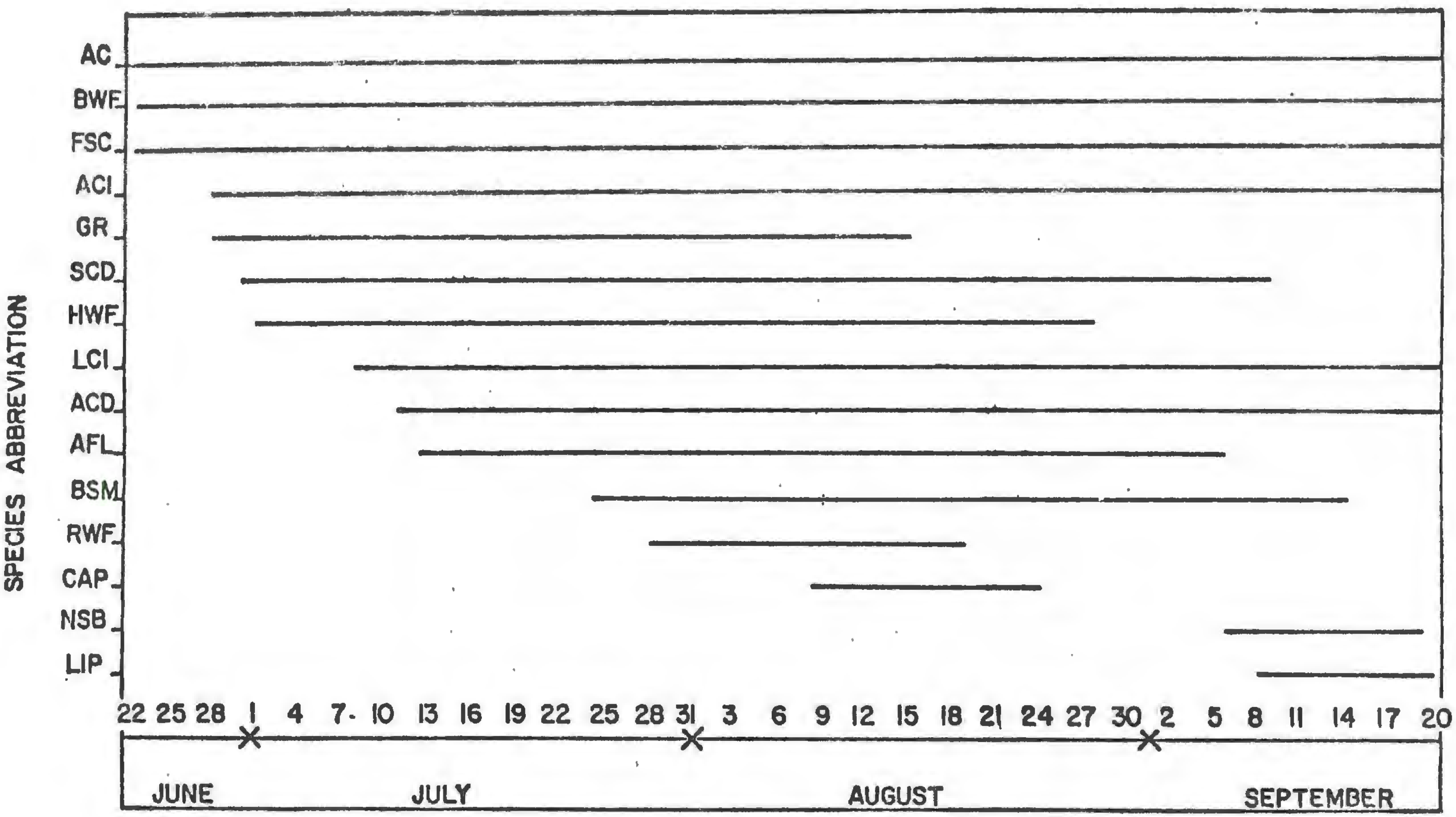


Figure 17: Seasonal Distribution of Fish Species Captured in Prudhoe Bay,1976.

Source: T. Bendock, Beaufort Sea Estuarine Fishery Study, 1977.

Phytoplankton blooms characteristically occur as localized blooms in late spring when leads open in the ice and as more intense blooms in early summer when ice breakup usually occurs. The epontic algae, although not very productive, are probably important because of their proximity to the ice leads along which animals migrate into the Beaufort and because of their very early productivity (maximum concentration in May). The very productive benthic micro-algae occur primarily in calm, shallow coastal lagoons.

Zooplankton includes a variety of animals such as microscopic crustaceans and early life stages of fish serving as food for many larger invertebrates and fish. Because of the short duration of the phytoplankton bloom in the Beaufort Sea, the zooplankton feeding and growth period is short. There is no indication of any consistent pattern of zooplankton abundance in the offshore waters. However, the euphausiid Thysanoessa, which is an important prey of the bowhead whale, is abundant in lagoon and offshore waters.

The invertebrate benthos populations in the Beaufort Sea vary greatly, both seasonally and annually, as do the primary producers. Polychaetes represent 70 to 80 percent of the total benthic infauna. The benthic infauna typically consume diatoms, phytoplankton, and sinking organisms in the water column and take in organisms from tundra and peat runoff. Living on top of the sediments are the immobile benthic organisms called epibenthos. Over 75 percent of these epifauna are echimoderms, which include brittle stars, sea cucumbers, sea urchins, sea lilies, and sea stars. Echinoderms provide little nutritional value to other organisms except in their planktonic stages. Other epibenthos organisms, however, such as amphipods, mysids, and ispods, are extremely important as prey species for the populations of fish, birds, and mammals within the project area.

The fauna of the Beaufort littoral (2 meters depth to shoreline) region is poor in species and biomass and is depopulated annually by shore-fast ice. In general, inshore areas that are exposed to ice gouging support benthic organisms adapted to this seasonal destruction. These are opportunistic species with reproductive cycles not closely associated with other biological cycles. Benthos species living in deeper water are more dependent on the seasonality of the area and may not adapt as easily as inshore counterparts. A study of benthos populations in Prudhoe Bay determined that near-shore invertebrates display increased species diversity, density, and biomass with increasing distance from shore.

When compared to the Bering and Chukchi Seas, the Beaufort Sea is a less productive environment for marine mammals, but nevertheless supports significant numbers. Although a number of different whale species have been sighted in arctic waters, only two--the bowhead and the beluga--are numerically or culturally significant in the Beaufort Sea. The gray whale may also appear along the arctic coast during the summer. Both the bowhead and beluga whales follow the ice leads during the spring migration, while the gray whale is more commonly found nearer shore or in open ocean waters.

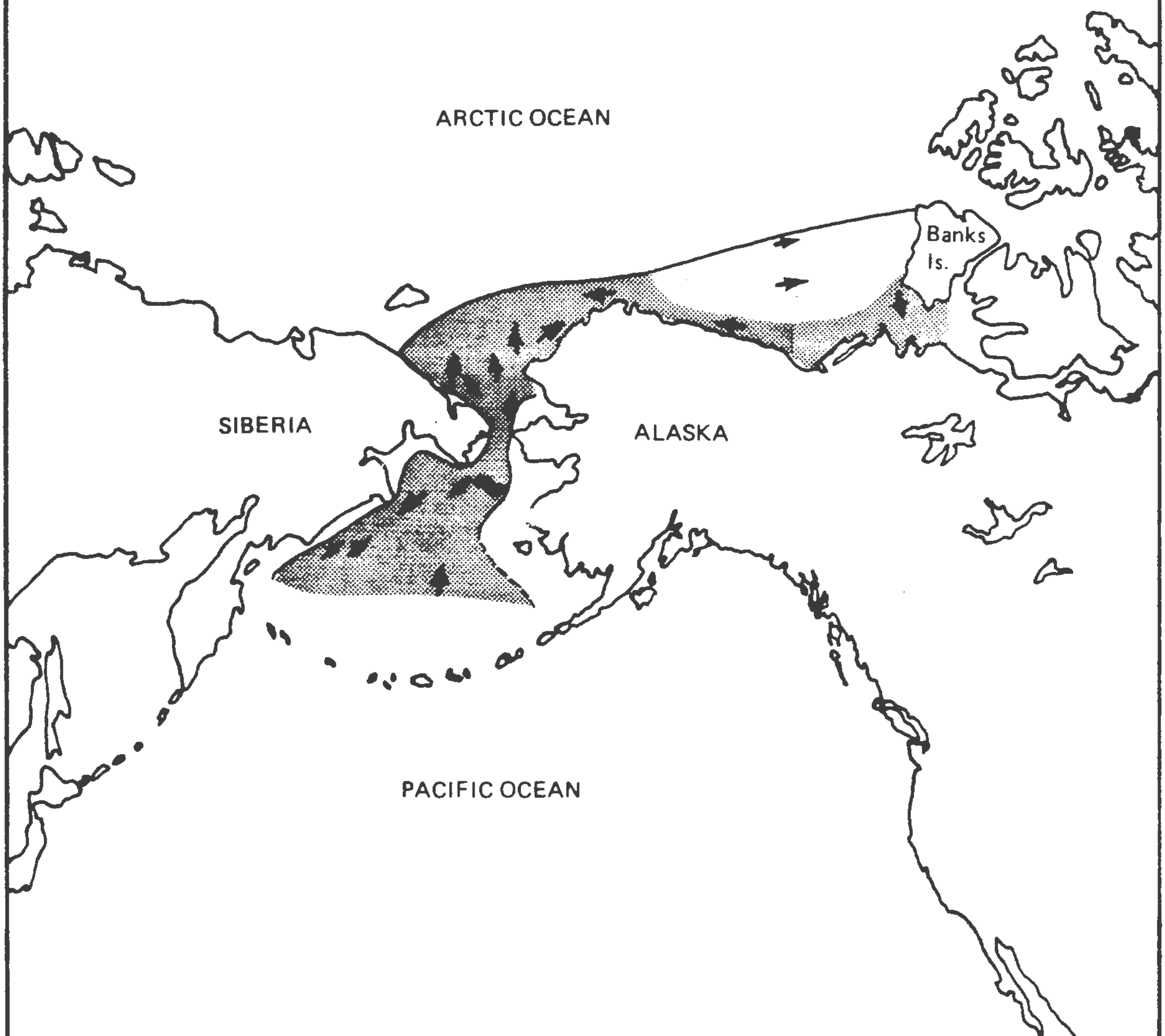
Beluga whales are common in the Beaufort Sea area as summer visitors, beginning their northward migration into these waters in April. By May and June, some belugas may have reached the eastern Beaufort Sea and the pack ice around Banks Island. Their habitat may be disbursed throughout these arctic waters, but generally they prefer the edge of pack ice. However, during the summer and fall, belugas enter river estuaries as soon as the ice moves offshore. The fall migration commences in September, and the Bering Sea is probably the wintering ground for beluga from the Siberian, Canadian, and Alaskan arctic, although confirming data are lacking. Beluga presumably feed on a variety of fish, especially arctic cod, crustaceans, and squid while offshore. When they move inshore, they may feed first on fingerlings moving down rivers, and later in the season, they prey on adult salmon moving upstream to spawn.

The bowhead whale population may be dangerously low, and consequently they are protected from all but subsistence hunting by Alaskan Natives by the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. Recent population estimates have indicated that the present bowhead population may range from the low hundreds to a maximum of

1700 in the Beaufort Sea. Bowhead whales migrate from the Bering Sea into the Chukchi and Beaufort Seas from March through June. Depending on annual ice conditions, bowheads may begin arriving in the Canadian arctic by mid May, first near Banks Island and later near the Mackenzie River delta, where they remain throughout the summer. Whales have been observed by Eskimos to occur within 91-182 meters of the shorefast ice. The bowhead returns to the Bering Sea on its southern migration that occurs from September to December. Figure 18 indicates the proposed spring and fall migration patterns of the bowhead whale in the Bering Sea and the Arctic Ocean. Very little, if any, information is currently available concerning bowhead breeding areas, reproduction, or growth. It is also not certain whether the Chukchi/Beaufort Sea provides calving grounds for the bowhead, although Eskimo whalers have observed calving in the area of the Colville River, west of the vicinity of the proposed project. These whales may do little feeding while migrating, especially during spring. However, mysids, phytoplankton, amphipods, small fish, mud-dwelling tunicates, and vegetation have been obtained from bowhead stomachs during fall migration.

Gray whales are more frequently sighted along the arctic coast of Alaska from Cape Thompson to Point Barrow. However, a few whales have been reported by the Eskimos along the shores of the Beaufort Sea as far east as Barter Island.

There are three species of ice-related seals found in the offshore area of Prudhoe Bay: the bearded seal, the ringed seal, and the harbor seal. The ringed seal and the bearded seal are permanent residents of the Beaufort Sea, while the spotted seal appears in July and leaves the Beaufort Sea area in the fall as ice reforms. The ringed seal usually inhabits areas of shorefast ice in winter and migrates farther north with the retreat of the ice pack in spring and summer. Pupping occurs in late March and April in landfast ice, and the seal pup remains in its birth lair for a 4- to 6-week nursing period. During summer and fall, feeding is intensive, consisting mainly of crustaceans and fish. The adult bearded seal is almost always associated with ice, but the young usually remain in ice-free areas, frequenting bays and estuaries. Mating season is in May and June, and pups are born in the following April and May. Bearded seals eat a variety of benthic invertebrates and some fishes. Harbor seals are found seasonally along the



PROPOSED MIGRATION PATTERN OF THE BOWHEAD WHALE, BALAENA MYSTICETUS, IN THE BERING SEA AND THE ARCTIC OCEAN. NORTHERLY DIRECTED ARROWS DEPICT THE MARCH TO JUNE MIGRATION AND SOUTHERLY DIRECTED ARROWS DEPICT THE SEPTEMBER TO DECEMBER MIGRATION. SHADED AREAS ARE WHERE DATA ARE AVAILABLE FROM HISTORICAL ACCOUNTS OR FROM RECENT SIGHTINGS.

Figure 18: Suspected Migration Routes

SOURCE: Braham, Krogman & Fiscus 1977

entire northern Alaska coast and also congregate near the edge of the pack ice. These seals commonly make use of the nearshore areas, hauling out on coastal beaches and offshore islands where they rest and feed. Harbor seals may enter estuaries and sometimes ascend rivers, presumably to feed on anadromous fish.

The area of the proposed project also includes the habitat for the Alaskan population of polar bear. Some of the most intensive denning on the Arctic coast occurs from the Colville River east to the Canadian border. This area, including the offshore islands, is approximately 80 km. wide and includes a corridor of land extending about 40 km. from the coast and the strip of adjoining shorefast ice. Pregnant females seek dens in undisturbed areas, and denning occurs from October until late March or April. Polar bears feed primarily on ringed seals, bearded seals, walruses, and carrion.

Marine birds, such as murres, black guillemots, and fulmars, are found on the open waters. The offshore barrier islands are important nesting habitat for eiders, shorebirds, and gulls. The protected lagoons behind the barrier islands may be even more important in providing a migration route along the coast, since most waterfowl and shorebird species found in this region are coastal migrants.

8. Land Use and Solid Waste Disposal

a) General Land Use

Just over 10 years ago, the North Slope of Alaska was, for all practical purposes, one of America's last great wildernesses used by indigenous Eskimo residents for subsistence fishing and hunting. Since that time, the country's largest domestic reserve of oil and gas has been discovered in the area, numerous oil industry support activities have been located in the immediate Prudhoe Bay/Deadhorse area, and a road has been built to connect Prudhoe Bay to the rest of the state.

The Prudhoe Bay/Deadhorse industrial enclave is located 13 to 16 km. inland from Prudhoe Bay near the mouth of the Sag River. The enclave encompasses a 995 square km. area containing oil production and operations facilities, support services, and living quarters for persons who work the oil fields. Oil production facilities occupy approximately 259 square km. of the Prudhoe Bay enclave. The facilities are connected by a gravel road running from the northwest to the southeast, with access roads leading to individual facilities. Facilities in the camp are strung out along the road and to the north and east. Prudhoe Bay is solely a work camp organized for onshore oil operations. As such, it does not contain social and governmental institutions that are associated with typical communities.

The small enclave of Deadhorse is located immediately south of Prudhoe Bay. This development, which consists of a state-owned and -operated airport and service company base camps, is the northern terminus of the haul road.

With the exception of several military Defense Early Warning (DEW) line stations and a scattering of Native allotments, almost the entire Prudhoe Bay coastal area belongs to the State of Alaska. The state has leased several tracts between the Canning and Coleville Rivers for oil and gas exploration and development. Soon the Beaufort Sea offshore area may also be leased for similar purposes. To the east of this state-owned land is the Arctic National Wildlife Range. To the west is the National Petroleum Reserve-Alaska area, presently under the supervision of the Department of the Interior.

Prior to the arrival of the military in the 1950's and the oil industry in the 1960's, the land in the Prudhoe Bay coastal area was entirely subsistence oriented. Most of this activity is now generally dispersed along the coast, the barrier islands, and the major rivers, where subsistence resources are most likely to be plentiful.

As a part of the Alaska Coastal Management Act of 1977, the North Slope Borough (NSB) recently published the first draft of its program for developing its own management plan within the Prudhoe Bay area. 1/ The NSB is primarily concerned with developing a program that causes the least possible impact on the fish and wildlife and subsistence needs of its residents. In this proposed program, the borough would classify the existing Prudhoe Bay/Deadhorse complex and the pipeline/haul road utility corridor as a zone of preferred development and, more specifically, as an industrial development zone. The proposed SGCF would be located within this zone. At the present time, however, neither the Alaska Coastal Management Program nor the NSB Prudhoe Bay program have been approved, and in the interim, the borough is capable of implementing plans and ordinances as interim measures.

b) Solid Waste Disposal

The North Slope Borough established Service Area 10 to handle and dispose of solid wastes in the Prudhoe Bay area. The borough has an Alaska Public Service Commission Certificate to operate a solid waste utility. The utility is authorized to process and to dispose of all solid wastes in the Prudhoe Bay area. The borough incinerator is currently undergoing acceptance and permitting testing and is expected to be operational by mid-1979. Other incinerators will be phased out of use. The proposed refuse incinerator for the SGCF most likely will not be necessary because the borough incinerators at Deadhorse will have about four times the capacity needed to incinerate the maximum solid waste generated at the Prudhoe Bay oilfields (8.5 pounds per capita x 4,000 persons = 17 tons per day).

The landfill presently utilized by Arco and the other North Slope companies is operated by Arco in the dunes area near the mouth of the Sag River. It is a state-approved landfill, but because of the uniqueness of the dunes and their shifting character, pressure has been exerted to have the landfill closed by September 15, 1979. Operation may continue for another year until a new site can be approved.

1/ The North Slope Borough is a local governmental unit which encompasses the natural physiographic province of the Arctic Coastal Plain.

At the existing landfill site, refuse is dumped in an excavated area where dune sand previously was removed to near the normal ground level. Because the sand is dry, there is adequate material available for cover during the summer. Ashes and debris, however, are not covered and are compacted daily during the winter because of the extreme cold which limits the use of mechnical equipment and prevents the operators from obtaining cover material. Biodegradable wastes are not allowed in the landfill when cover materials are not available.

The North Slope Borough in conjunction with Arco is exploring the feasibility of using the Put River borrow area, an oxbow where about 3 million cubic yards of gravel have been removed, as the replacement landfill site. This site also is proposed as the gravel source for the proposed SGCF. The existing excavated area would be adequate as a landfill for the expected lives of all oil and gas activities in the Prudhoe Bay area (30 years). Assuming 4,000 persons (estimated maximum oilfield population) on the North Slope generating wastes at 19 pounds per capita per day (76,000 pounds or 38 tons per day) and dumping them directly into the excavated area with compaction to a density of 800 pounds per cubic yard, the presently excavated area would last 88 years. Additional capacity would be created if the borrow area were excavated further.

Although 6.1 to 7.6 meters below ground surface, the borrow pit is dry. This is not unusual in permafrost areas. If the gravels were well drained before being frozen, they usually remain dry but below freezing temperatures until they are disturbed. Any water leaching through the tundra is quickly frozen until an impermeable ice-gravel layer caps the gravel strata.

A dike has been placed between the borrow pit and the Put River to protect against severe flooding. The solid waste site plan specifies another dike around the area as a backup to insure site dryness.

All lands in the North Slope oil field are the property of the State of Alaska, and land-use permits are issued by the Department of Natural Resources (DNR). Any landfill operation also must be permitted by the Alaska Department of Environmental Conservation (ADEC). Until these permits are obtained, the landfill cannot be transferred to the Put River borrow area. Although the plan for the new landfill has not been approved by the State of Alaska or by EPA Region X, Arco envisions approval because it plans to comply with the requirements of the Resource Conservation and Recovery Act. Metals would be disposed of in one pit and ashes in another. This would facilitate future resource recovery.

The Parsons report does not indicate the production of any toxic or hazardous wastes that would require special disposal practices. During 1977-1978, Arco made a survey of its North Slope operation to determine if there was any equipment that contained or generated PCB's. None was found. Three methods currently are available to Arco to dispose of hazardous wastes. The wastes can be pumped into an existing injection well, oxidized in a thermal oxidizer, or shipped south for reclamation.

9. Socioeconomic Considerations

The only permanent residents of this area have been the Inupiat Eskimos. In the treeless tundra of the North Slope, four Native villages exist within 320 km. of the Prudhoe Bay complex: Barrow--population 2,800; Kaktovik--population 136; Anaktuvick Pass--population 99; and Nuiqsuit--population 161. Other residents of the area--including Federal, state, and local government employees who provide services to the local Eskimo population, military employees at the DEW Line stations, and those associated with oil and gas resource extraction--are essentially transients.

The last state population estimate of July 1, 1977, indicated there were 9,163 people in the North Slope Borough, an increase of 158 percent since the 1970 census. Of these, only an estimated 3,612 people were living in permanent borough communities. The composition of these permanent communities is approximately 85-percent life-long Inupiat residents and 15 percent other residents who have moved to the borough for employment in public service.

The major source of recent population growth was the development of the Prudhoe Bay field and the resulting construction of TAPS. Construction of TAPS ended in August 1977. The only people now in the region because of this project are maintenance and pump station personnel.

In 1970, the population composition of the North Slope Borough was approximately 83-percent Inupiat. Since that time, Alaska Natives are no longer the dominant group. As of July 1977, 57.6 percent of the borough's total population consisted of persons engaged in oil-and gas-related activities in the Prudhoe Bay area, plus those associated with pipeline camps. The Prudhoe Bay complex population continues to be dominated by males between the ages 18 and 65. Alaska Natives made up less than 10 percent of the population at Prudhoe Bay and Deadhorse in 1970, even though they comprise 83 percent of the population in the North Slope region as a whole.

According to statistics published by the Alaska Department of Labor, the Barrow North Slope division had an unemployment rate of 3.7 percent in 1976, the lowest in the state and well below the 8.2-percent statewide average. However, this figure may not be representative of conditions in all areas. In July 1976, 71.1 percent of the borough's population lived outside traditional communities, mainly in the Prudhoe Bay/Deadhorse area and in pipeline camps. All of these people were employed, and when their jobs ended, they simply left the region. Therefore, in some of the borough's traditional communities, unemployment rates are relatively high.

Persons employed at the Prudhoe Bay/Deadhorse complex and along the Alyeska pipeline route enjoy extremely high incomes compared to those in the borough's traditional communities and even to incomes statewide. Furthermore, these incomes are not substantially diminished by the high cost of living on the North Slope, since most goods and services are provided by the employer and almost all dependents live outside the region. Although income levels in traditional communities in the North Slope region have improved significantly since 1970, they remain, on the average, well below state levels. Because of high living costs and large families, a significant portion of the region is still living in extreme poverty. Consequently, subsistence hunting and fishing is still an economic necessity.

Compared with the rest of the state, the North Slope Borough has relatively undeveloped trade and services sectors. This is common in rural Alaska, where people with limited incomes and locally high costs of living rely almost exclusively on mail order purchases and demand few services. The lack of development reflects the sizeable transient population housed in pipeline camps which make virtually no demands on the region for goods and services.

The Prudhoe Bay/Deadhorse complex is not an organized political unit of government but rather a private industrial development located primarily on state-owned land within the North Slope Borough. It pays taxes to the borough and is subject to its areawide powers. The property taxes levied on the facilities at Prudhoe Bay account for approximately 90 percent of the borough's budget. In the past, the borough has been required to provide only limited services to the Prudhoe Bay industrial area. As a result of an agreement between the oil companies and the North Slope Borough shortly after incorporation in 1972, Prudhoe Bay has remained a private industrial complex generally responsible for providing its own services. However, in 1976, because of recurring problems with the subdivision's solid waste, sewage, and water supply systems, the borough created a utility service area at Deadhorse. It will assume responsibility for these services when construction is completed.

While the cultural base of the Inupiat of the North Slope is largely the subsistence pursuits of the people, the economic base for these Eskimos, as of the entire state, is continuing to shift to the oil and gas industries. Borough taxes levied in these areas support most local government employment in the region, and greatly increased levels of spending by the borough government and its employees also support employment in other sectors. These added revenues provide needed facilities and services to the people. However, continued natural resource development in the area poses a real threat to the traditional social and cultural well-being of the North Slope Borough.

10. Recreation and Aesthetics

Even though there is considerable potential for recreational and tourist use of the North Slope and Prudhoe Bay coastal area, there is currently little demand for these activities because the region is remote and because facilities and access are lacking. Generally, existing recreational facilities are limited to conveniences installed by the oil companies at the Prudhoe Bay/Deadhorse complexes for the use of their employees. Some tour buses have been allowed to use the haul road to visit the Prudhoe Bay complex. However, as long as access to the area is largely limited to air transport, tourism and recreational use of the area will remain limited. If the haul road is opened to unrestricted use, there would undoubtedly be a marked increase in the demand for recreation and tourist facilities in the Prudhoe Bay area.

A few nonresident hunters and fishermen fly into the area annually to fish and hunt moose and caribou, but exact numbers are unavailable. Prudhoe Bay complex personnel are allowed to fish in the area; hunting is prohibited. Currently, there is little demand in the coastal area for recreational boating. However, if portions of the Coleville River are designated as wild and scenic, the demand for that use will increase. The Sag River is also being studied for possible designation as a wild and scenic river. The North Slope area with its flat topography and low vegetation are particularly conducive to sightseeing and wildlife and waterfowl viewing. Cross-country skiing and snowmobiling are potential late winter and early spring sports when days are longer and temperatures have moderated.

Probably the greatest attraction of the Prudhoe Bay coastal area is its primitive condition and the wide variety of unique arctic geological and ecological phenomena that exist there. To protect the unique ecological, biological, and geological features of the arctic lowland from intrusion by development, the National Park Service initiated a program in 1974 to identify unique examples of tundra environment to be included in the Natural Landmark Program. In connection with this effort, the Park Service identified 16 geographic locations within the Prudhoe Bay area as appropriate for nomination as National Landmarks. ☆

11. Cultural Resources

Although there is currently no permanent Native population living within the immediate Prudhoe Bay area, the land has been the site of numerous temporary settlements and seasonal hunting and fishing camps. Recent archaeological and historical studies undertaken by the North Slope Borough and the Federal government have identified numerous old grave sites, sod hut and ice cellar outlines, and a variety of artifacts indicating the historical and cultural significance of the land. These sites are heavily concentrated along the entire coast, the barrier islands, and the river valleys, particularly with Coleville River.

☆ UNIQUE means one of a kind; no duplicates or varieties; no plurals.

The Prudhoe Bay area was included in a 1975 archaeological site file and literature search conducted by Iroquois Research Institute for the Federal Power Commission. This study assessed the cultural resource potential of competing routes for the ANGTS. One recent Eskimo shoreside site has been recorded on Prudhoe Bay, and another very early Eskimo occupation was found and excavated nearby. The study notes that the Prudhoe Bay area has all the ecological prerequisites attractive to prehistoric and historic Eskimo bands and recommends a field survey for archaeological sites be taken before any facilities are constructed.

C. ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

1. Climate

Because of the size of the project and relatively insignificant amount of heat that will be given off by construction and operation of the facility, neither would affect the existing temperature, wind, or precipitation patterns on either a short-term or a long-term basis. There might be some micrometeorological, or site-dependent, impacts. The gas turbine units and the space and process heaters associated with the SGCF might cause an increase in "snowfall" near the units during December, January, February, and March, when the ambient air temperature averages between -23°C. and -29°C. Water vapor from the units would freeze along the lateral borders of the plumes; the larger water droplets ($\gtrsim$20 microns) would form large ice crystals and fall out as snow. This would generally occur in the immediate vicinity of the units and could occur up to 1 km. downwind of the units. Distribution of this "snowfall" would depend on ambient air temperature, wind velocity, and the size of the water droplets or snowflakes. This phenomenon would not significantly increase the measurable snowfall in the Prudhoe Bay area, nor would it have any long-term effects on the precipitation patterns of the area.

The construction of the proposed project would not exacerbate ice fog in the project area because a majority of construction would occur during the summer. The operation of the proposed facility would have a minimal effect on the frequency and severity of ice fog. The major contributing factors would be increased pickup and diesel truck use, an increased number of fossil fuel space heaters, increased use of the sewage treatment plant, and additional population. The gas turbine facilities are not expected to be a major contributing factor to ice fog. The formation of ice fog would be enhanced by various operating facilities which exhausted moist heated air. The discharge of treated effluent would also contribute to this phenomenon.

The impact of the ice fog would generally be micro-meteorological, that is, site-dependent. In isolated areas, the effects would be primarily operational, resulting in delays or interruptions of air and surface traffic. Outside the immediate vicinity of the facilities, impacts would be insignificant.

2. Topography, Geology, and Soils

The primary impact to topography would result from cut-and-fill, gravel pad emplacement, excavation, and permafrost degradation should that occur. To avoid excessive permafrost degradation and consequent engineering hazards, very little cut-and-fill is expected. It is possible, however, that isolated mounds would have to be removed if they could not be avoided. Depressions would probably be filled with additional gravel.

Excavation would occur at gravel pits and probably at the water reservoir and the wastewater lagoon. The reservoir and lagoon would probably be formed by modifying existing lakes; gravel pits would probably tap river channel deposits or large thaw lakes underlain by gravels.

Surface area of the wastewater lagoon would be approximately 20 acres, assuming a depth of 2 meters. More definite figures for the location or depth of this facility are not available, so the quantity of material to be excavated cannot reasonably be estimated--especially because existing lakes and/or depressions would probably be utilized to some extent. The Parson's report estimates 300,000 cubic meters of excavation for the water storage reservoir.

This project would impact geologic resources, erosion and siltation, and permafrost, Construction of the facility would facilitate the transportation and therefore the use and ultimate depletion of natural gas from the Prudhoe Bay area. This is compatible with the national goal of making these resources available for use.

The only other geologic resource required by this project would be gravel needed for roads, workpads, foundations, etc. This resource is currently being extensively utilized for development of the Prudhoe Bay area. Construction of TAPS drew on these resources, as will construction of the Northwest Alaskan pipeline. Further use may be expected during exploration and development of the Beaufort Sea. 1/ However, gravel for the Beaufort Sea lease area will come primarily from offshore sources.

Gravel would provide an insulating base under road and all facility components to avoid permafrost degradation. These gravel pads, about 1.5 meters thick, would be similar to those used under most of the existing facilities at Prudhoe Bay. Gravel would also be required for a dike around the proposed flare area and for expansion of the existing dock or for construction of a new dock and causeway. A minimum of approximately 1,747,000 cubic meters of gravel would be required. (See table 14.) However, if a new dock and causeway were to be constructed, more than 470,000 cubic meters would have to be added to this total.

Extraction of gravel, excavation of waste disposal and water reservoir areas, and construction of the gravel foundation mats would all increase turbidity and siltation. Turbidity levels would be very high but would be contained within the construction areas. The primary exception would be gravel extraction from river and stream beds, where turbidity and siltation could be carried downstream. However, most of the impact would probably be borne by areas affected by existing extraction activities.

Because of the relatively low slopes and low rainfall in the project area, water erosion should not be a serious problem. This is especially true because of the limited excavation required. If construction removed the layer of organic material lying over the soil, wind erosion could be a problem. However, because of engineering and environmental constraints related to permafrost, disturbance of this organic mat would be minimal.

Permafrost is highly sensitive to temperature changes. Any modification of the amount of solar radiation reaching the surface of the ground or the ability of the surface materials to absorb that radiation changes the thermal regime and will

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1/ U.S. Department of the Interior, Bureau of Land Management, Alaska OCS Office, DEIS on Proposed Federal/State Oil and Gas Lease Sale, Beaufort Sea (Anchorage, 1979).

TABLE 14

SUMMARY OF GRAVEL REQUIREMENTS

	Construction Areas	Gravel Requirements cubic yards (cubic meters)
MODULE PADS		
	SGCF pad	723,000 (553,000)
	Camp pad	612,000 (468,000)
	Crude cooling pad	28,000 (21,400)
	Subtotal	1,363,000 (1,042,000)
ROADS	SGCF North access	19,000 (14,500)
	SGCF South access	27,000 (20,600)
	Camp pad East access	12,000 (9,200)
	Camp pad West access	105,000 (80,300)
	Camp-SGCF road	42,000 (32,100)
	Flare road	60,000 (45,900)
	Subtotal	265,000 (203,000)
OTHER		
	Dike for flare area	43,000 (32,900)
	Dock expansion	613,400 (469,000)
	Total	2,284,400 (1,747,000)

Source: Parsons 1978 and Plengrer, 1979.

change the extent of the permafrost. Most construction affects the thermal regime. The resultant effects on permafrost persist for many years, since the entire column of frozen material from the permafrost table to the bottom of the permafrost must come to equilibrium with the new regime.

Temperature changes can result from climatic changes, from changes in the insulating qualities of the surficial material, and from water standing or flowing over this material. A climatic change would be an increase or decrease in the mean annual temperature or in the variation of temperature of the near-surface permafrost. Compaction or removal of the surface material would reduce the insulation between the permafrost and the surface, allowing more summer heat to reach the permafrost. The creation of standing water bodies would raise the effective average temperature and decrease the seasonal temperature variation at the ground surface; removal of such water would lower the average ground surface temperature and increase the amplitude and duration of seasonal temperature fluctuations.

Degradation of the permafrost results from one or both of the following mechanisms: thermal erosion or thawing. Excessive heat will thaw some permafrost. Heat sources include direct solar radiation, warm air, and free water. If permafrost is brought into contact with running water, thermal erosion will take place, since the water not only melts whatever interstitial ice exists but also carries away the soil particles. Gullying and new drainage patterns may result. In an ice-rich area, subsidence of the permafrost soil may result as the ice melts, saturating the soil and reducing its ability to support loads, including the weight of the soil itself.

Human activities that disrupt the vegetation include vehicular traffic, placement of structures, and excavation. The builders would probably follow normal construction methods such as placing approximately 1.5 meters of gravel directly on the undisturbed tundra in building roads and gravel parking areas. This thickness has been determined by mathematical models and by trial and error to be adequate to preserve the permafrost in the Prudhoe Bay area in most instances. If too much gravel is placed, the permafrost table (top of the permafrost) is raised into the fill.

Although this could produce frost heaving, frost heave would not be a problem as long as the original active layer were not very thick.

There would be changes in drainage patterns along gravel pads and roads. Snow would drift on the leeward side of these structures and, upon melting, would cause ponding of water on the tundra if no drainage were provided. Operating companies on the North Slope have found that ponding along roads has not caused significant degradation of the permafrost. There is evidence that the areas immediately adjacent to the roads and pads melt sooner than other areas. This early melting is caused by the heat absorbed by dust blown from the roadways onto the snow, but it has not created any major permafrost degradation. The ponded water will gradually evaporate or, if the tundra is not disturbed, percolate horizontally through the active layer. The convective cooling caused by the evaporation process reduces the transfer of heat to the active layer.

The wastewater disposal lagoon proposed for the SGCF is an evaporative lagoon similar to the one at the Arco base camp. It is not known whether that lagoon loses water primarily by evaporation, by horizontal flow through the tundra, or by a combination of both.

To determine the potential for permafrsot degradation, it was assumed that a full 8-month wastewater flow would be stored in a 1.83-meter deep lagoon. 1/ The side slopes of the lagoon are assumed to be 1 by 3; thus, the lagoon would have a surface area of 74,900 square meters (18.5 acres). The area covered by the bottom of the lagoon would be 18.3 acres (272 meters by 272 meters).

Because the lagoon would receive warm water from the base camp, the staff assumed the minimum water temperature at the bottom of the lagoon to be 4°C. and the mean annual soil surface temperature to be -10°C. Thus, the steady state thaw would occur approximately 57.9 meters below the bottom. 2/

1/ 150,000 gallons/day x 8 months = 36 million gallons. It is unknown whether the lagoon would be excavated or whether an existing lake would be diked.

2/ Determined by utilizing the graphical solution advanced by Lachenbruch (1957).

This is a 57.44-meter increase in the steady state thaw level because, as Alaska Consultants, Inc. reported in 1978, the maximum naturally occurring thaw level in the area is 46 cm. deep. The length of time for this to occur and the extent of the thaw bulb were not determined. The lateral thaw is not expected to be more than 61 meters; thus the potential for structural damage can be limited by careful planning. It is estimated that it will take 5 to 8 years to reach the maximum thaw condition.

The effect of the proposed water storage pond on the permafrost was similarly determined. The staff assumed, however, that a natural lake would be excavated and enlarged. If the slopes of the pond were 1 by 3 and the pond was 7.6 meters deep, the surface of the bottom of the square pond would be 37,100 square meters (9.2 acres). The temperature of the water in the lake is estimated to be about 1.5° C., because the lake would generally receive only spring flow from the Put River. Based on these assumptions, the depth of thaw below the pond would be 12 meters.

Since the soils in the project area have very little potential for agricultural use because of the climate and the low level of nutrients, impact to fertility would not be significant. Construction could impact the engineering properties of the natural soils as previously discussed.

3. Hydrology

a) Surface Drainage

The construction of the proposed facilities would result in local alterations of surface drainage patterns. Road embankments, gravel pads, and berms would be sufficiently thick to prevent thaw of underlying permafrost. However, the permafrost table could rise under the gravel emplacement and dam lateral movement of water above the permafrost. Such alterations would create new areas of wet and dry conditions. Secondary impact of concentrating or redirecting surface drainage would be the potential for both thermal and surface erosion.

Table 14 gives a summary of gravel requirements for the construction of gravel pads, roads, and the expansion of the existing dock. If a new causeway were required, it could utilize as much as 298,178 cubic meters per km. of gravel. Construction of the water injection facilities would require 2,293,680 cubic meters. The Put River has been used as a gravel source and could supply a portion if not all of the gravel required for the proposed project.

Physical changes in stream length, pool-riffle ratio, substrate, groundwater, water velocity, gradient, width, and depth can result from gravel removal. Even if gravel were initially extracted from outside the watered channel, shifts of water throughout the floodplain could eventually bring the excavation into the watercourse. The river profile would start to adjust by refilling the excavation during high water cycles with materials from the upstream side of the excavation. Gradually the deep water would migrate until the river profile had reached its new point of equilibrium. This straightening of the river channel increases water velocity in the channel and alters pool-riffle ratios.

According to 1973 studies of the Brazos River in Texas by Forshage and Carter, substrate changes could also occur. Following gravel extraction, the depth of the river increased in the dredged zone and the substrate changed from gravel to sand. Additionally, substrate changes in the river were observed as far downstream as 1.6 km., and turbidity increases were detectable 12 km. downstream 6 months after the completion of the gravel extraction.

b) Water Resources and Withdrawal System

The water supply system for the proposed project would be similar to the existing Prudhoe Bay field unit system. Water would be pumped from the Put River to replenish a reservoir lake as necessary. Water from the reservoir would be drawn through a treatment plant and then distributed throughout the camp. Filter backwash and sediment would be conveyed to the sewage treatment facility.

The reservoir would be constructed in an existing thaw lake (figure 19) and would require the excavation of 305,824 cubic meters of material. Two existing 0.71-meter (2 feet) deep lakes with a surface area of approximately 19 acres would be deepened 7.6 meters (25 feet) to provide a working reservoir capacity of 1.5 million barrels (63 million gallons) below the winter 1.1 meter (6 feet) ice cover.

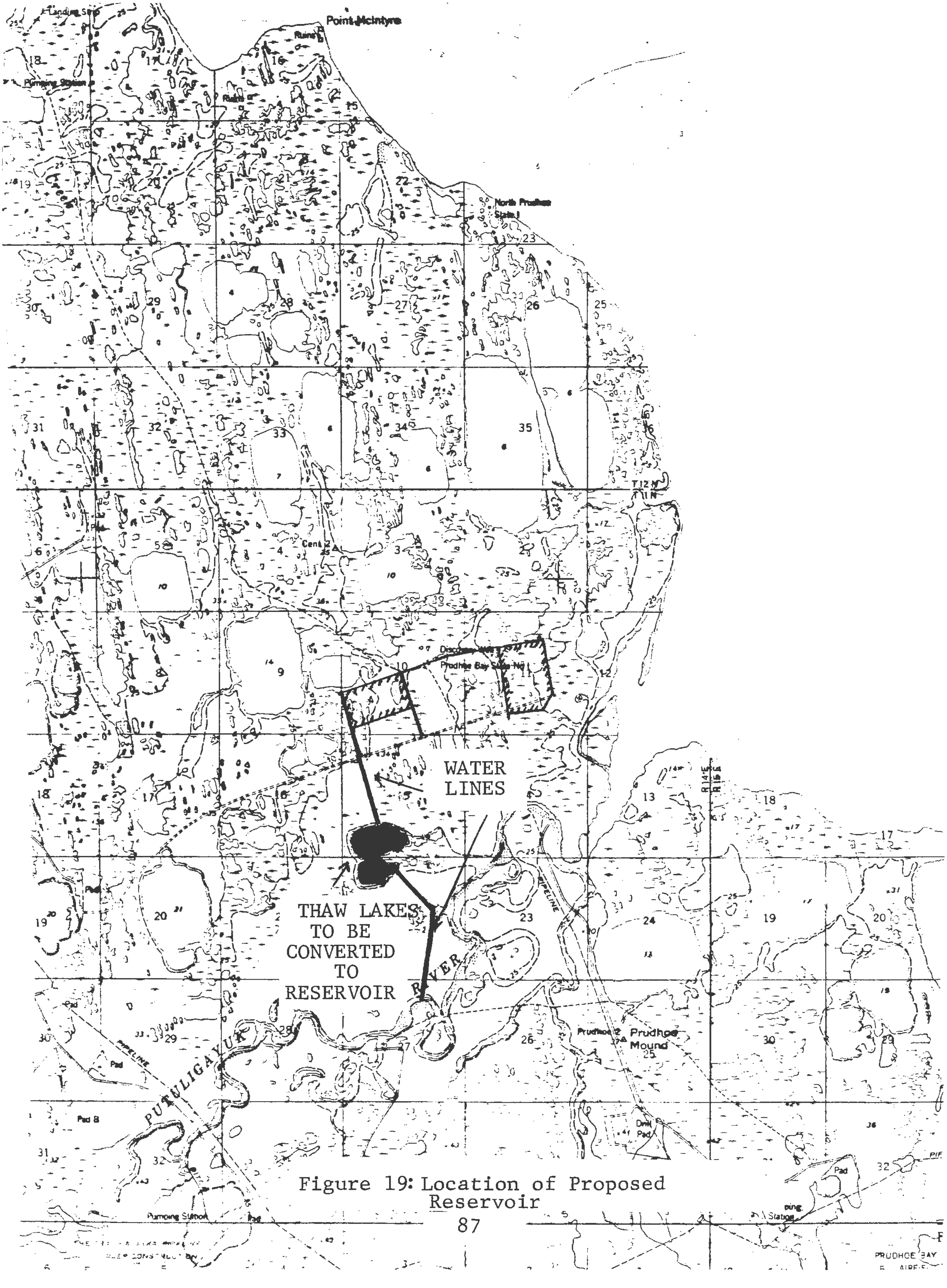

Figure 19: Location of Proposed Reservoir

According to a winter water availability study performed for FWS, artificial storage of excess spring-summer surface runoff such as this proposal is one feasible solution to water use conflicts between humans and fish and wildlife during the winter. Support for this method was provided by FWS, USGS, State of Alaska Fish and Game Commission, Arco, and BP Alaska, Inc.

Arco and BP Alaska have both used the Put River for water supplies. The lower Put River has been deepened, and Arco uses brackish water from this "reservoir" primarily for well drilling. Water Permit No. 890, issued by Alaska's Department of Natural Resources provides Arco with up to 300,000 gpd from the Put River until January 1981. BP Alaska has extracted gravel from an oxbow lake adjacent to the Put River and used the deepened lake as a reservoir. BP Alaska plans to enlarge this reservoir, even though it has been only marginally successful because of high salt content, and is considering the construction of an additional reservoir somewhat upstream from the first.

Assuming that water would be pumped from the Put River during June, July, August, and September at a rate of 287 gpm and using discharge data for water year 1974, the river would have been pumped nearly dry on 10 days during the month of August and on 6 days during September. During the remainder of August and early September, on an additional 13 days about 50 percent of the stream flow would have been diverted to the SGCF. Based on the limited available data, the staff therefore recommends that water withdrawal for both water supply reservoir replenishment and daily usage be limited to the months of June and July. Water for daily operations and construction-related operations (81 gpm or 0.18 cfs) could be extracted from the river during most of August and September without significantly altering stream flow.

The resultant water withdrawal rate during June and July would be approximately 617,400 gpd (428 gpm or 0.96 cfs) during the 3-year construction period. (Slightly larger pumps or additional backup pumps would be required under this scenario.) This rate of withdrawal represents less than 0.3 percent of the mean daily discharge of the Put River during June 1974. If Arco were to exercise its water rights and withdraw 300,000 gallons of water per day (208 gpm or 0.46 cfs) from the Put River in addition to the extractions from the proposed SGCF, the total withdrawal would approximate

0.5 percent of the mean daily discharge during June and 8 percent during July. Therefore, ample water is available in the Put River during June and July to accommodate both demands, although it is unlikely that Arco would exercise its right to the water. Regardless, because the Put River has no known populations of char or grayling, possible flow reductions are not regulated by the State of Alaska.

The impact of construction in the channel of the Put River could be more extensive than the impact of water removal. The riverbed may be adjusting to the effects of past construction, especially the two culvert causeways and the berms for the gravel removal operations. The main channel location and elevation may be changing; in this case, stabilization and maintenance of the channel would be required before the pump intakes could be installed, since the pump intakes must be located in the main channel to be effective during low flow. Sediment concentrations accompanying changes in channel stability might interfere with the water supply system operations.

c) Docking Facilities

Enlargement of the existing facilities would require widening the causeway and a possible enlargement of the docking area. Assuming that gravel would be used to widen the causeway, the short-term effects of the application of gravel along the length of the existing causeway would be as follows:

- Increased turbidity will occur as the gravel stirs up the bottom silt. This will decrease the amount of light available for algal growth. Bottom-dwelling organisms (primarily Polychaeta, Bivalvia, and Crustacea) could be covered as the fine particles settle. Deposition of these sediments would have the greatest impact on the sedentary species of marine organisms. These species are found in the ice-free, deeper waters of Prudhoe Bay.

- Although an investigation of the biotic communities occurring on the gravel slopes of the existing causeway has not been conducted, it is likely that a distinct community has formed on the submerged slopes. This community will be eliminated until it can reestablish.

- Resuspension of detritus into the water column and subsequent decomposition of organic material could reduce the level of dissolved oxygen. This effect is minor if resuspension occurs in the oxygen-rich summer waters.

- Re-entry of nutrients into the water column may stimulate additional algal growth.

Long-term effects could include the following:

- The bottom habitat would be altered by the erosion created from the reflection of waves and the deflection of currents off the causeway. The fine-grained sediment substrate will be converted to a rocky substrate. The existing gravel slope habitat also would be covered with new gravel.

- If the docking area is widened more than the rest of the causeway (e.g. by forming a long-armed "I" at the end), the current patterns might be changed. A spiralling current, or gyre, could develop on the west side of the angled causeway when the longshore current is eastward, and when the currents become westerly, a gyre would be created on the east side of the causeway. If there were a large "T" at the end of the causeway, this gyre would become more pronounced. When the prevailing current is eastward, water on the east side of the causeway probably flows parallel to the outer leg, then veers off eastward. If the causeway were to have a T-shaped end, a small gyre could form on the eastern side of the tip with either a westward or an eastward current.

- The gyres would impede further the mixing of marine and estuarine waters. Although the result of this disturbance of circulation patterns is difficult to anticipate, the influence of saltwater on the biota probably would become more pronounced on the west side of the causeway and less pronounced on the east side.

- Additional deposition of fine sediment will occur at the extended dockhead as a result of the gyres, which in turn will provide a modified substrate for benthic organisms.

The construction of a new causeway and dock, including the addition of a new arm to the existing causeway, would have the same short-term effects as those described for expansion of the existing facility. Long-term effects cannot be discussed in detail without knowledge of the exact location of the dock. However, a number of potential effects are identified below:

- Lunar tidal currents that flow under the ice during the winter would be deflected by the dock. This could result in increased scouring of the bottom until total freezing occurs.

- Storm surges during the open water period would be deflected and possibly could cause a higher surge on one side of the dock.

- A new causeway would reflect waves. Waves reflected back into the bay during a storm could cause increased shoreline erosion.

- The movements of drifting ice during freezeup and breakup could be limited. This might lengthen freeze-over in the bay. The causeway could deflect or intercept ice pushed shoreward by storms. If the causeway blocked the breakup of ice near a river mouth, bottom scouring by river water draining through channels in this ice could be increased. This increased "strudel" scour could affect the bottom topography of the bay.

- Construction of a causeway would affect the currents in its vicinity. Some longshore currents probably would be deflected around the causeway and gyres could form. If the causeway had extra-wide passing areas along its length, these bulges could cause more complex patterns of currents running along the length. Small gyres and eddies could be produced on either side of the bulges. The strength of wind-driven currents would be decreased on the leeward side of the causeway because the structure would act as a wind break and interrupt the momentum of currents.

- The sedimentation patterns would be changed. When a jetty interrupts a prevailing longshore current, sediment is deposited along the "upstream" side, and scouring often occurs along the downstream side. This would suggest that sediment would accumulate on the east side of a new causeway and that some scouring of the bottom and erosion of the shore would occur on its western side. However, because arctic storms can reverse such processes and because longshore currents occur in both directions, the net effect over a period of years cannot be predicted. If the construction of a new causeway also required dredging an access channel, deposition and scouring would be more complicated.

- A new causeway could interfere with the mixing of river water with sea water or of nearshore water with deeper waters by changing current patterns. The present causeway apparently prevents the relatively warm, fresh Sag River water from entering Simpson Lagoon. Instead, some colder, and more saline, offshore water is drawn in through the channel between the causeway and Stump Island. This effect appears to be cancelled partially during stormy weather, when only slight differences in salinity exist between the waters on the two sides of the causeway. Nevertheless, the benthic communities are more characteristic of a marine environment on the west side of the existing causeway.

- Nutrient cycles will be affected if the mixing of water masses is altered. If nearshore waters are not mixed with river water during the summer, the supply of detritus to the nearshore algae could be reduced and, consequently, an important source of nutrients disrupted.

The only long-term effect of the expansion of the existing causeway would be the loss of habitat. If the existing causeway were widened, some of the bottom habitat and some of the gravel slope habitat would be replaced by a new gravel slope. If a new causeway were constructed, a larger area of existing bottom habitat would be replaced by a gravel slope, but no existing gravel slope habitat would be destroyed. The severity of these effects (without additional information on the organisms that may depend on these habitats) on the Prudhoe Bay ecosystem cannot be estimated.

Precise data for predicting the effect of a new causeway on ice formation and movement are not available. Because most biological productivity occurs during the short period of open water, reduction of that period could decrease the productivity of the Prudhoe Bay area. The period of open water varies from year to year due to differences in weather conditions. Therefore, it is unlikely that a new causeway would have a significant environmental impact, unless the anchoring effect of the causeway effectively blocked ice breakup and, thus, resulted in increased strudel scour in a small area. This would alter the shape of the bottom and could produce significant changes in currents and mixing of nearshore waters with river water.

A major new structure, such as a long causeway, could have significant effects on waves during both mild and stormy weather, and increased shoreline damage could result during stormy weather. Studies of the existing causeway have indicated that little wave refraction is caused by the existing structure. This is due to the low energy of most of the waves and to the sheltering effects and dissipation of stormwaves by the offshore islands and shallows. Nevertheless, a new causeway located in a higher energy area of Prudhoe Bay could have a significant effect on the local wave regime.

The existing dock has caused changes in sediment deposition on the eastern side of the causeway at its junction with the shore that are indicative of the impacts expected from a new causeway. Approximately 1,999 cubic meters per year of sediment have been deposited since construction of the original causeway. No net shoreline changes have been reported west of the existing causeway, but relatively few major storms have occurred since its construction. Regardless, the causeway may have significant effects on erosion or deposition if one or more severe storms were to occur.

A new causeway could cause additional piling up of water during a storm, depending on the restriction imposed on the bay waters by the causeway and on the orientation of the winds and currents. The present causeway could cause a heightened surge on its west side during a storm from the west. This could result in increased flooding and erosion of the low shoreland immediately west of the causeway.

Tidal currents under the winter ice may cause scouring of the bottom. If further restrictions were imposed by a causeway, these currents could excavate new and perhaps deeper channels in the bay that might affect the mixing of nearshore with offshore water. These changes would cause a modification in the present salinity, temperature, and nutrient regime that, in turn, could interfere with the functioning of the ecosystem in Prudhoe Bay.

The severity of these effects would depend on the design, size, and location of the structure. Any of the resulting physical or chemical changes mentioned may influence the biotic communities of the Prudhoe Bay area and result in a change in the biological productivity of the bay.

Although the widening of the existing causeway will have some effect on the erosion/depositional patterns, bottom topography, substrate, and benthic communities of Prudhoe Bay, the extent of these impacts should not be serious. However, a significant extension of the dockhead would modify the existing environment and could alter measurably the productivity of the bay.

Of the alternatives considered, the construction of a new causeway would have the most significant impacts on the bay. If the new facility were located on the eastern shore, the impacts might be severe because of the resulting disruption of the inflows from the Sag River. Because these inflows have an important influence on the depositional patterns, available nutrients, and saltwater-freshwater mixing of Prudhoe Bay, negative impacts are possible. These impacts are likely to be related to the length of the causeway and the proximity of the facility to the mouth of the Sag River.

d) Water Injection Facilities

The proposed water-injection facilities would not impact permafrost beneath the ocean floor, because the intake structures and conduits would be isolated by 60 to 70 meters of sediments from the subocean floor permafrost. As the intake conduits approached the shore (and permafrost nearer the surface), they would be insulated by being buried in the gravel causeway.

Dredging for the intake conduits could produce significant turbidity levels. The sediments of the area range from approximately 35-percent silt and clay to approximately 80-percent silt and clay. Depending on the nature of the sediments, local increases in the chemical oxygen demand could occur, with a corresponding decrease of dissolved oxygen.

Construction of another causeway would continue to tax what appears to be the area's faltering capability for producing required amounts of gravel. Likewise, the causeway could alter circulation within Prudhoe Bay, with corresponding changes in sediment transport patterns.

Depending on the relative location of the intake and discharge units, temperature, turbidity, and salinity differentials could impact the marine environment in the vicinity of the discharge.

Reportedly, an antifouling biocide would not be used to prevent fouling of the intake and discharge conduits.

e) Miscellaneous Impacts

Saltwater intrusion can occur in river channels which are below sea level once freshwater flow ceases during the winter. Although the staff is unaware of the stream bed elevation at the proposed water withdrawal location, it does not anticipate that brackish water would be encountered when sufficient flow was available to supply the proposed reservoir.

Information on the type of excavation spoil and how it would be disposed of is not available. Ideally, the spoil would be gravel which could be used for construction. If not properly isolated from flowing water during spring flooding, ice-rich spoil would increase siltation.

Heat from water and sewage pipelines and the reservoir and disposal lake would thaw permafrost, in turn altering local groundwater flow systems. Permafrost thawing could produce some groundwater that would drain along and eventually out of the water and sewage pipeline trenches.

Returning camp waste waters to the disposal lake would increase ice fog and icings. If the proposed wastewater treatment facilities are designed and operated similarly to the existing Arco plant, the environmental impacts would be minimal. However, monitoring data are sparse, and the ultimate fate of the effluent is unknown. The disposal pond for the SGCF would be located well away and downstream from any potable surface water source. Because the permafrost extends 468 meters below the ground surface, vertical percolation of water from the disposal pond will not be a problem. Nutrient-rich effluent that might escape from the pond through the active tundra layer or flow over the tundra would cause minimal adverse effects, because nitrogen and phosphorus would be taken up from the waters by the tundra plants. No changes in tundra species composition, density, or plant vigor are reported in the literature as the result of nutrient enrichment from the operation of a wastewater stabilization pond. Bacterial contamination is not expected to be significant because the wastewater would be chlorinated prior to discharge to the stabilization pond. Regardless, the active layer is not used as a source of potable water. The saturated condition of the active layer would result in very slow movement of effluent through the active layer.

Any spills or leaks of petroleum products associated with construction and operation which entered surface watercourses would adversely affect water quality.

The flood hazard for the proposed facilities would be negligible. The proposed facilities are located about 1.6 km. from the Put River at an elevation of about 7.62 meters msl. The pumping station would be located in the active flood channel and would be constructed to withstand flood flows. No flood hazard maps were available for the area. At the USGS gauging station, 11.8 km. upstream from the mouth of the river and 61 meters upstream from the SOHIO/BP river crossing culverts, the recorded maximum gauge height is 7.47 meters above msl. This height was caused in part by the formation of ice dams at the culverts during ice breakup.

4. Air Quality

a) Construction-Related Impact

During construction of the SGCF and its ancillary facilities, pollutant emissions would depend on the type and amount of equipment used and the extent of equipment use. Concentrations of pollutants would also depend on the relative locations of the construction activities. Generally, the emissions would include hydrocarbons (HC), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), particulates (TSP), and water vapor. The major activities that would produce emissions include gravel extraction and placement, including dock expansion, and transportation of the modules from the barges to the pads and other support functions. Detailed estimates of these pollutants are contained in appendix E.

The extraction and the placement of the gravel could contribute significant quantities of dust to the air. Water spraying would be used to minimize the dust. Spraying water prior to extraction, periodically throughout extraction and placement, and immediately after placement would reduce the dust emitted to the atmosphere substantially. Periodic spraying of any gravel access roads would minimize the dust created by trucks hauling gravel, construction materials, and equipment to the various construction sites. Until revegetation occurred in the borrow area, dust might be a minor problem during the summer. However, 8 months of the year the borrow area would be covered with snow, and fugitive dust would not be a problem.

Construction of the SGCF would cause temporary and minimal deterioration of the ambient air quality in the vicinity of the project site, as can be seen in table 15. Dust would be visible over the natural landscape. Adverse impact on the aesthetics of the natural landscape would not be significant, however. Because of the limited population in the Prudhoe Bay area and the short-term nature of construction, the dust would have a minimal impact on visibility.

Dust settling in the area would increase snowmelt to some extent during construction. It would reduce the amount of light reflected from the ground surface, thus increasing the surface air temperature and the rate of snowmelt.

The pollutants emitted during construction have adverse effects on public health. The specific effect of a pollutant on an individual depends on concentration, duration of exposure, and susceptibility. Respiratory effects on healthy individuals as well as hypersusceptibles from exposure to particulates, SO_2, NO_x, and photochemical oxidants have been documented in the laboratory. These pollutants may irritate lung and/or lung passages individually or through synergistic reactions. Carbon monoxide may impair cardiac function. The risks associated with the levels of pollutants resulting from the construction of the SGCF, however, are not expected to be significant. Because there is a constant wind and because construction would be scattered, the pollutants would be dispersed easily and pollutant concentrations would not increase significantly. In addition, exposure to pollutants will be short-term.

TABLE 15: COMPARISON OF NAAO STANDARDS AND MAXIMUM DOWNWIND GROUND-LEVEL INCREASES IN POLLUTANT CONCENTRATIONS RESULTING FROM CONSTRUCTION EQUIPMENT

Pollutant	Time of Average	Primary Standard	Secondary Standard	Estimated Maximum Groundlevel Increase in Pollution Concentrations
Particulate matter (TSP)	Annual (geometric mean)	75 ug	60 ug (guideline for 24-hour standard)	0.04 ug/m^3
	24-hour	260 ug[b]	150 ug[b]	0.76 ug/m^3
Sulfur oxides (SO_x) (measured as SO_2)[x]	Annual (arithmetic mean)	80 ug (0.03 ppm)		0.06 ug/m^3
	24-hour	365 ug (0.14 ppm)[b]		1.15 ug/m^3
	3-hour	--	1,300 ug (0.5 ppm)[b]	3.24 ug/m^3
Carbon monoxide (CO)	8-hour	10 mg (9 ppm)[b]	Same as primary	2.6 ug/m^3
	1-hour	40 mg (35 ppm)[b]	Same as primary	49.67 ug/m^3
Hydrocarbons (HC) (nonmethane measured as CH_4)	3-hour (6 A.M. to 9 A.M.)	160 ug (0.24 ppm)[b] (guideline for O_3 standard)	Same as primary	11.35 ug/m^3
Nitrogen dioxide (NO_2)	Annual (arithmetic mean)	100 ug (0.05 ppm)	Same as primary	0.99 ug/m^3
Ozone (O_3)[d]	1-hour	240 ug (0.12 ppm)[b]	Same as primary	--
Lead (Pb^{+2})[e]	Calendar quarter	1.5 ug[c]	Same as primary	--

[a] Concentration in weight per cubic meter(corrected to 25° and 760 mm of H_g).

[b] Concentration not to be exceeded more than once per year.

[c] Concentration not to be exceeded more than one day per year.

[d] Revised February 8, 1979; 44 FR 8220

b) Operation-related Impact

The staff conducted an air pollution dispersion analysis for the SGCF and its ancillary facilities. Results indicate that the increases in ground-level concentrations resulting from the estimated emissions are below the Minimum Significance Levels defined by the Emission Offset Interpretative Ruling, with the sole exception of the predicted annual NO_2 increase. (See table 16.) The increases in ground-level concentrations would also be below the maximum allowable increases for both Class I and Class II PSD areas. (See table 17.) In addition, increases in ground-level concentrations over the predicted background levels will not violate NAAQS. (See table 10.)

Several assumptions were used in the dispersion analysis to assure conservative results.

They include:

- All nitrogen oxide emissions were assumed to be NO_2.
- No reduction in NO_x emissions was assumed, although a lower combustion temperature resulting from the exhausting of waste CO_2 through the gas turbine unit will reduce NO_x emissions.
- Exit velocities used for the turbines were multiplied by 0.24 to reduce the plume rise by at least 30 percent for all stability conditions.
- The three turbine units were assumed to be operating at 100-percent load 100 percent of the time, although only two units would run while the third would be kept in reserve.
- The space and process heaters were assumed to be operating at 100-percent load 100 percent of the time, although two of the process heaters and one space heater would be kept in reserve.
- A worst-case mixing height of 900 meters was used to prevent the plume from rising above the top of the temperature inversion lid.

TABLE 16

MAXIMUM PREDICTED INCREASES IN GROUND-LEVEL CONCENTRATIONS RESULTING FROM THE OPERATION OF THE SGCF AND ITS ANCILLARY FACILITIES AND MINIMUM SIGNIFICANCE LEVELS
(Values are in $\mu g/m^3$)

Pollutant	Averaging Time	Maximum Predicted Increase	Minimum Significance Level[a]
NO_2	Annual[b]	4.2	1.0
	1-hour[c]	84	-e
SO_2	Annual[b]	0.25	1.0
	24-hour[d]	3.0	5.0
	3-hour[d]	4.3	25
	1-hour[c]	5.2	-f
TSP	Annual[b]	0.2	1.0
	24-hour[d]	2.4	5.0
	1-hour[c]	4.1	-f

[a]Defined by the Emission Offset Interpretative Ruling (Federal Register, January 16, 1979).

[b]Annual levels were predicted using the EPA VALLEY computer program. Maximum levels were predicted to occur 5 km. west of the proposed facilities.

[c]One-hour levels were predicted using the EPA PTMTP computer program. Maximum levels were predicted to occur 1 km. from the proposed facilities during C stability conditions with a wind speed of 10 meters per second.

[d]Turner's power law equation was used to correct the 1-hour predicted values to 3-hour and 24-hour values.

[e]No short-term standard has been officially proposed. The annual standard is 100 $\mu g/m^3$.

[f]No signficance level has been established.

TABLE 17

PREVENTION OF SIGNIFICANT DETERIORATION INCREMENTS

	Maximum allowable increase ($\mu g/m^3$)
Class I Area	
Particulate matter	
Annual geometric mean	5
24-hour maximum	10
Sulfur Dioxide	
Annual arithmetic mean	2
24-hour maximum	5
3-hour maximum	25
Class II Area	
Particulate matter	
Annual geometric mean	19
24-hour maximum	37
Sulfur Dioxide	
Annual arithmetic mean	20
24-hour maximum	91
3-hour maximum	512

For a more detailed review of the air pollution dispersion analysis, refer to appendix F.

There would be no signficant increase in air pollution emissions produced by transportation related to the operation of the proposed facilities. Onsite use of vehicles and the use of the haul road is expected to be minimal. The majority of the supplies would be barged by sea. In addition, scheduled commercial flights would be adequate to accommodate the operation's work force, and therefore, no additional air flights to Prudhoe Bay will be necessary.

The operation of the SGCF would not result in any significant deterioration of the ambient air quality. Emissions during operation would have minimal impact on the aesthetic character of the area and would cuase minimal deterioration of structures. Particulates might soil surfaces of facilities in the immediate vicinity of the plant. They might also act as catalysts to increase the corrosive reactions between metals add gases. Inorganic gases (i.e., SO_2 and NO_2) are likely to tarnish and corrode metals. Over the lifetime of the facilities (20 years), these impacts may require cleaning and/or replacement of components.

Although estimated maximum ground-level concentrations of all but one of the pollutants are below the minimum significance levels, there is no threshold concentration below which health effects do not occur. Any increases in pollutant concentrations could adversely affect the health of some individuals. As table 15 and table 10 show, the proposed facilities would not add significant amounts of pollutants to the atmosphere, and the NAAQS will not be violated. Because the primary standards were established to protect public health, it can be assumed that the existing and future population at Prudhoe Bay would not experience any adverse health effects from the operation of the SGCF.

5. Noise Quality

The general construction plan assumes three phases of work: a small sealift in 1980 supplemented by truck hauling and two major sealifts in 1981 and 1982. Pre-sealift work at the Prudhoe Bay site would be initiated in 1980. Typical activities for each phase of construction will include the following:

- Extraction and placement of gravel for module work pads, access roads, staging areas, construction camp, and operations center.

- Installation of piling, using the auger drilling and slurry placement method.

- Unloading and transporting of modules and cargo.

- Erection of the module units.

Gravel placement and grading will generate the most noise. These activities require construction equipment with high noise levels for long work periods, whereas other phases of construction, such as pile driving (dock construction) will generate lower noise levels for shorter duration, assuming that haulers and bulldozers would bring gravel from an extraction site and that a grader would roughly level the gravel. The noise levels produced by the major equipment expected to be used at the SGCF site are:

Equipment Type	Engine Power (hp)	Maximum Noise Level at 15m
Bulldozer	235-410	89 dBA
Grader	135	96 dBA
Scraper	415	91 dBA

These noise levels are based on equipment with mufflers. Assuming a worst-case condition of simultaneous operation of the equipment, the resulting noise level during gravel placement and grading would be 98 dBA at 15 meters. This phase of construction, therefore, would be audible from the construction site. The noise generated by all construction activities would depend on the duration and number of work shifts and the use of construction equipment each day. Other than at the camp dormitories, there are no humans within a 3-km. radius of the proposed construction site.

The major noise source associated with operation of the SGCF would be the compressor plant. It would be located next to the existing central gas compressor plant. The expected noise level with both plants in operation is 63 dBA at 0.8 km., an increase of 6 decibels above the existing noise level.

The background ambient sound level at the peripheral areas around the oil fields is expected to be 39 dBA, an increase of 3 decibels.

6. Terrestrial Communities

The proposed construction would destroy wet tundra vegetation in the immediate vicinity of the proposed facilities. Changing the thermal balance by removing or reducing vegetative cover would result in thermokarst subsidence, slumping, rutting, and other types of permafrost degradation. Once initiated, these processes are long lasting and difficult to control. There is little information on what effect such a vast new network of roads, collecting pipelines, and permafrost degradation could have on the flora of the tundra wetlands. Possibly such facilities could alter water levels and form new wetlands, thereby influencing vegetative growth and succession.

Because of the relatively short duration of construction and the scattered construction sites, pollutants emitted to the air would not have significant impact on vegetation. The equipment used would have minimal effects because the resultant ground-level pollutant concentrations will be low. The dust created by construction could have adverse effects, but it would be in the immediate vicinity of the construction sites. Potential effects include abrasion and impairment of plant functions.

Primary effects on wildlife from pollutants emitted during construction and operation of the proposed facilities would be minimal since predicted ground-level concentrations are low and wildlife populations residing in the immediate vicinity are small. Secondary effects on wildlife are also expected to be minimal. These effects would be caused primarily by emissions affecting the lichen community, the source of food for most indigenous wildlife communities. The impacts on the lichen community are expected to be minimal.

Emissions from construction and operation and resulting increased ground-level concentrations could adversely affect vegetation. Effects could include impairment of plant functions, susceptibility to microbial infections, and reduced plant growth. Vegetation in the Prudhoe Bay area is limited, and lichens are often the predominant vegetation.

Lichens are also often the only accessible forage material during the arctic winter and therefore determine the carrying capacity of reindeer and caribou. Any disturbance of arctic lichen communities could have far-reaching ecological implications. However, terricolous or saxicolous lichens, which are the predominant lichens in the area, are considered less sensitive to air pollutants than other species. Exposure to SO_2 concentrations of 775 $\mu g/m^3$ would inhibit essential metabolic activities of lichens at Prudhoe Bay. The predicted maximum SO_2 ground-level concentrations of 38.4 $\mu g/m^3$, however, are substantially less than the concentrations reported to produce adverse effects to lichens.

Removing the wet tundra vegetation to construct the work camp, gas processing facilities, and roads, would eliminate lemming habitat. Gavin states that there were few if any lemmings in the immediate area around Prudhoe Bay in 1977. However, lemming populations are prone to cycles of abundance, and their population are also affected by other physiological and biological factors.

Because construction would occur in the same area as the SOHIO-Alyeska facilities, many of the impacts would be cummulative--e.g., noise and pollutants from the proposed gas conditioning facility added to noise and pollutants from existing oil facilities. Noise from construction coupled with increased noise from construction vehicles would reach unnaturally high levels for the area and could have a significant effect on the area's wildlife. No definite studies have quantified long-term impacts of noise on wildlife. Studies do indicate that the most probable effect would be to reduce use of habitat areas impacted by noise. Whether this effect would be long- or short-term is unknown. The kind and severity of the impact would vary by season, type of species, and probably life stage. For those species that do not migrate from the area, such as fish, seals, arctic fox, and polar bears, the impacts of winter activity would be more severe than summer activities. During the winter, the habitat of these species is severely restricted by ice cover, and animal survival needs are more precise. Migratory species would be more affected during their periods of Beaufort Sea occupancy. Certain species of seabirds, for instance, would be more susceptible to spring and summer activities that would disturb their nesting habitats, possibly causing the failure of a year's nesting cycle.

Post-calving concentrations of caribou use coastal zones, beaches, and spits for relief from insects from late June to August. Caribou have been observed throughout the Prudhoe Bay enclave development during the exploration, development, and production phases of the oil and gas field there. While there has been a decline in one of the major herds that utilizes the North Slope, evidence has not shown that development was the prime or only cause. Because construction would disturb caribou during their summer activities and reduce their habitat, it is probable that caribou populations using the area will decline. The extent of this decline is unknown.

The sealift would use ocean-going barges to deliver the construction equipment and modules. Barge scouring could occur during August and September when breakup of ocean ice would allow access to the east dock. Scouring would generate waterborne noise that might be transmitted from 22 to 67 km. This might impact the bowhead whale, which uses the area as a habitat from April to November. The scouring noise might frighten the bowhead away, mask or distort their voice sounds, and complicate feeding and navigation. As a result, the bowhead might avoid an area of noise stress and not return for several years after the source had been removed.

Human disturbance would have its major impact on avian species from May through September, the most intense period of avian activity on the arctic coast. During this time, the greatest concentration of birds would occur in the nearshore areas, which include deltas, barrier islands, and lagoons. The most sensitive species to human disturbance are whistling swans, geese, oldsquaw, eiders, phalaropes, semipalmated sandpipers, black guillemot, Ross' gulls, and sabine's gulls. The greatest impact would be the loss of habitat. However, the extent of the impact is not currently quantifiable.

7. Aquatic Communities

Ship traffic to the Prudhoe Bay area would use the same access route as the bowhead and other whales. This disturbance might affect whales along their entire migration route, as well as on their summering grounds in the Beaufort Sea. Human activities offshore could disturb those whales using shallow waters for migrating, breeding, or feeding.

There is additional concern about the effects of noise on whales. Inupiat whalers have stated that whales are highly sensitive to high-frequency noises produced by outboard engines as well as boat paddles. In addition, there is recent evidence that suggests bowheads "vocalize" in the frequency range of 40 hertz to 2 kilohertz and perhaps slightly beyond. This range is well within the low frequency sounds expected from drilling and ship operation.1/ It is not known what effect such overlapping of frequency ranges may have on bowhead navigation or communication.

Of major concern during the summer are calves with cows. Juveniles are more susceptible to disturbances than adults. With an endangered species such as the bowhead whale, death of one juvenile can be more serious than death of a few adults.

Bowheads may incur greather impact from construction during their fall migration, when they are assumed to be closer to shore (See figure 18). Any offshore construction or vessel traffic when bowheads were in near-shore waters could affect the whales' migration patterns, feeding behavior, and possibly birthing.

Both the bowhead (Balaena mysticetus) and gray whales (Eschrictius robustus) whales are endangered species that may occur within the area of the proposed action. In compliance with section 7 consultation requirements of the Endangered Species Act, the FERC staff has initiated a section 7 consultation with the National Marine Fisheries Service (NMFS) to determine if a biological assessment would be required for the proposed project.

Evidence indicates that certain seal populations can be quite sensitive to human disturbances and that human harassment has caused them to avoid their traditional habitats. Onshore and offshore construction and operation of facilities and noise resulting from construction and vessel traffic could cause a decline in seal populations in this area. Human

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1/ Letter from Howard Braham of March 12, 1979. Leader, Arctic Whales Research Program, Marine Mammal Division, National Marine Fisheries Service.

activity and concomitant noises may cause certain seals to abandon traditional hauling grounds, breeding rookeries, and foraging areas, and may cause the seals to alter their migratory routes.

Increased noise and activity could affect polar bears within the area. Denning females might resort to sea ice instead of land or landfast ice. However, sea ice may be less stable as a denning environment and more suscepitble to current movements and fracturing. Additionally, it is not known how much disturbance denning polar bears will tolerate and what effects this disturbance could have on critical adult-cub relationships.

Construction would require gravel from open pit mines, the Beaufort Sea, beaches, streams, or riverbeds. Gravel removal from streams or rivers may alter stream morphology, creating a number of impacts on the aquatic biology.

Gravel removal or other construction activities in a stream during fall freezeup, when fish are beginning to inhabit an overwintering area, could block fish passage. Additional significant impact would occur as a result of increased siltation caused by the gravel removal operations. Freshwater fish would suffer direct and indirect mortality, reduced growth rate, decreased resistance to disease, and modifications to migrations and movements. If sediments were introduced near freezeup, they could cover spawning gravels, smother newly deposited eggs, or divert spawning fishes away from their spawning and overwintering grounds to less productive areas. The silt would also reduce the escape cover of young fry and reduce the available food supply needed by the fry.

Year-round water supplies for the proposed project would be drawn from the Put River and either Prudhoe Bay or offshore Beaufort Sea. However, withdrawal especially from the Put River during biologically sensitive times--mid to late winter and the months preceding and following freezeup--may have serious consequences on organisms concentrated in or around unfrozen waters for spawning, feeding, or overwintering.

Immediate or near-immediate alteration of overwintering habitat may stress organisms concentrated there. Winter withdrawal from unfrozen pockets of water, increased sport or subsistence fishing of fish harbored in these pockets, and waste discharge which may percolate into aquatic habitats beneath ice cover would create direct conflicts. If all water were withdrawn from an area supporting aquatic organisms, mortality of some species might occur. If only a portion of water were removed, crowding the organisms into the remaining volume may cause a buildup of the organisms' waste metabolites or dissolved oxygen concentration could decrease. Partial removal might dewater marginal gravels which contain developing fish embryos.

During the winter, the intake of the water injection facilities would be within a confined ice-covered pool bounded by grounded ice at the shear zone and bottom-fast ice inshore. Arctic cod and fourhorn sculpins both inhabit this environment during the winter. The potential for significant losses of these species would depend on their under-ice distribution and the location of the proposed intake mechanism.

Some construction, such as the proposed dock or construction of offshore water-injection facilities, would impact some aquatic flora and fauna. Dredging would destroy some benthic organisms within the immediate area, and the resulting increased turbidity could decrease levels of primary and secondary productivity. Turbidity from dredging or construction of offshore structures could have potentially significant impact on anadromous and marine fish. Arctic char from the Sag River and Least cisco from the Colville River both use the nearshore and offshore area of Prudhoe Bay for migration. However, anadromous fish populations originating from other drainages may be present at any particular coastal location as well.

The Sag River Arctic char population may be particularly susceptible to impact. There are indications that the last four new-year classes (1971-1974) of Sag River Arctic char did not enter the river in the migrating group of the anadromous stock for 1975. The exact cause of this has not been definitely ascertained, although it is believed to be related to gravel removal in and around the Sag River. If these are accurate observations, additional losses to the migrating group of the anadromous stock as the result of trenching-related impacts and/or impingement or entrainment at the seawater intakes could result.

The completed dock facility could change existing water temperatures, salinities, circulation patterns, and fish migration routes. It could also effect a change in turbidity, reducing effective light penetration and thus decreasing photosynthesis of phytoplankton. The decline in photosynthesis would cause direct changes at the bottom of the food chain. The completed dock facility could affect the availability of food for fish, birds and other organisms. Primary sources of food along the arctic coast are the erosion and coastal transport of peat in the shore zone; both of these may be affected by the dock. Any of these impacts or a combination of them would result in reduced populations of some species because of a redistribution or a reduction of food items or habitat quality.

The endangered peregrine falcon (*Falco peregrinus tundrius*), particularly nonbreeding peregrines and unsuccessful nesters, may utilize the Beaufort Sea coast as hunting territory. Formal section 7 consultation was established with the United States Fish and Wildlife Service in connection with the ANGTS, and a biological assessment is currently being prepared.

8. Land Use and Solid Waste Disposal

a) General Land Use

The development of oil and gas resources in the Prudhoe Bay area on the North Slope of Alaska has caused subsistence land use by Alaskan Natives which existed 10 years ago to suffer. Residents of the area indicate that the increased presence of men and machinery has decreased the fish and wildlife populations upon which the Inupiat Natives depend for a living. Oil and gas development has also compromised the former "wilderness" land use of the area.

Adding a new gas processing plant within the existing Prudhoe Bay development complex would probably have little additional impact on the land use of area as it exists at the present time. Since the modification from subsistence and undisturbed wilderness to a petroleum complex has already taken place, the addition of a gas processing plant on the premises would cause little additional land use impact. However, the addition of facilities spurring further gas and oil development leads to some concern about the continuing impact to traditional land uses.

Continued increased oil and gas development in the area will add the possibility of opening the haul road to increased public use. North Slope Borough residents contend that public use of the road, with the potential for an influx of large numbers of people, will put extreme pressure on the fish and wildlife and, therefore, the land resources of the area. Borough officials are concerned that open access will necessitate their providing extensive facilities and services to motorists, which could become an economic burden. Increased access to the area would bring outside visitors into direct contact with local villages and, with the exception of Barrow, none of the villages currently have facilities to accommodate visitors.

b) Solid Waste Disposal

Any disturbance to the surface cover over permafrost increases the depth of the active layer. In silty soils, this can create environmental problems, such as subsidence and erosion. In dry frozen sands and gravels, however, the effect of the increased depth of the active layer is nil. There are no ice lenses to melt causing subsidence, and no water is present to increase erosion. Both the existing landfill and SGCF sites are situated on well-drained soils.

Solid waste placed in the existing or proposed landfill would be frozen permanently within several years whether it is covered on the surface or buried in a trench in the permafrost. If covered with approximately 1.5 meters of cover, the active layer will move up into the cover material within a few years and the materials in the fill will be frozen perpetually.

Inadequate information is available on the types or quantities of hazardous wastes, if any, that would be generated at the SGCF. It is assumed that the multiple disposal system now available to Arco will be available to the operators of the SGCF.

Because the conditions of the pending state and Federal permits will require the landfill to be properly designed and operated, the environmental impacts of the landfill operation on groundwater and surface waters are expected to be minimal. The normal precipitation is not expected to penetrate the active surface layer of the fill which would create a leachate problem. Even if it did, the active zone of the permafrost (about 0.45 meters deep) is not used as a source of potable water. There is little water in the active layer because it is shallow, rainfall is limited, and it is frozen 9 to 10 months of the year. Furthermore, during the winter, most lakes either freeze to the bottom or concentrate dissolved solids to the point that the water is not potable. In addition, both the existing and the planned landfill sites are underlain and surrounded by well-drained permafrost that does not readily transmit water.

The existing landfill is well above flood elevations of the Sag River and of Prudhoe Bay. The proposed landfill is below the natural ground surface but presently is and will be protected further from inundation by the flood waters of the Put River by dikes. The available disposal area at the Put River borrow is more than adequate for the estimated 30-year life of the Prudhoe Bay oilfields. No alternative sites for the landfill have been proposed.

9. Socioeconomic Considerations

These facilities would do little to add or detract from the impact which has already occurred to the Native socioeconomic and cultural framework.

The oil and gas "industrialization" of the North Slope Borough has increased business opportunities, services, and facilities for the people of the North Slope. It has also provided a source of increased tax revenues. On the other hand, the continued natural resource development in the area poses a real threat to the traditional social and cultural well-being of the North Slope Natives.

The traditional communities of the North Slope would again experience some growth in population and employment. Construction of the proposed SGCF could provide temporary peak employment for up to 1,000 people. Operation of the facility could add about 200 long-term jobs. Employment related to construction would probably affect only a few Native people, since about 20 percent of the workforce is local. Operation of the facility would probably require only skilled personnel brought in from outside the area, unless the facility operator is committed to a training program for Alaskans. Some basic maintenance activities could be carried out by local people.

The cumulative effect of additional industrial facilities in the area would probably spur increased oil and gas development, producing future socioeconomic and cultural impact to this area. These proposed facilties could be utilized for any future oil and gas resources that are discovered and developed, both onshore and offshore, along the North Slope. Increased development could lead to industrial expansion outside the immediate confines of the Prudhoe Bay complex,which could then affect additional subsistence hunting and fishing areas or result in intrusions on Native villages themselves.

Subsistence living, with all of its attendant aspects of sharing, bonding, identification, pride, nutrition, and adventure, is gradually being replaced by a cash-based life-style. As a result of the proposed construction of the SGCF and other industrial facilities, lifestyle in the traditional North Slope communities is expected to continue toward the cash-based lifestyle. Because there are so many unpredictable events on the village level, quantitative projections cannot be made with a high degree of accuracy. Older residents fear that the increased cash income will lessen dependency on subsistence hunting and fishing. With the need to hunt and fish removed, the old skills required to conduct these activities will be lost, thus affecting the basis of the Inupiat Native culture.

10. Recreation and Aesthetics

The "unspoiled wilderness" and associated aesthetic values of the immediate Prudhoe Bay area have already been impacted by facilities installed there for the TAPS project. The SGCF will add only incrementally to this existing impact. This type of impact must be considered less harmful to the aesthetics of the area than placing the new facilities in an as yet unimpacted area on the North Slope. If the SGCF adds to air quality degradation in the area, this could also increase aesthetic impact to an area which 10 years ago was undisturbed.

The SGCF would have little direct effect on the recreational resources of the area. Construction workers will probably engage in limited sport fishing in the Prudhoe Bay area, although the companies in the area generally frown on it. However, if these facilities increase oil and gas development in the area, pressure on the recreational resources of the area will also increase.

Tourism into the Prudhoe Bay coastal area is not expected to increase because of the SGCF. The proposed construction and operation will not provide tourists with new embarkation points, and existing tourist attractions have very limited as well as costly transportation approaches and accommodations.

11. Cultural Resources

The land in the area of Prudhoe Bay has been the site of numerous temporary settlements and seasonal hunting and fishing camps of the Alaskan Natives. Associated with this activity are various grave sites, sod huts, and ice cellar outlines which still exist today. Although these types of historical landmarks have been found in the area, it is not known at this time if any exist on the Prudhoe Bay industrial complex or on the immediate site of the proposed SGCF. If any are present on the proposed site, installation of the proposed facilities would cause irreversible impact to these resources.

This impact could be minimized, however, if a thorough historical and archaeological survey of the site were carried out before construction was allowed to proceed and any historical or archaeological finds were salvaged. The fact that this immediate area has already been substantially impacted by humans and machinery also minimizes the potential impact to historical resources, since less relative damage would be done to an area already impacted than to an area previously unimpacted.

D. MEASURES TO ENHANCE THE ENVIRONMENT OR TO AVOID OR MITIGATE ADVERSE ENVIRONMENTAL EFFECTS 1/

Avoiding or mitigating any adverse effects to the environment, the regional economy, and the safety of the public and plant personnel is essential. Approval of Federal, state, and local agencies on various aspects of the applicant's proposed SGCF is required, and the regulations and stipulations of these agencies must be followed during construction and operation. These agencies, their jurisdictions, and the statutes and codes defining their authority are listed in appendix G. Standards applicable to the construction and operation of the proposed conditioning facilities are listed in appendix H.

1. Design and Construction

The severe climate on the North Slope makes conventional construction methods inefficient; therefore, modular construction would be used to construct the SGCF. This involves constructing a steel frame building supported by a steel base to house the processing equipment at a site in the lower 48 states, not yet selected. The modules would then be barged to the North Slope, unloaded, moved to the plant site by low-speed transporters, and placed on a prepared foundation. This method of construction would minimize the amount of work that must be done on the North Slope, thereby avoiding higher construction costs and minimizing the environmental effects of construction.

Since barges are considered unmanned, there are fewer U.S. Coast Guard regulations for them than for other vessels. However, after two stability casualties with barges this past year, Coast Guard concern for adequate design and loading stability of barges has increased. In addition to the load

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1/ The project as assessed in this section of the EIS is assumed to be the project as proposed in the Ralph M. Parson's Inc. study conducted for the North Slpoe gas and oil producers.

line requirement on barges of 150 gross tons and design/ strength regulations, the Coast Guard has stability guidelines for the industry to follow covering amount of roll, 4.6 meter (15 foot) degrees to highest part of righting arm curve. (The righting arm is the built-in torque that a ship has to right itself.) Regulations for "Cargo and Miscellaneous Vessels" are found in 46 CFR part 90-109, subchapter I.

Barge operators must possess certificates of inspection from the U.S. Coast Guard to operate oceangoing barges of 100 gross tons. The U.S. Coast Guard regulations require an annual inspection of ships (including oceangoing barges) after initial certification. In addition, there is a required dry docking inspection every 5 years. Since the barges for this project are already being used by an oceangoing shipper, they should currently be certified for operation; the certificates note the permissible load line and height limits of each barge. With operation through ice hazard areas into Prudhoe Bay, the Coast Guard may require additional barge strengthening for heavy module shipments.

The U.S. Coast Guard monitors all ship/barge movement. The Officer in Charge of Marine Inspection (OCMI) is in touch with all activities in his district. The OCMI also monitors critical ice flows and potential hazards to navigation; the OCMI has a daily plot of activities, weather, and troubles. The Alaska North Slope activities are under the jurisdiction of U.S. Coast Guard Seventeenth District in Juneau.

The principal barge route to Prudhoe Bay from Seattle uses the inland passage, across the Gulf of Alaska/Pacific Ocean, through the Aleutian Islands into the Bering Sea northwards, skirting the Seward Peninsula and entering the Arctic Ocean to Prudhoe Bay. U.S. Coast Guard involvement in environmental impact and protection is limited to regulating harbors and waterway shipping activities to avoid vessel collisions.

Inquiries directed to headquarters Coast Guard personnel have revealed no information on potential barge/bowhead whale conflicts.

The pile foundation which would support the SGCF would be prepared by drilling holes in the permafrost, inserting wooden piles, and filling around the piles with sand. The piles could not be driven through the permafrost. Concrete would be used as an insulator between the modules and the piles to minimize heat transfer from the modules to the permafrost.

The areas between the piles would be filled with gravel. The resulting gravel pad would help distribute the load imposed by the SGCF. It would also provide an insulating blanket to protect the permafrost, since it would be thicker than the thaw depth of the permafrost. The gravel would be gathered from streams, lakes, or rivers. The applicant has not announced any provisions for mitigating the effects of increased siltation which would result from gravel removal. However, one precaution would be to avoid removing gravel from active streambeds.

Gravel would be needed for three major pads: the SGCF pad, the camp pad, and the crude cooling unit pad. The camp pad, which would support the construction camp and operations center, would be located 914 meters from the SGCF, while the crude cooling unit would support the facilities to cool the NGL's from the SGCF before they were blended with the crude oil streams.

In addition to construction convenience, the modular design of the SGCF would allow the entire plant to be totally enclosed and protected from the severe climate. Each module would be installed on the gravel pad and sealed to an adjacent module so that plant personnel would have easy access between modules.

2. Safety and Fire Protection

The modular design of the SGCF, while convenient from construction and operation points of view, presents unique safety problems requiring careful design of safety and fire protection systems. To this end, the applicant has stated that the NFPA Life Safety Code 101 and NFPA Standard 70 National Electric Code would be followed.

For fire protection, the SGCF would be subdivided into fire zones, each enclosed within walls constructed of metal studs covered with gypsum board. These walls would be rated to withstand a 2-hour fire. According to the National Electric Code, the fire zones would be classified as hazardous or nonhazardous. Potential ignition sources such as switches and electric motors would generally be located in nonhazardous areas. Those located in hazardous areas would be sealed and certified explosion-proof. Ventilation systems would maintain higher pressures in nonhazardous zones than in hazardous zones to prevent the migration of flammable or explosive gases into areas containing ignition sources. Differential pressure gauges with alarms would be installed between fire zones to ensure that differential pressure is maintained.

Each fire zone would be protected by a hydrocarbon gas detection system and a fire detection system. The hydrocarbon gas detection system would be composed of primary gas detectors calibrated for methane and secondary detectors calibrated for propane and heavier hydrocarbons. The applicant has not discussed any measures for ethane detection. If a gas sensor detected a gas concentration of 25 percent of the Lower Explosive Limit (LEL), alarms would sound and the ventilation system would double the air circulation rate to help disperse the gas. This would also occur if a propane sensor or a methane sensor detected a gas concentration of 75-percent LEL. It is not known how long the applicant would allow this condition to exist before shutting down to search for the source of the leak. If two or more methane sensors detected a gas concentration of 75-percent LEL, the halon extinguishing/inerting system would be activated, inerting the area where the gas was detected and preventing ignition.

The fire detection system would consist of thermal and ionization (smoke) detectors. Ultraviolet detectors would not be utilized. Activation of an ionization detector would cause alarms to sound and the halon system to discharge. If a thermal detector sensed a temperature of 88°C., the ventilation system would be shut off.

An automatic halon inerting/extinguishing system would be installed in each fire zone. Halon is an odorless and colorless gas which is an effective fire and/or explosion suppressant. It has a low toxicity and will not damage electrical equipment. During an emergency, the halon system could completely inert a fire zone within 10 seconds. The system would discharge automatically if it received a signal from two or more methane detectors and/or a signal from a thermal detector. Manual activation would also be possible.

In most fire situations where Halon 1301 automatic protection systems have been used, the concentrations of HF and HBr have been found to be less than 20 parts per million (ppm), often barely detectable to the nose. The results of severe fire tests have indicated that larger concentrations of HF (200 to 300 ppm) and HBr (40 to 50 ppm) are produced when Halon 1301 decomposes while extinguishing a large, hot fire. Such concentrations are noxious and irritating and may be harmful if exposure is prolonged. The primary effect of the decomposition products is irritation. Irritation becomes severe well in advance of hazardous levels. Test animals exposed to sublethal concentrations of decomposed Halon 1301 appeared to recover completely after exposure. The effects of exposure are not believed to be cumulative. Combustion products of the fire, especially carbon monoxide, generally are potentially more hazardous than the thermal decomposition products of Halon 1301.

To aid in assessing the impact of a Halon dump, an estimated maximum, downwind ground-level concentration was determined, using the box model under the following assumptions:

- A complete dump of 24,000 pounds of Halon.
- Meteorological conditions with a windspeed of 5.45 meters/second and a mixing height of 500 meters.
- A total Halon evacuation time from the modules of 24 hours.

Under the above conditions, a maximum downwind, ground-level concentration of 134 $\mu g/m^3$ was obtained. Based on these results, it is believed that no significant impacts on human health, wildlife, or the surrounding environment would result from a Halon dump.

A firefighting water system would be provided at the SGCF to supplement the halon systems. The water would be stored in a 420,000-gallon storage tank and pumped through a distribution network by two 1,500-gpm pumps to hose stations and connections for mobile pumpers. Hand extinguishers and wheeled dry chemical units would also be provided, along with cart-mounted skids carrying dry chemical and foammaking solution.

In addition to the onsite fire protection systems, agreements have been reached to share firefighting equipment with other facilities on the North Slope.

No information has been submitted describing the training program to be given to plant personnel to acquaint them with the firefighting equipment or techniques for fighting hydrocarbon fires.

A nitrogen generation plant at the SGCF would provide an inert gas for purging air or combustible vapors from equipment during emergencies or maintenance. The generation plant would be a packaged unit which would extract enough nitrogen from the air to purge one CO_2 removal train three times within 24 hours.

3. Other Emergency Systems

To contain the effects of a plant emergency, an emergency shutdown system (ESD) would be installed to allow a full or partial shutdown of the SGCF. Activation of fire or gas detectors would cause an automatic local shutdown. A total ESD could only be activated manually and would block off all flow into, out of, or through the SGCF and vent the appropriate systems to the flare stack.

A hydrocarbon spill containment and disposal system would be provided to direct spills away from process areas and dispose of them safely. Ramps would be provided at doorways to prevent the spilled liquid from migrating between modules.

A drain sump would be provided in each fire zone to collect all spills. A sump pump would automatically send the spilled hydrocarbons to the slop oil system via an open drain system which would be designed for hydrocarbon and water rates of 525 gpm. A closed hydrocarbon drain system would be provided to contain equipment drainage during operation and/or maintenance. Vapors from this system would be vented to the low pressure flare, and liquid would be pumped to the slop oil tank. There, the water would be separated, some of the hydrocarbons would be recycled to the deethanizer, and the rest would be disposed of. The method of disposal is unknown.

All joints between the wall and floor around the perimeter of each module would be sealed with a caulking compound to provide a liquid-tight seal.

4. Vent and Flare System

Two relief systems would be provided at the SGCF. A high pressure system would provide relief for all loads greater than 200 psig; a low pressure system would be provided for loads under 200 psig. The flare would be located north of the plant, while the burning area would be over a lake. The prevailing winds would direct the flare away from the plant. A 40-acre area would be provided to dissipate radiation from the flare. A constant flow of low Btu "sweep" gas would keep the flare system purged, and high Btu pilot gas would keep the flare burning during normal plant operations. Approximately 250 Mcf of gas per day would be needed for this operation.

A cursory analysis was performed on the potential impact of the flare. It is estimated that downwind concentrations of the total plume emissions (including water vapor, CO, CO_2, HC, NO_x, SO_x, etc.) could reach as high as 7,176 mg/m^3. However, most of the plume at this point would consist of water vapor and CO_2. Only a relatively small percentage of the total plume is made up of the criteria pollutants. At this time, it is impossible to determine the exact concentrations of the criteria pollutants, because the makeup of the gas that will be flared is unknown. Further analysis should be performed once the constituents of the feed gas are known and the emission rates of the criteria pollutants can be established.

The area where the flare would burn would be enclosed with a gravel berm to contain any liquid hydrocarbons which might drip from the flare tip. A radiation fence would be mounted on the berm.

5. Electrical Power

Three 25.9-megawatt (MW) gas turbine generators would be provided at the SGCF. Two would supply the plant's electricity requirements; one would be a reserve. The maximum continuous load on the generators would be 45.8 MW during the summer. The maximum winter load would be about 40 MW, because half of the air coolers would be shut down. At various points in the gas conditioning process, power would be recovered by installing generators driven either by hydraulic turbines using solvent letdown or by expander turbines using stripping gas letdown. In this way, approximately 12 MW of power would be recovered.

Emergency power would be provided by four of the 2.5-MW gas turbine generators used during construction. They could be operated with field fuel gas or diesel oil and would provide power for lighting, instrumentation, and fire protection. There is considerable excess capacity in the emergency system, since 10 MW are available but only 2.3 MW are required for the emergency systems. A battery system would supply electricity if the emergency generators failed to start. The batteries would be able to power lights, instrumentation, communication, and fire detection systems for about 30 minutes.

6. Operation

Normal SGCF operations would be controlled from a central control room. Local control rooms would also be provided to monitor and control specific process equipment during startup and shutdown. Enough instrumentation would be provided in the local control rooms to allow an operator to sustain steady state operations for a short time during power outages. In addition to the necessary instrumentation, monitors, and controllers to maintain normal operations, the central control room would have indicators for monitoring the smoke, gas, and thermal sensors, controls for the ESD and ordinary shutdown systems, alarm indicators and controls, and the centralized communications and data transmission system. No detailed design of the control system has been done at this time. Neither operating procedures nor maintenance schedules and procedures have been developed.

Potable and utility water for the SGCF would be brought in by tank truck from the existing water treatment plant at the operations center. Expansion of the treatment plant would not be necessary to serve the SGCF; however, it would be necessary to expand the gathering system. An additional water intake at the Put River would be necessary and the existing water reservoir would have to be expanded by about 305,824 cubic meters, to a total capacity of 1,500,000 barrels. Water is usually pumped from the Put River throughout the summer to replenish the reservoir. The applicant has not discussed how the 305,824 cubic meters of dredge material will be handled, nor the measures to be taken to avoid any effects on the permafrost from dredging.

To house plant and support personnel, an operations center would be constructed about 914 meters from the SGCF. Approximately 200 persons could be housed in these facilities. Construction would be accomplished by modular techniques; however, steel piles would be used instead of the wooden piles used for the SGCF, and a 2.13-meter (7-foot) open air space would be provided between the module and the gravel pad. A fire station would be provided at the operations facility, as well as an ambulance, two fire trucks, and a rescue truck.

Solid waste would be burned in an incinerator large enough to accommodate the waste from 1,500 workers. Collection trucks would dump waste inside the building to prevent wind-blown trash from being scattered in the tundra. A waste treatment plant would be provided at the operations center. It would have a capacity of 150,000 gallons per day, which would be treated by an activated biofilter process followed by tertiary filtration. Sludge would be processed by centrifuge and filter press before being incinerated. The effluent would be chlorinated and pumped to a disposal lake. No information is presently available on construction of the lake or its effects on permafrost.

Two 6,000-gallon utility water drums would be provided to supply enough water to serve plant personnel for 1 week. A chlorinator would be provided as part of the system, and periodic laboratory analyses would be performed to determine the necessary rate of chlorination. A vacuum-assisted collection system would direct all sanitary waste into a collection tank. It would be periodically trucked away to a sanitary landfill near the Sag River.

Internal communications would include a sound-powered telephone system which would require no external power source and is ideally suited for maintenance, construction, operation, or emergency situations when power is unavailable. A conventional telephone system would also be provided, as would a paging system. A separate telephone system would be provided for offsite communication. Transmission on this system would be via microwave. All fire alarms would be connected to this system. External communication systems would also include a low-powered radio system to contact persons not otherwise accessible.

The principal gaseous pollutants that may cause odor emissions from a typical SGCF are hydrocarbons, hydrogen sulfide, and mercaptans. Odor can be minimized in a number of ways, including good housekeeping procedures and maintenance checks of all process equipment. Under normal operating conditions, a constant low Btu (CO_2 enriched) sweep gas would be flared at the proposed plant's flare system. If overpressurization or malfunction of process vessels should occur, all hydrocarbon vapors would be discharged through the emergency flare system. The expected hydrocarbon emissions from the low Btu sweep gas and hydrocarbon vapors generated during an emergency shutdown would have little adverse impact upon the existing air quality.

E. UNAVOIDABLE ADVERSE IMPACTS

Implementation of the proposed project would result in several unavoidable adverse changes in environmental quality during the construction and operation of the SGCF. During construction, there would be a temporary increase in dust and noise levels resulting from vehicle traffic and construction activities in the Prudhoe Bay area. There would be some localized degradation of air quality during operation of the facility, but the regional aggregate impact on air quality will be small.

The onshore construction would result in minimal loss of wildlife habitat. Significant shifts in species composition and distribution can occur through habitat alteration. Offshore construction would result in adverse impacts that would affect existing physical and chemical patterns, resulting in impacts to nearshore biological producitivity. As a result of the continuing industrial development and increased human presence in the Prudhoe Bay area, a further reduction in wildlife population may occur in the immediate vicinity of the Prudhoe Bay site. Further reduction of any wildlife populations utilized by the residents of the area would produce the unavoidable effect of further eroding the subsistence lifestyle.

During the construction of any offshore facilities, bottom sediments would be resuspended, resulting in a short-term increase in turbidity, and these suspended sediments would have a minor effect on long-term water quality. If the Put River would be used as the source for gravel requirements, then the proposed project would cause the continuation of the degradation of the hydrologic features of this river.

Unavoidable impacts on land and present land use would be minimal since many of the roads, gravel pits, airfields, and other existing facilities in the Prudhoe Bay/Deadhorse area would be used for construction of the SGCF and most of the new land impacts would be contained within the existing industrial enclave.

The North Slope haul road is expected to be open to the public sometime after the ANGTS has been completed. When this occurs, sport hunters and fishermen may be encouraged to hunt and fish in the area, putting them in competition with many of the Natives who are true subsistence food gatherers. As Prudhoe Bay development continues, as evidenced by TAPS construction and the proposed construction of the SGCF in connection with the ANGTS, the lifestyle of the Native residents may be affected. The subsistence lifestyle may gradually be replaced (especially among those in the younger generation) by a lifestyle dependent on cash and commercially available foods.

Further degradation to the wilderness qualities within and adjacent to the Prudhoe Bay are unavoidable should the proposal be implemented. Since the proposed SGCF would be located near an existing industrial facility, the impact would be minimal.

Unavoidable damage may occur when historic sites are not preserved or are not identified in time to take action for their preservation. Onshore archaeological sites or artifacts may not be detected with total certainty by surveyors. Those which remain undiscovered may be damaged or destroyed partially or wholly if construction occurs.

The proposed construction of the SGCF involves the barging of prefabricated modules from west coast fabrication site(s) to the Prudhoe Bay site. This would cause an increase in barge traffic in the Pacific, Bering, Chukchi, and Beaufort ocean waters. The number of barge arrivals at Prudhoe Bay could range from 2 to 25 over a 2-to 3-year period, depending on whether a full capacity or phased start is initiated. Barge traffic may utilize a transportation route along the North Slope during the time of several marine mammal migrations. At the present time, it is impossible to identify unavoidable effects as a result of this activity on the marine mammal populations.

F. THE RELATIONSHIP BETWEEN THE LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

In the short term, the gas conditioning plant is not expected to produce any adverse environmental effects which cannot be effectively minimized. To date, the concerns of North Slope citizens have focused on the incremental expansion of the Prudhoe facilities as well as any future expansion of petrochemical operations. However, any expansion of the proposed facility will take place only after environmental acceptability of the project has been demonstrated and after the appropriate permits are obtained from the state and Federal governments. The state will also review and approve operating permits every 5 years. Some of the Federal permits, such as the NPDES permit, also requires review and renewal every 5 years. These procedures are designed to protect and enhance the long-term productivity of the environment. They will also allow local planners, citizens, and other decisionmakers the opportunity to determine the extent and degree of growth that will or will not take place.

G. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The principal natural resource which would be irretrievably lost because of the proposed action would be the land on ? which the facility is built. The tundra covering the 200 acres of the SGCF site and the construction camp would also be lost. Removal of this vegetative cover and the active layer of permafrost, following the installation of the gravel pads, would destroy the habitat of small mammals and birds which could occupy the area.

The project would commit large amounts of renewable and nonrenewable resources. Substantial amounts of labor, energy, gravel, cement, steel, and other construction materials would be irretrievably committed to the proposed use. Construction of the conditioning facility is an irreversible action, since it is unlikely that the facility would be removed. why not? ??

Important fossil fuel resources would also be irretrievably lost. The development and consumption of these large gas reserves would constitute a significant depletion of this nation's nonrenewable hydrocarbon resources which, of course would not be available as a primary oil recovery medium.

no, used. It is only lost, if unused.

H. ALTERNATIVES TO THE PROPOSED ACTION

This section discusses alternative siting of the SGCF, alternative pipeline pressure, and alternative process designs. Other considerations such as (1) alternative pipeline routes, (2) alternative gas transportation modes and systems, (3) alternative sources of energy, (4) energy conservation, and (5) the alternative of no action were previously addressed in the FEIS's prepared by the Federal Power Commission and the U.S. Department of the Interior issued in April 1976 and March 1976, respectively; they are adopted by reference. 1/

1. Alternative Site Criteria

In an effort to determine the most suitable SGCF location from environmental, engineering, and economic standpoints, the staff conducted a multiphased site-selection analysis. Certain physical requirements for continued operation of the proposed project, combined with environmental and safety concerns, were used to formulate several criteria for analyzing each specific alternate site. An ideal site would meet or exceed all these requirements; however, the possibility of locating such a site is remote. Therefore, the most suitable gas conditioning site would be one whose physical characteristics correspond most closely to the criteria.

a) Location

To maximize economic feasibility and minimize the environmental disruptions associated with the construction and operation of a gas conditioning facility, a proposed site should be located as close as possible to the source(s) of unconditioned gas. It should also be located in the vicinity of an existing or potential end user of Alaskan royalty gas, NGL's, and crude oil so that the state can utilize its hydrocarbon products most efficiently.

1/ Federal Power Commission, Alaska Gas Transportation System: FEIS (Washington, D.C., April 1976).

U.S. Department of the Interior, Alaska Natural Gas Transportation System: FEIS (Washington, D.C., March 29, 1976).

The facility would ideally be located adjacent to a large body of water so that large oceangoing barges could transport construction materials to the site. Large-scale docking facilities capable of loading and unloading these barges should already exist or be capable of being modified to meet project needs. If barging construction materials is not feasible, an adequate combination of air and rail facilities and highways must be located within the vicinity of the site.

b) Topographic and Seismic Conditions

To minimize preconstruction site preparation, the site should have few topographic irregularities such as hills, valleys, or terraces so that extensive site preparation is unnecessary. Sites which would require excavation into the bases of mountains or leveling large topographic irregularities would necessitate hauling large quantities of spoil material and developing spoil disposal sites. This would increase cost as well as the potential for additional adverse impact.

The slope of the site should be minimal but sufficient to permit adequate drainage. Construction on poorly drained sites could increase the potential disruption to the active layer of the permafrost.

The plant site should not be located on or adjacent to any fault zones which could jeopardize the structural integrity of the facility by ground movements or other events which could accompany a major seismic disturbance.

The site should not have a potential for extensive shoreline damage from tsunamis. Areas with past histories of shoreline damage could pose a threat to a gas conditioning and storage facility. The site should be well above the elevated water levels resulting from major storm tides, river flooding, or tsunamis.

c) Foundation Conditions

Foundation conditions at the proposed site should provide adequate stability during both static and dynamic loading. Soils in the continuous and discontinuous permafrost regions should be dense and granular to provide strength and resist settlement. The soils should not be susceptible to liquefaction caused by rainfall, subsurface water movement, or seismic events. If bedrock is present, it should be relatively close to the surface in order to preclude high tension pile loads, but at a sufficient depth to avoid interference with site preparation.

d) Climatic Conditions

The plant site should be sited in an area which is conducive to safe and economical year-round operation with minimum downtime resulting from major adverse climatic conditions. Winds exceeding a velocity of 50 knots should occur infrequently and only for brief periods. Reduced visibility from ice fog and/or precipitation should also be infrequent and minimal. Extended or frequent periods of reduced visibility could reduce the efficiency of plant operations.

e) Land Use Conflicts

The site should not be located where conflicts would arise between operation of the proposed project and existing, planned, or potential land uses on or near the site. These potential conflicts include residential-, commercial-, recreation-, or conservation-oriented activities.

f) Air Quality

All estimated air emissions at the site should meet EPA and state air pollution standards. The atmospheric dispersion of all air pollutant emissions should preferably not cause an air quality control region to violate Federal or state air pollution standards nor exacerbate existing air pollution in a nonattainment area. In cases where nonattainment of the standards occurs, air pollution trade-offs will be required. Meteorologic and topographic characteristics of the site should promote good air pollutant dispersion.

g) Noise Quality

Noise levels are a function of the numbers and types of equipment being used, the operations being performed, and the size of both the construction and operating areas. Noise levels should attenuate to ambient levels within several hundred feet of the facilities or within the confines of the site.

2. Initial Alternate SGCF Sites

After a regional overview of Alaska and portions of Canada in conjunction with discussions with the State of Alaska staff and other experts familiar with the Alaska and Canadian environs, the following six sites were initially chosen for alternative siting analysis: (1) Fairbanks, Alaska, (2) TAPS Yukon River Crossing, Alaska, (3) Tok, Alaska, (4) Haines, Alaska, (5) Whitehorse, Canada, and (6) Haines Junction, Canada. (See figure 20.)

The primary engineering factor limiting selection of the SGCF site is the preliminary selection of a 1,260-psig (with possible later modification to 1,440 psig) pipeline system by the Alaska Gas Project Office (AGPO) of the FERC. Hydrocarbon dewpoint calculations generated by Arco, Exxon, and SOHIO have shown that a 1,260-psig pipeline system requires that most heavier molecular-weight hydrocarbons must be removed from the unconditioned gas stream at Prudhoe Bay. All lower molecular weight hydrocarbons (C_1 - C_3 fractions) would then be blended into the pipeline gas, while the heavier molecular weight portions (C_4's - C_5's) would be blended into TAPS for transport to Valdez. Thus, if the 1,260-psig system is adopted by FERC and the gas transporters, none of the six alternative sites would be feasible from an engineering standpoint.

Even if a higher pressure pipeline system were adopted--e.g., a 1,680-psig system--an alternative site must still be located within the vicinity of an existing or sincere potential end user of Alaskan royalty gas, NGL's, and crude oil. At present, none of the six identified alternatives meet this criteria, with the possible exceptions of Fairbanks and the TAPS Yukon River Crossing site, which would require a separate NGL pipeline to Fairbanks. A point of note here is that the State of Alaska specifically requested the FERC staff to examine these two sites.

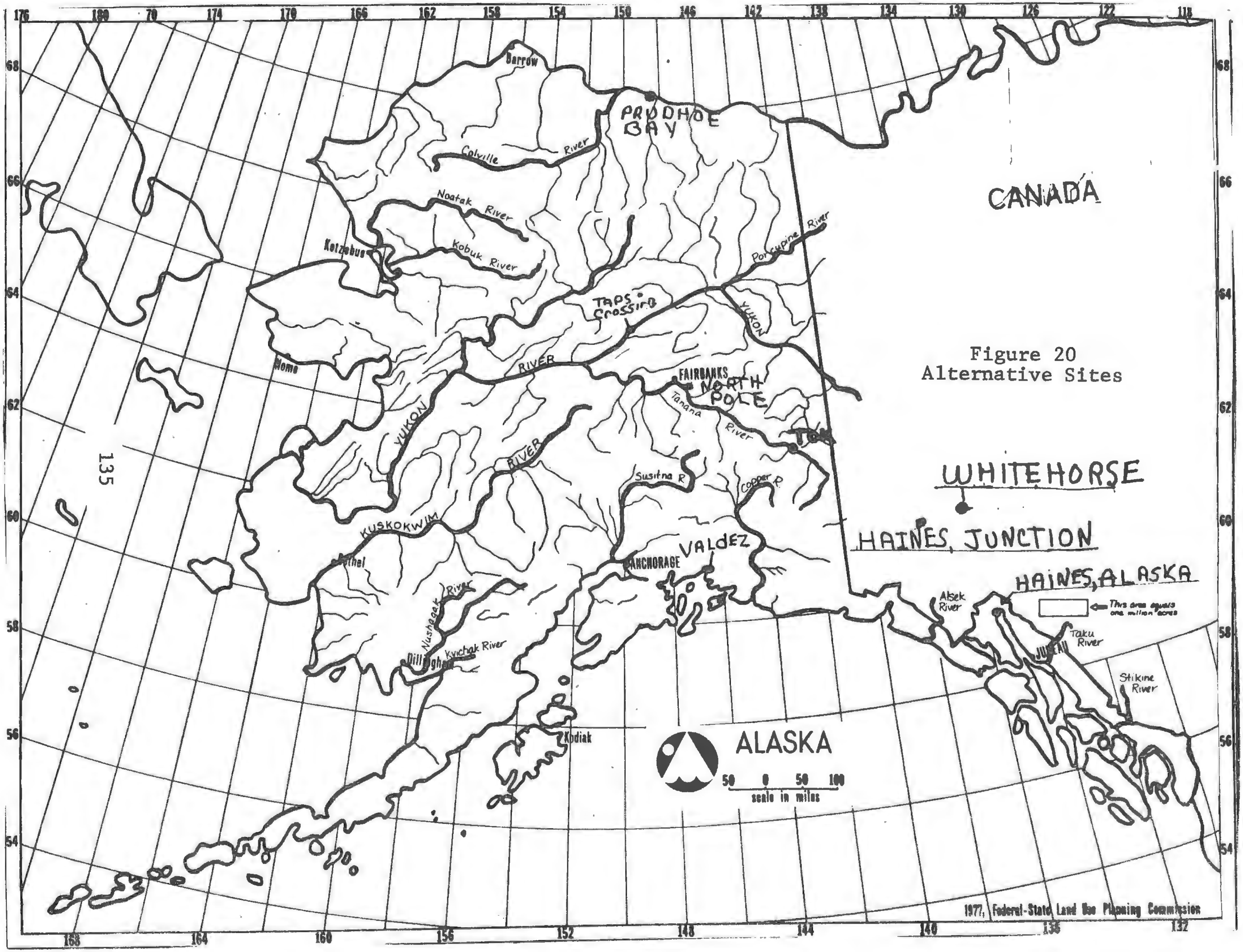

Figure 20
Alternative Sites

Another disadvantage of the Tok and the two Canadian alternatives is the absence of either barge transportation or other adequate transportation network to carry construction material and personnel to the sites. Although Haines would have barge transportation available, it would require construction of an additional 161 km.(100 miles) of pipeline from the Northwest Alaskan system, a considerable economic and environmental expense.

3. Analysis of Retained Alternate Sites

a) Fairbanks

Construction of a gas conditioning facility at Fairbanks or in the surrounding vicinity would require all construction materials and process equipment to be transported to the site by railcar or truck. Although barging of construction materials is not feasible, an excellent transportation network consisting of air/rail/highway presently exists in the Fairbanks area. In addition, the Fairbanks area is in close proximity to the Northwest Alaskan pipeline system. The method of transportation would dictate the size and number of vehicles required. The Fairbanks alternative would require subarctic construction techniques and completely enclosed process equipment for safe and efficient year-round operation. A Fairbanks alternative would require construction of at least a 1,680-psig pipeline system from Prudhoe Bay to the proposed alternate site.

Four specific sites southeast of Fairbanks were initially screened. Three of these were identified by the State of Alaska, while the fourth was selected by the FERC staff. (See figure 21.) The fourth site, also southeast of Fairbanks, has all the appropriate merits of the state's selections, with the advantage of being located within a parcel of land previously zoned for industrial development. In addition, an existing "topping" plant which could be expanded to utilize the NGL's and ethane as a feedstock is located here. An environmental impact statement has been issued for this topping plant. 1/ For these reasons, only the fourth site

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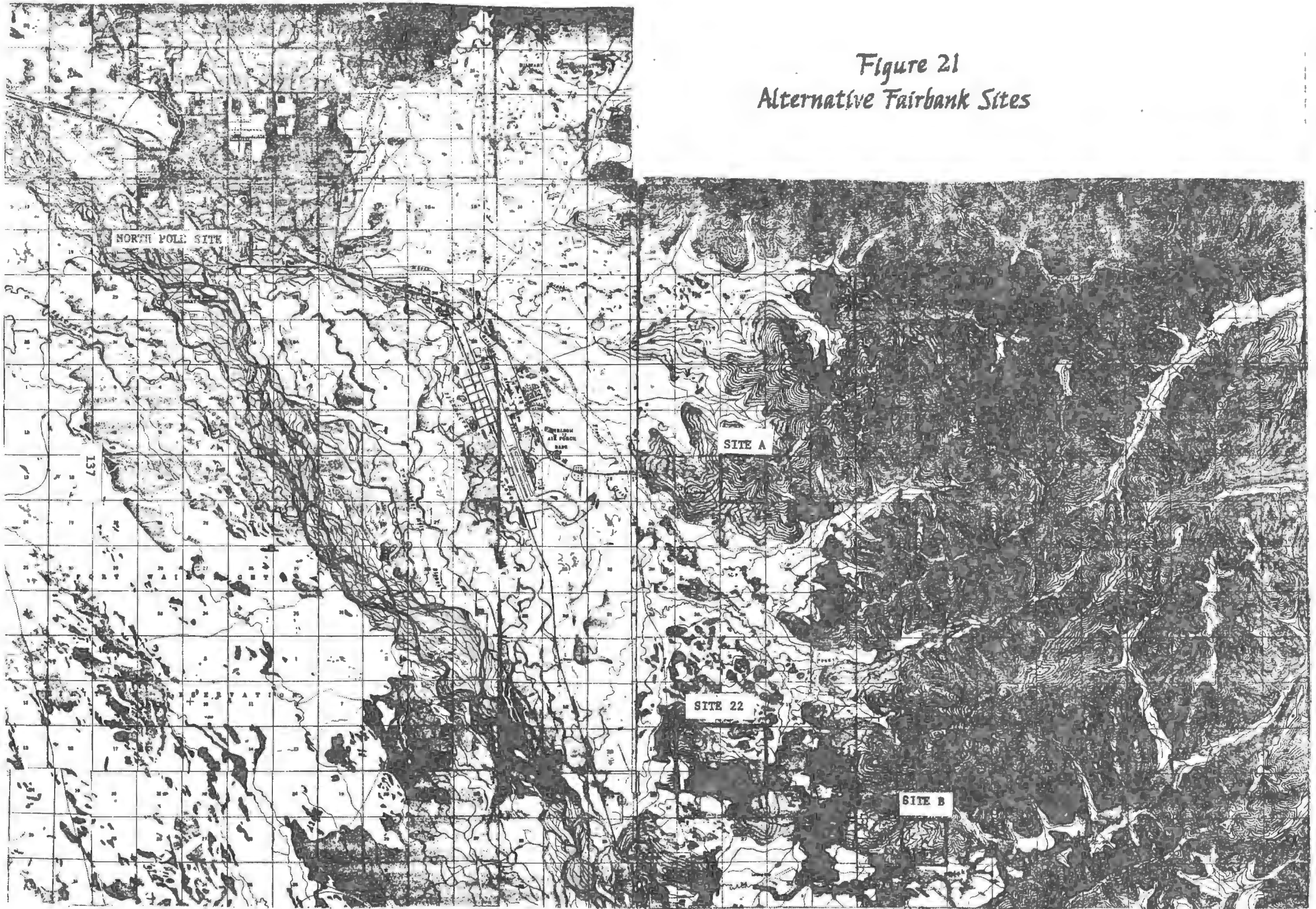
1/ Environmental Protection Agency Region X, Final Environmental Impact Statement: Energy Company of Alaska Topping Plant, North Pole, Alaska, Seattle, 1976. This EIS would probably have to be supplemented should the plant be expanded.

Figure 21
Alternative Fairbank Sites



(commonly called the North Pole site) will be examined in further detail in this environmental analysis. (See figure 22.) A significant disadvantage of this site is that it has been redesignated in February 1979 as being in a nonattainment area for carbon monoxide pollutants.

i. North Pole Site

Climate

The Fairbanks area, including the North Pole alternative site, has a continental climate. The sun is above the horizon from 18 to 21 hours each day during the months of June and July. During this period, daily average maximum temperatures reach the lower 70's. Temperatures of 27°C. or higher occur on about 10 days each summer, and extreme highs of 32°C. or more occur during the months of May through August. Conversely, during the period from November to March, when the period of sunshine ranges from 10 hours to less than 4 hours per day, the lowest temperature readings are below -18°C. Extreme temperatures of -40°C. and colder occur, on the average, only 14 days each winter. Extremes of near or below -51°C. have occurred during the three midwinter months.

Fairbanks is a semiarid area, with a normal annual precipitation of approximately 30.5 cm. Precipitation is highest during the months of June, July, and August. The highest precipitation normally occurs during August (7.6 cm). Snow appears almost year-round. July is the only month for which snowfall has not been reported. Snowfalls of 10 cm. or more in a day occur only three times during an average winter, and blizzard conditions are extremely rare. There is a noticeable decline in precipitation from September through November. The lowest monthly average precipitation occurs during April, the month with the largest percentage of sunshine.

Ice fog occurs frequently during the winter months and can occur any time from late November through March. Ice fog occurs as a result of introducing water vapor into a stagnant atmosphere sufficiently cold (lower than -23°C.) to cause extremely rapid condensation, cooling, and freezing. It is the direct result of urbanization in cold regions, since the major sources of water vapor are stationary combustion

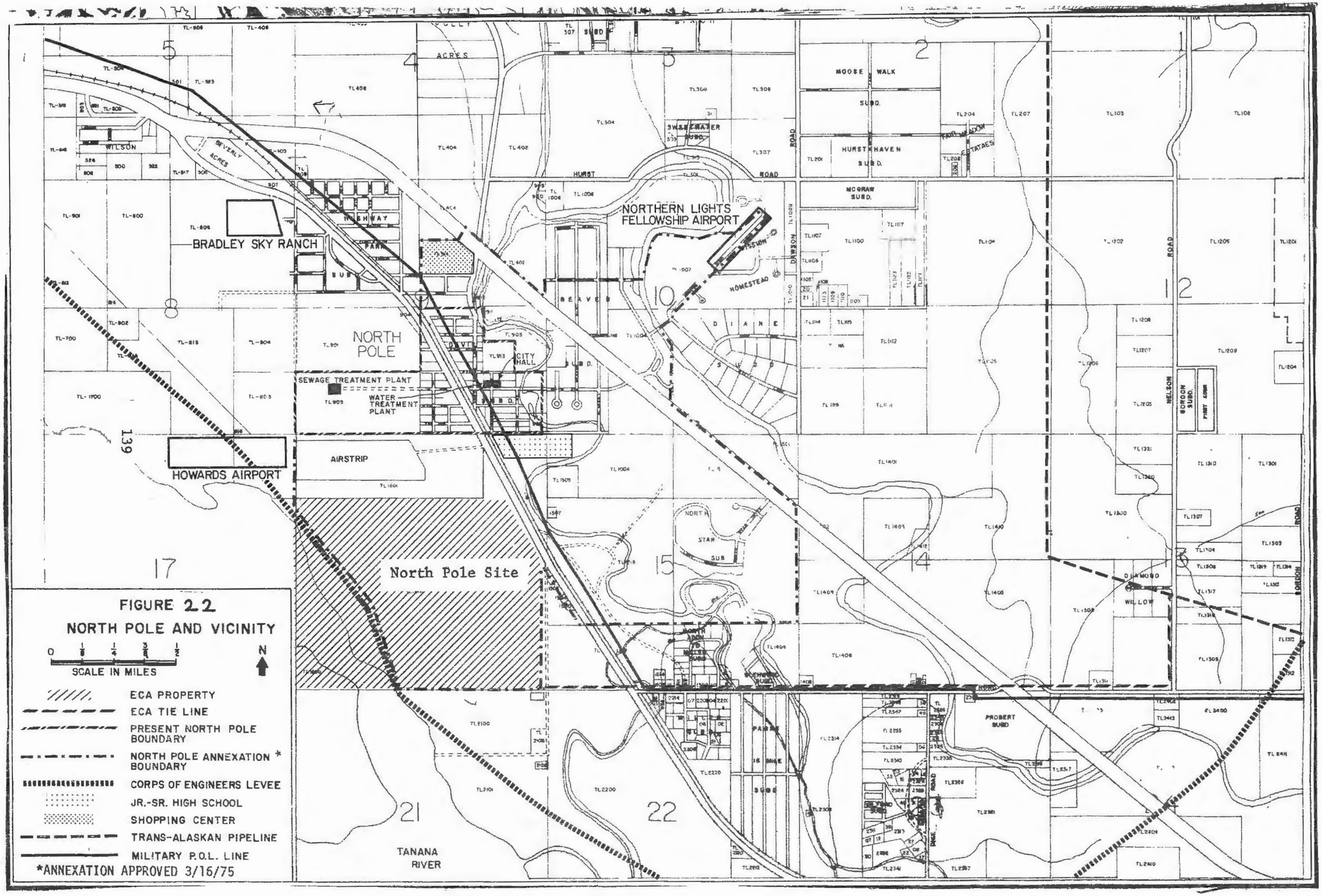


FIGURE 22
NORTH POLE AND VICINITY

processes (home heating, power plant stacks), open water surfaces, and vehicular exhaust. In Fairbanks, the depth of the ice fog layer is usually less than 91 meters (300 feet), but it has been observed as deep as 182 meters during prolonged cold periods. Exhaust plumes from power plants normally create minimal surface ice fog.

Ordinarily, air cools at higher altitude and moves horizontally and vertically. The resulting turbulence mixes and clears the air. In cold, snow-covered areas, however, radiation from the earth's surface cools the air by natural convection, reversing the gradient from cold to warm. This reversal creates an inversion and limits mixing within the lower atmosphere. The inversion and ice fog become thicker as the extreme cold continues.

When warm exhaust gases are discharged into the air, the air may cool 150°C. in a few seconds. Many small ice crystals (10 microns) form, creating serious visibility problems. Once these crystals form, they act as heat sinks from which convective heat is radiated faster from the surrounding air.

Three major factors in the Fairbanks area cause ice fog to disappear. The first is horizontal transport winds, generally stronger than 7 knots. The second is warmer temperatures, which may or may not be associated with strong winds. A third major factor in eliminating or preventing ice fog is the onset of snow, which combines warmer temperatures with cloud cover. The cloud cover helps reduce radiation from the top of the ice fog layer, thus preventing growth of the layer. (See figure 23.)

The impacts that can be expected as a consequence of the construction and operation of the proposed facility on this alternative site are similar to the impacts to be expected from the construction of the facility on the preferred site at Prudhoe Bay. The only dissimilar projected impact would be a possible increase in the severity of the ice fog phenomenon. As previously mentioned, the occurrence of ice fog in the Prudhoe Bay area is minimal, primarily because of the constant winds at that location. However, this is not the case in the Fairbanks area. Low-lying areas near Fairbanks can experience long periods (up to 1 week) of ice fog conditions when the temperatures are below -32°C. and the meteorological conditions are stable. Construction of the

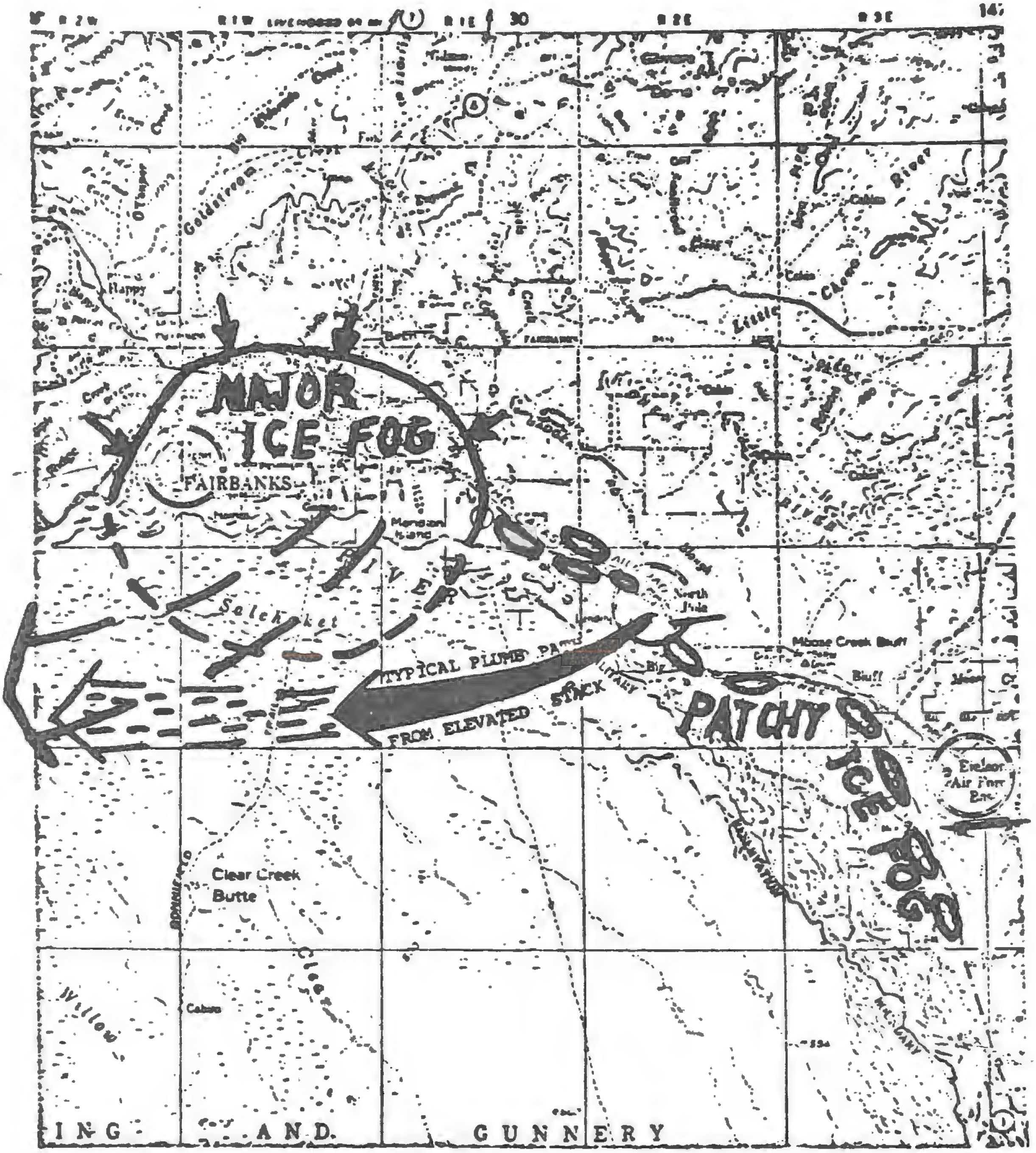


Figure 23: Typical Patterns of Light Surface Airflow During Extended Ice Fog Periods and Associated Plume Path From an Elevated Stack Source Near North Pole, Alaska.

proposed facility in a low-lying area in the vicinity of Fairbanks would aggravate the ice fog problem in the affected region. The construction of the facility would increase the severity but not the duration of ice fog episodes, because the duration is a function of ambient temperature and stability and most construction is expected to take place during the summer months. It is conceivable, and in fact quite probable, that the operation of the facility would add to the overall severity of the ice fog episodes in terms of increased concentration and extent (physical boundaries).

Topography

The North Pole site is located within Section 16 of T2S, R2E Fairbanks Base Line in the Tanana-Kuskokwim Lowland section of the Intermontane Uplands and Lowlands physiographic division. It is within the floodplains of the Tanana and Chena rivers at an elevation between 145 and 152 meters. There is very little relief on the site, and the average slope is less than 4 meters per kilometer. The topography surrounding the North Pole site is identified in figure 24.

Only very minor impact would be expected at this site. Because it is nearly level, there should be no need for cut-and-fill, and the general absence of permafrost should reduce the need for the extensive foundation preparation required at the Prudhoe Bay and Yukon River sites.

Because of the proximity of the Tanana River and the existence of a commercial water supply, no reservoir would be required. Some wastewater treatment facility would certainly be necessary because of the limited capacity of existing facilities; however, such a facility would not require a wastewater lagoon.

The North Pole site, which is within the Tanana lowland of the Tanana River basin, is also within the floodplain of that river. The floodplain has been strongly influenced by the very large coalescing alluvial fans to the south and by the hills bordering the lowland to the north. The alluvial fans are formed of sediments carried north from the Alaska Range by tributaries to the Tanana.

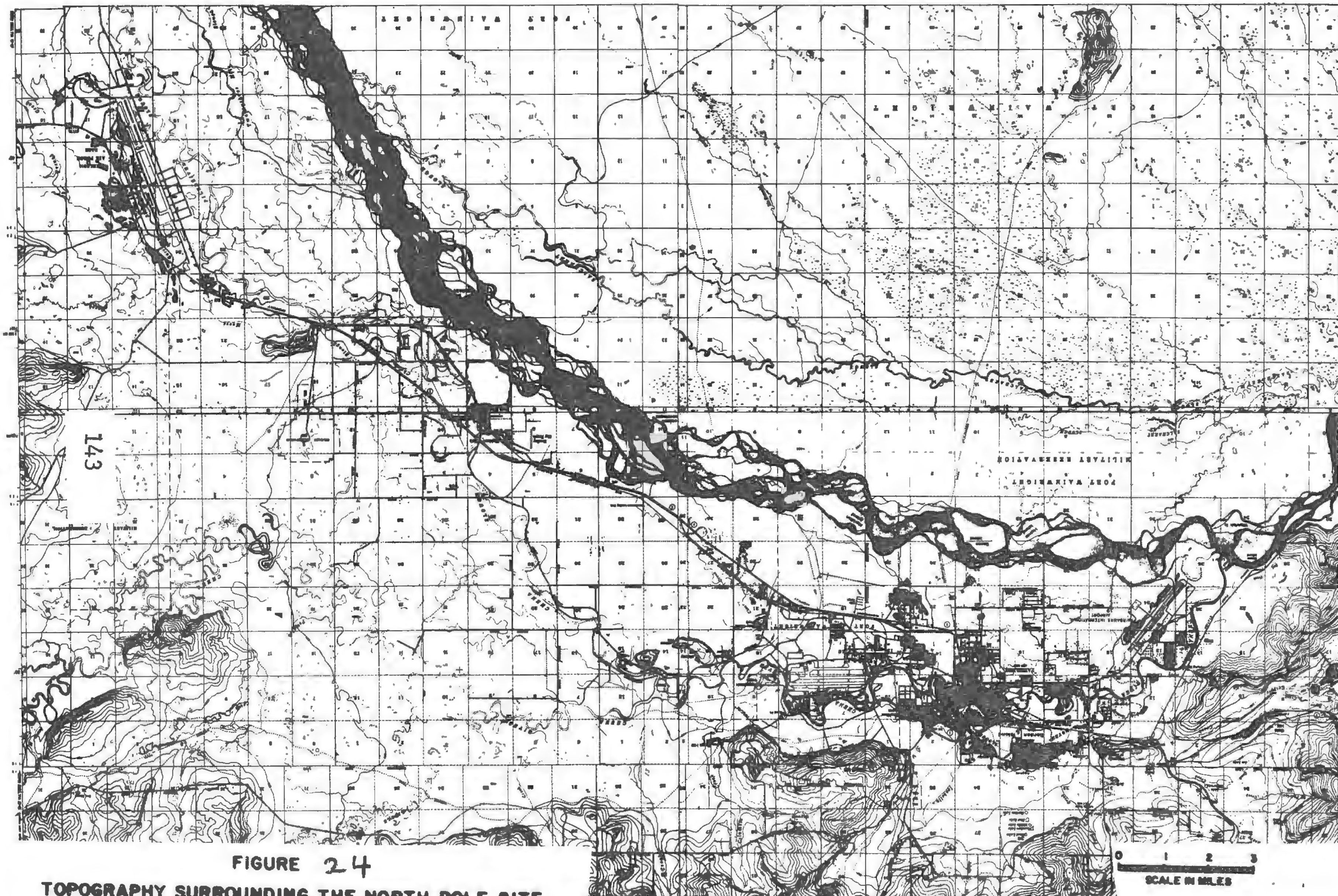


FIGURE 24

TOPOGRAPHY SURROUNDING THE NORTH POLE SITE

map upside down —

Although the North Pole area was not glaciated during the Pleistocene Epoch (roughly the last 2 million years), most of the floodplain deposits are derived from glaciated areas. Outwash deposits of gravel and sand are as much as 200 meters thick near the river. This coarse material is commonly covered by 0.3 to 7 meters of alluvial sand and silt within which the present soil profile has formed.

This site is within the discontinuous permafrost zone. Because of the proximity of the Tanana and Chena Rivers and the nature of the onsite soils and geologic materials, most of the site should be free of permafrost. Those areas where minor stream channels and sloughs have existed contain more fine-grained material, are more poorly drained and would be more likely to contain permafrost. Permafrost occurred in about 25 percent of the borings made during the planning for the existing facilities near the site, resulting in a revision of the facility locations.

There are no known major faults in the immediate vicinity of this site; however, the Fairbanks area in which this site is located is one of high seismicity. The largest recorded event in the site area occurred in October 1947 and registered 7.4 on the Richter scale. The Modified Mercalli Intensity assigned to this event, which has a mean recurrence rate of about 40 years, was VIII. The maximum projected intensity for this area is IX-X, which would correspond to considerable damage in specially designed structures.

Selecting this site would have minor impact on erosion, siltation, geologic resources, and permafrost. The onsite soils are not very susceptible to erosion and that fact, coupled with the very low relief of the site, reduces the potential for erosion and subsequent siltation to a minimum.

Because of the general absence of permafrost on the site, the extensive foundation preparation necessary at Prudhoe Bay would not be required here. While a certain amount of gravel would still be required, it would probably be an order of magnitude less and would be readily available. Some material could probably be obtained onsite.

The permafrost at this site, where it exists, is not ice-rich; therefore, degradation of the permafrost should not cause subsidence. If large patches of permafrost thawed, problems could be avoided by design measures or by intentionally thawing the permafrost before construction. Neither approach would result in significant impact.

Although a number of soil types have been mapped within the floodplain of the Tanana River, only three are present on this site. About 90 percent of the site is covered by the well-drained, sandy Salchaket soils, with the poorly drained Bradway and imperfectly drained Tanana soils comprising about 10 and 1 percent, respectively.

The Salchaket soil is a very fine sandy loam generally grading from ML within the upper 0.3 meter to SM or ML within the next 0.3 meter and then underlain by GP or SP. In other words, there is a general increase in grain size with depth. The seasonably high water table is 3 to 5 meters below the surface, with permafrost at a depth of at least 5 meters, if present at all. Alluvial gravels are generally 0.3 to 2 meters below the surface. This soil is generally suitable to build on.

The Bradway soil is a poorly drained very fine sandy loam occupying old stream channels--two of which cross the site. The upper 5 cm. has a high organic content and is classified OL; the rest is classified ML. The high water level is generally 0.3 meter below the surface. Permafrost may be at a depth of 1 meter, and alluvial gravels are more than 2 meters below the surface. The high water table and permafrost are the primary adverse engineering features of this soil.

Soils within the area affected by construction would be removed from the site, and structures would occupy the cleared space. Obviously, this area could not be used for agriculture during the life of the facility and for an extended period thereafter, because topsoil would have to be replaced after removal of the facilities. Construction of a feeder pipeline from the Northwest Alaskan pipeline to the site would reduce the fertility of the soil above the pipeline trench and within the right-of-way. However, existing rights-of-way could probably be utilized, thereby reducing the additional impact of this project.

Because these soils are not very susceptible to erosion, only minimal impact of this kind would be expected.

Hydrology

The Tanana River originates in the mountainous regions near the Canadian border and flows generally west and north to its confluence with the Yukon River. Most of the Tanana River's largest tributaries from the south drain glacial meltwaters from the Alaska Range and, consequently, carry high silt loads. Streams entering from the unglaciated north are generally cleaner. Major tributaries of the Tanana include the Chisana, Nebesua, Salcha, Chena, Nenana, and Kantishna. As the Tanana River flows past the proposed site, it is a wide, heavily braided stream. The annual streamflow pattern of the Tanana River basin consists of high flows during May through September and minimum flows during the winter.

According to USGS records, the Tanana's average discharge at Nenana is 24,350 cfs. The 10-year (1963-1972) maximum peak discharge was 186,000 cfs, and the minimum daily discharge observed during this same period was 4,800 cfs. At Nenana, the Tanana drains approximately 27,500 square miles, which is approximately 7,000 square miles more than it drains at the proposed site. Mean annual runoff rates average about 0.5 to 1.0 cubic feet per second per square mile (cfsm) in the lowlands and basins north of the Tanana River, and approximately 1 cfsm to more than 4 cfsm in the upland regions in the Alaska Range.

Flood flows of the Tanana River in the vicinity of the proposed site are controlled by the Tanana-Chena Levee. Based on the levee design specifications, floods overflowing the proposed site would be expected to occur no more than once every 200 years.

Studies conducted by EPA and the Arctic Environmental Research Laboratory during February 1975 showed the water quality to be very good in the Tanana River. Sulfides, phenols, and oil and grease were at or below detectable levels. The dissolved oxygen concentration was 14 mg/l at 0°C. The chemical analysis results for the samples taken during these two winters are presented in tables 18 and 19. The results of hydrological studies near the North Pole

TABLE 18. WATER QUALITY OF THE TANANA RIVER NEAR NORTH POLE, ALASKA

	T-900[a]		T-800[b]	
	Range	Average[c]	Range	Average[c]
Total solids (mg/l)	180-200	194	180-200	190
Total volatile solids (mg/l)	60-110	87	64-120	84
Total suspended solids (mg/l)	3-6	4.2	3-5	3.4
Volatile suspended solids (mg/l)	1	1	1	1
pH	6.7-7.4	7.2	7.3-7.7	7.5
Turbidity (JTU)	2.0-3.3	2.4	2.2-3.3	2.6
Conductivity (umhos)	220-291	244	220-275	246
COD (mg/l)	1-6	5.6	1-8	4.0
Cl (mg/l)	1.7-2.0	1.8	1.7-3.4	2.3
Ca (mg/l)	42	42	42	42
Ag (mg/l)	<0.01	<0.01	<0.01	<0.01
Hg (ppb)	<0.1	<0.1	<0.1	<0.1
Na (mg/l)	3.8-4.0	3.9	3.8-4.0	3.9
Mg (mg/l)	14-15	14.8	13-15	14.2
K (mg/l)	2.0-2.1	2.1	1.9-2.1	2.0
Cu (mg/l)	<0.01	<0.01	<0.01	<0.01
Total carbon (mg/l)	27-30	28.8	27-31	29.2
Total organic carbon (mg/l)	15-25	21.2	15-26	22.0
NH_3-N (mg/l)	0.01	0.01	0.02-0.05	0.03
NO_3 (mg/l)	0.08-0.19	0.14	0.10-0.18	0.13
O-PO_4 (mg/l)	0.002-0.006	0.004	0.002-0.012	0.004
SiO_4 (mg/l)	13-14	13.8	14-15	14.2
Total nitrogen (mg/l)	0.04-0.06	0.05	0.03-0.13	0.10
Total phosphorus (mg/l)	0.007-0.014	0.010	0.007-0.013	0.011

[a] Approximately 3 miles upstream from the Topping Plant site.

[b] Approximately 15 miles downstream from the Topping Plant site.

[c] N=5

NOTE: Samples were collected by the Arctic Environmental Research Laboratory during an 11-day interval beginning in late February 1975 and were analyzed by that EPA laboratory.

Source: EPA, 1976.

TABLE 19. WATER QUALITY OF THE TANANA RIVER

Parameter	Concentration (mg/l)[a]
Total suspended solids	3.6
Chemical oxygen demand	1.3
Total Kjeldahl nitrogen	0.016
Ammonia (as nitrogen)	0.11
Nitrate-nitrite (as nitrogen)	0.16
Total phosphorus	0.042
Calcium	26
Fluoride	<1
Sulfide	<0.02
Phenolic compounds	<0.002
Oil and grease[b]	0.2
Cadmium	0.003
Chromium	<0.001
Copper	0.004
Iron	0.480
Nickel	0.015
Zinc	0.002
Lead	0.02
Manganese	0.13

[a] Samples collected in a channel (140 cfs) of the Tanana River near the ECA site.

[b] Gravimetric method of analysis (American Society of Testing and Materials). The reported value is essentially at the detection level.

Source: Samples taken on February 6, 1976 (EPA, 1976)

Refinery indicated that some sloughs of the Tanana River have very low flows (0.1 cfs) during the freeze-up period. Any wastes dumped into a low flow area could degrade the water quality. The Chena River, which drains into the Tanana several kilometers downstream of the alternative site, receives waste discharges from the Fairbanks area and is the major source of pollution in the Tanana River.

At the North Pole plant site, the groundwater table is thought to be influenced by the nearby Tanana River. Depth to the water table at the site varies from 1.5 to 3 meters. A shallow drilled well near the Tanana River probably would produce water of acceptable quality and quantity. Shallow wells properly constructed in the sands and gravels of the Tanana Valley have yielded water at rates of 1,500 to 3,400 gpm. A well of this size would produce between 2.2 and 4.9 million gallons of water per day. Chemical data for water from a well adjacent to the proposed SGCF site that was drilled for the Golden Valley Electric Association are presented in table 20. Because this well is shallow and possibly subject to contamination, the potable water supply should be disinfected.

The main hydrological concerns about constructing and operating the proposed facilities at the North Pole site would be those associated with the domestic water supply and sewage disposal and groundwater impacts resulting from construction. The Fairbanks treatment plant went on-line in December 1976. It is an indoor, pure oxygen, activated sludge plant with disinfection of the effluent before disposal to the Tanana River. The plant is designed for an ultimate capacity of 8 million gpd but presently is operating significantly under that capacity, at approximately 3.6 million gpd. Assuming that many operators would live in Fairbanks, the 100,000 gpd additional flow generated by an additional 1,000 residents could easily be handled by this plant. The plant has effluent limitations of 25 mg/1 BOD and 25 mg/1 suspended solids. After initial startup problems, the plant is now consistently meeting these criteria.

The operating plant is assumed to have toilets and showers for the work crew. The daily flow is assumed to be 25 gallons per capita. The domestic sewage would be treated to meet the EPA discharge standards by a small onsite extended aeration plant. The effluent would be disinfected before it is discharged to a slough of the Tanana River, which has adequate flow during the winter.

TABLE 20. RESULTS OF THE ANALYSIS OF WATER FOR THE PROPOSED GOLDEN VALLEY ELECTRIC ASSOCIATION WELL AT NORTH POLE, ALASKA

Parameter	Concentration Range (mg/l)
Iron	0.05
Barium	0.1
Silica	0.1
Suspended solids	0.1
Sodium	68-106
Potassium	10
Calcium	4
Magnesium	6-7
Sulfate	22-26
Chloride	8-10
Hydroxide	--
Carbonate	--
Bicarbonate	195-281
Total dissolved solids	214-297
pH	6.5-6.6[a]
Total hardness ($CaCO_3$)	39
Total alkalinity ($CaCO_3$)	160
Fecal coliform bacteria	--[b]

[a] Standard units.

[b] No./100 ml.

NOTE: Samples were obtained from a shallow (20-foot) well at Station G-2 on 26 May 1975.

Adapted from EPA, 1976.

The city of North Pole's potable water supply and distribution system consists of a deep well, storage tank, chlorination, a green sand pressure filter and both constant pressure and circulation pumps. The system is presently designed to serve a population of 4,000 people. The SGCF as proposed for Prudhoe Bay requires accommodations for a construction crew of 1,000 and an operations staff of 200. There should be no significant impacts associated with obtaining a sufficient domestic water supply for the proposed facilities. If the existing city water system were insufficient, a water treatment facility is proposed in association with the SGCF, and adequate water sources are available.

Discharges of treated domestic wastes from the proposed facilities should have very little impact on the Tanana River, whether discharged through the municipal plant at Fairbanks or through a separate treatment facility at the SGCF.

Because of the modular construction of the SGCF, excavation at the North Pole site would not be anticipated. As a consequence, the near surface groundwater table would not be exposed in the course of construction, and adverse impacts would not be expected. It is possible that this shallow aquifer could become contaminated by oil or chemical spills. The plant construction procedures should be such that runoff would be diverted away from the well area into impervious settling basins before it is allowed to enter the river. All spill containment pits should be lined with impervious materials.

Air Quality

The ambient air quality in the Fairbanks area generally is good, with the exception of carbon monoxide (CO) levels. Fairbanks is located in the Fairbanks North Star Borough Air Quality Control Region (AQCR). The air quality standards applicable to the Fairbanks alternative site (i.e., NAAQS and AAAQS) are the same as those applicable to the site at Prudhoe Bay. The Air Quality Attainment Plan for the North Star AQCR (February 26, 1979) lists the North Pole area as being in a nonattainment area for CO. The major contributing sources to the CO problem in the AQCR are vehicles, and residential, small commercial, and industrial heating units.

It is not possible at this time to quantify the impacts that might result from constructing the SGCF at the Fairbanks site for two reasons. First, the proposed facility must be "stick or skid built" rather than totally prefabricated at a site in the lower 48. This means that the facility, as presently designed, cannot be constructed at this site. A different design would require a radically different approach to construction of the proposed facility. This, in turn, could require totally different construction vehicles (and thus different emission rates), a change in the size of the construction site, and a need for ancillary and support vehicles. All of these factors must be considered in the analysis of the potential impacts.

Second, the materials and equipment necessary to construct the proposed facility cannot be brought to the site on large barges because there is no nearby waterway sufficient to accommodate such barges. Instead, the materials would be transported to the site by rail and/or truck. Because there is no design for this stick-built type of plant, there also is no definitive transportation strategy that would permit selection of the mode of transport or estimation of the number of carriers.

No matter which alternative process were selected or how construction were approached, the fact remains that the Fairbanks alternative site is in a nonattainment area for CO. Any construction would exacerbate this situation and make it more difficult for this area to achieve attainment status.

The impacts resulting from the operation of the SGCF at this alternative site also are impossible to quantify until several critical decisions are made. It has not been determined if the proposed facility would obtain energy from the local utility district or would supply its own power. If the proposed project could in fact obtain power from the local utility, numerous problems could be solved. If, however, the proposed facility must produce enough energy to meet its own needs, three more problems would arise.

First, operation of the proposed project would exacerbate CO nonattainment levels to some extent. Second, the meteorological conditions of this area are not conducive to dispersion of pollutants. This is especially true during the winter, when there are long periods of extreme stability with very low mixing heights (approximately 300 to 600 meters). It is expected that the gas turbine units would not pose much problem during the winter. The operation of the space and/or process heaters, however, could produce very high pollutant levels within 1 or 2 km. downwind of the proposed facility. Finally, if the SGCF were required to supply its own power, there would be an increase in the severity and physical extent of the ice fog that occurs frequently in the area during the winter. If the Fairbanks site receives further serious consideration as a possible site, an in-depth study should be undertaken to more adequately determine these potential impacts.

Noise Quality

Ambient noise levels have not been monitored at the Fairbanks alternative site. The ambient noise level at this site has been estimated to be about 40 dBA. This estimate is based on the general characteristics of the site, which is a semirural area with one industry located in the general vicinity.

It is impossible at this time to quantify the noise impacts associated with construction of the SGCF at the Fairbanks site, for the reasons listed in the air quality section. However, the overall impact that results from the construction of the proposed facility should be insignificant because of the location and character of the site. The site is not in a heavy residential area; therefore, the impact on a surrounding population should not be a problem. Conversely, because the site is not entirely rural, no large sensitive wildlife populations would be affected.

If the SELEXOL process were utilized at this site and the SGCF at this site included the gas turbine facility, the level of noise generated by the SGCF at the Fairbanks site would not differ significantly from the level of noise generated at the Prudhoe Bay site. The noise increase produced by the operation of the facility at Prudhoe Bay was estimated to be at 6 dB at 0.8 km. from the facility. Because of the location and the semiindustrial character of this site, the impacts on human and sensitive wildlife populations would be minimal.

Terrestrial and Aquatic Communities

The forest which covers the landscape in the Fairbanks-North Pole area is termed "taiga," a spruce-dominated coniferous forest characteristic of subarctic climates.

The North Pole site is located in an ecosystem oftentimes referred to as a lowbush bog or muskeg. The characteristic vegetation is dominated by the black spruce-tamarack and the dwarf or resin birch, an ericaceous shrub type. Other common vegetation in this area includes occasional willows, tinleaf alders, and poplars growing in a substrate of grasses, lichens, and mosses of various species.

Wildlife is relatively plentiful in the heavily forested outlying areas of Fairbanks and North Pole. The more common large mammals in the area include the snowshoe hare, red squirrel, beaver, wolf, red fox, mink, lynx, moose, and black bear. Many species of small mammals--shrews, lemming, voles, muskrat, rat, and porcupine--are also found in this area.

Numerous species of birds are residents of the Tanana Valley (either year-round or in the summer) or nest and forage there during migration. The Tanana River and its floodplain provide appropriate habitat for a variety of waterfowl and shorebirds, including mallards, pintails, green-winged teal, bufflehead, lesser yellowlegs, snipe, and sandpipers. Various raptors, gamebirds, and passerine birds are also found in the general area. Peregrine falcons, ospreys, and bald eagles are known to nest in the Tanana Valley. Other raptors there include goshawks and sharpshinned hawks; great horned, great gray and boreal owls; and red-tailed, Harlan's Swainsons, rough-legged, marsh, pigeon, and sparrow hawks. Gyr falcons are observed usually above 760 meters (2,500 feet) elevations.

The Tanana River, like other glacially fed rivers in Alaska, is typically high and heavily laden with silt during the summer and low, clear, and ice-covered during the winter. The drastic seasonal changes in the character of the Tanana River bring about corresponding seasonal variations in fish populations. The year-round fish residents include the burbot, humpback whitefish, inconnu or sheefish, and suckers. Fish that reside in the Tanana River only during winter include the arctic grayling, round whitefish, and northern pike. King salmon, chum salmon, silver salmon, and arctic lamprey use the Tanana River primarily as a migration route.

During the spring, there are several intense but short sport fisheries for arctic grayling or round whitefish in the Tanana River. These usually occur in the vicinity of the mouths of tributaries. During the winter, the burbot is fished all along the Tanana.

No threatened or endangered species are known to inhabit the alternate site.

The construction of the proposed facility at the alternative North Pole site would result in cumulative impact to the fauna and flora, since much of the area near the site has already been subject to human disturbance. Cumulative impacts would include increases in noise from construction and operation of the SGCF, incremental air and water degradation, and the commitment of additional acreage to an industrial facility siting.

The vegetation which would be eliminated would include those species which characterize bog-type communities, such as stunted, noncommercial tree species (dwarf birch and black spruce) and numerous shrubs. None of the species affected are classified by the U.S. Fish and Wildlife Service as threatened or endangered.

The removal of approximately 200 acres of vegetation for construction of the proposed facilities would eliminate existing available habitat for many small mammals, such as shrews, rats, porcupines, voles, and muskrat. These small mammals would probably be lost or displaced. Displaced wildlife would be forced to compete for comparable habitat which may exist in the surrounding area. The competition for food and cover and other environmental stresses, such as increased predator pressure, might substantially reduce the populations of small mammals in the area.

This area is not considered winter range for moose; however, they have been observed in the area during the summer. Moose and other large mammals, such as black bear, would not frequent the project site area because of increased human activity and disturbance.

Construction of any water lines to the Tanana River would not be expected to have significant adverse impact on the fisheries resources of the river. Construction of these lines would result in short-term, reversible impacts such as increased turbidity and sediment load. Sedimentation increases in the Tanana River would be insignificant during the summer when the river carries a heavy silt load. However, sediment increases when arctic grayling spawn could be detrimental to these populations. Sedimentation and related impacts to fish populations would be similar to those at the Prudhoe Bay site.

Land Use and Solid Waste Disposal

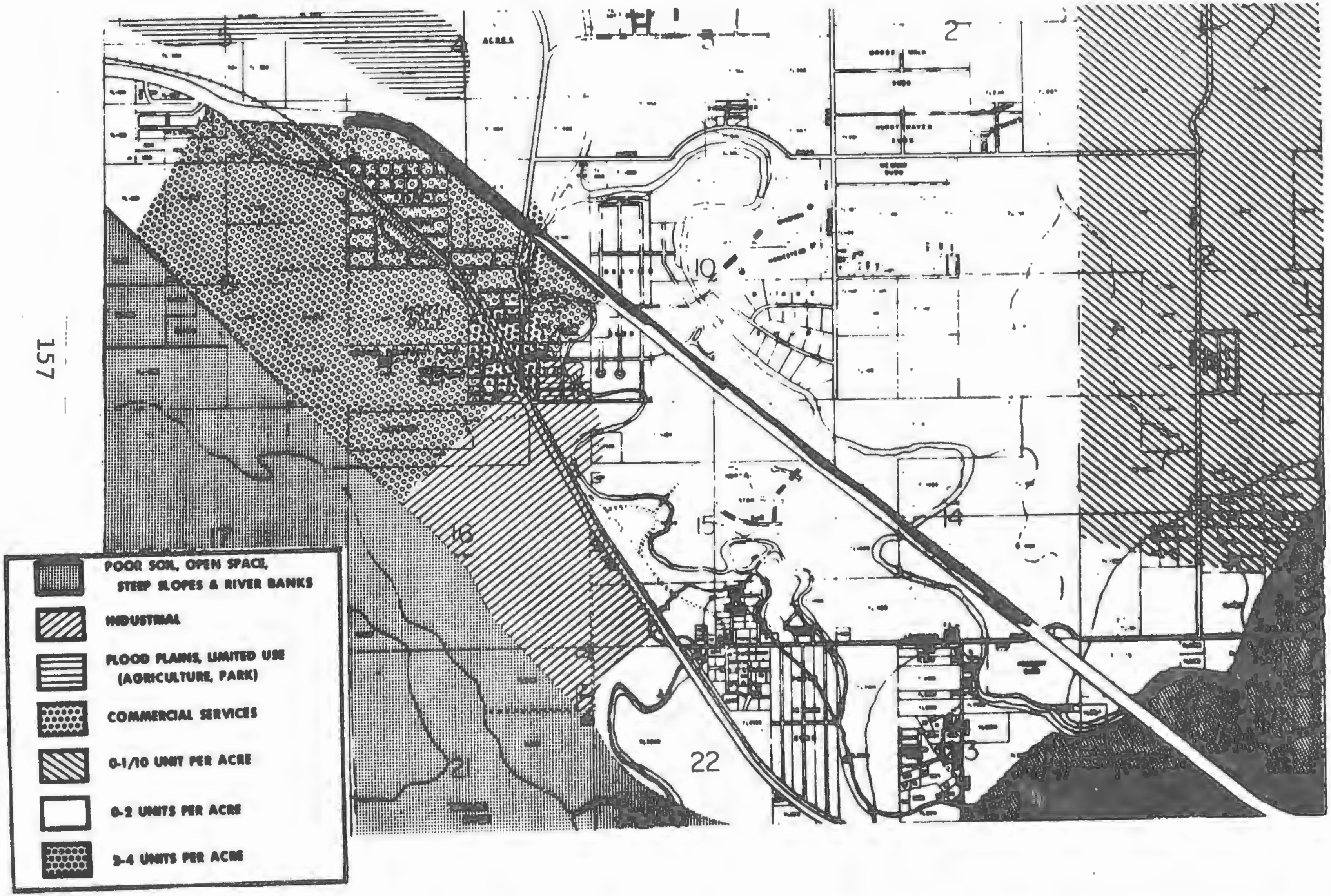
The alternate site at North Pole is located in the North Pole Planning Area which covers approximately 67 square miles east of Fairbanks and Fort Wainwright, extending along Badger Road and the New Richardson Highway. The alternate site at North Pole is zoned Heavy Industrial; the state-owned property north of the site is zoned General Agriculture; property to the east and on the opposite side of the Old Richardson Highway is zoned General Agriculture and Rural Residential, respectively; and privately owned property south of the alternate site is zoned for unrestricted use. Figure 25 indicates the existing land use patterns for the North Pole alternate site.

The Fairbanks North Star Borough adopted its Comprehensive Plan for land use in 1975. Among the many recommendations made, those pertinent to the North Pole area include: (1) concentrated commercial, urban, and suburban residential development in the North Pole city center, within the capacity of the existing water and sewer systems, (2) low suburban-rural densities on land suitable for development but outside the limits of sewer and water services, (3) retention of lands along Chena Slough as part of a proposed open-spaced trail system, and (4) heavy industrial use south of the city center, between the Old Richardson Highway and the Tanana River and east along the railroad tracks. At the present time, the zoning plan for the North Pole Planning Area is consistent with the borough's comprehensive land use plan.

The alternate SGCF site would be adjacent to the Energy Company of Alaska Topping Plant that has been operational since August 1977. This plant is significant as the first of the "pipeline industries" and as the first oil refinery to be located on freshwater in Alaska. The topping plant is designed to process up to 25,000 barrels per day of crude oil from TAPS and is capable of manufacturing heating oils, diesel fuel, industrial turbine fuel, military jet fuel, and asphalt. As previously indicated, locating the SGCF adjacent to the oil refinery would place it in an area that has been designated for industrial growth.

Figure 25

LAND USE RECOMMENDATIONS FOR THE NORTH POLE AREA



Although many of the streets in North Pole are unpaved and many residential streets are not equipped with street lighting, generally an excellent network of air/rail/highway systems presently exists in the Fairbanks area. For instance, the New Richardson Highway runs east of North Pole and accommodates the Fairbanks-Eielson Air Force Base traffic. A road joining the Chena Hot Springs and Badger Roads, which connects the Chena Hot Springs area northeast of Fairbanks to North Pole, was completed in late 1975. In addition, the Fairbanks-North Pole area is situated in proximity to the already constructed TAPS and the future ANGTS.

The most significant land use impact would be the conversion of the site from undeveloped woodland to additional industry. Such a commitment would make this land area unavailable for other uses and could conflict with the surrounding land which is zoned for less intensive uses.

Increased use of existing roads as a result of increased traffic due to construction and permanent SGCF personnel will intensify the need for additional maintenance and repair of these roads. There will also be an increase in traffic hazards and noise levels. The increased traffic, including truck traffic, will affect the in-town circulation patterns to some degree.

Presently, the Fairbanks-North Pole area is an important air and road hub for people and materials enroute to the North Slope. As a result, this area is projected as having a high growth potential. Because of such ongoing developments, the impact of the SGCF on land use patterns in the borough is expected to be minimal. However, placing this facility near the existing oil refinery at North Pole could stimulate the development of other industries in the area. Such an industrial complex could significantly influence the borough and North Pole plans for future industrial growth and land use planning policies.

Solid wastes from a SGCF at the North Pole site will probably be hauled to the Fairbanks North Star Borough refuse disposal facility by a private contractor. Solid waste generation rates should be similar to the current generation rates of 5.9 kilograms/capita/day for the general population and 4.5 kilograms/capita/day at the North Pole topping plant. The Fairbanks North Star Borough operates the solid waste disposal facility, located approximately 3 km. south of the city, for the residents and industry within the borough's boundaries. Some wastes are received from the North Slope of Alaska. Except for charges for the refuse from the North Slope, the facility is financed by the general tax revenues. Little effort was made to determine the quantities of refuse placed in the fill during construction of TAPS.

With the installation of a baler at the landfill site, disposal practices have changed. Automobiles, large appliances, and scrap metal are segregated, baled, and sold. Community organizations collect aluminum, which is baled and sold. Money from the sale of the aluminum goes to the community service organizations, whereas money from the sale of other scrap goes into the general fund. General refuse is baled to a density of 1,043 to 1,283 kilograms/cubic meter.

The baler capacity is approximately 400 tons per day. At present, the facility is processing and disposing of approximately 150 to 200 tons per day. There is adequate volume for the foreseeable future, and the operation and site characteristics conform to all applicable Federal, state, and local codes and criteria. The borough has indicated that it might discourage the incineration of refuse to simplify the baling operation. It is also possible that the incinerator ash would simply be used as cover material. In either case, the operation could easily handle the additional solid waste (possibly up to 4 tons per day, unincinerated). The environmental impact would be negligible for either case.

The baled refuse volume for the 1,000-person construction crew would be 5.7 cubic meters per day. During the construction period of 4.5 years, the total volume of landfill needed would be 9,290 cubic meters. For the operating period, the daily volume generated is estimated to be 1.9 cubic meters. The borough does not anticipate that these quantities would create any problems in its existing landfill operation.

During construction, the daily solid waste generation for the borough would increase by 1.6 percent over what is presently generated by the 64,000 residents. During operation, the increase would be only 0.3 percent above this current level. Over a 20-year period, the increase in landfill area needed would be 0.7 acre. The impact on the existing site would be minimal.

Socioeconomics

The North Pole alternate site is within the Fairbanks North Star Borough. Borough population estimates indicate a 13-percent drop in area population in 1978 over 1977, with 27,116 persons residing in Fairbanks and 33,729 outside the city but within the borough. These current estimates also indicate a 21-percent increase in population over prepipeline levels in 1973 but a 16-percent drop from the borough's peak population in 1976 during pipeline construction. Recent information indicates that there are about 800 people living within the North Pole city boundaries and over 12,000 living outside the city but within the North Pole Planning Area.

Until the existing refinery became operational in August 1977, North Pole was generally regarded as a residential community dependent on outside employment centers. However, residents of North Pole remain largely dependent on commercial and professional institutions in Fairbanks, at Fort Wainwright, at Eielson Air Force Base, and those provided by Alyeska for its employees.

In the past, North Pole has obtained the majority of its operating revenues from water and sewer receipts and from state and Federal revenue sharing. More recently, North Pole has received significant increases in revenues as a result of the construction of the North Pole refinery.

Besides the refinery, there is no other appreciable nongovernmental industry in the Fairbanks North Star Borough to provide economic support for the area. Construction has primarily occurred in public or military projects rather than in private developments. Lack of manufacturing in Fairbanks requires that most manufactured goods be imported, this creates an outflow of monies from the local economy, thereby reducing internal development potential. Government, trade, and services currently dominate the Fairbanks economy in its role as the distribution center for the north-central region of Alaska.

Even before construction of TAPS, the cost of living in Alaska was higher than in the United States as a whole. Part of the increase in Alaskan price levels can be attributed to the impacts of TAPS construction. Since Fairbanks was directly impacted by the pipeline to a much greater extent than Anchorage, it is generally believed that inflationary pressures in Fairbanks were more severe than in Anchorage. Fairbanks had a relatively small support sector prior to pipeline construction. Pressures on the economy produced gross dislocations, shortages, and rapidly rising prices. Economic developments in Fairbanks during the pipeline construction, which included expansion of the retail trade, service, and transportation sectors of the economy, increased competition. This likely dampened inflation somewhat. Presently, prices in Fairbanks are somewhat higher than in Anchorage, but considerably lower than prices in the small, remote villages of western and northern Alaska which have traditionally experienced the state's highest costs.

Both Fairbanks and the North Pole area have historically experienced critical shortages in housing. This shortage has been caused not only by large in-migration of workers seeking pipeline construction jobs but also by the rising cost of building materials, a labor-intensive construction industry, severe climatic and topographic constraints, and an isolated, fluctuating market. More recently, however, the Fairbanks borough has become more able to fill housing needs. The 940 rental units vacant in October 1978 and the 1978 household density average of 2.7 indicate that this area could absorb 2,500 people with no new housing construction.

Construction of TAPS did not have the major impact on school enrollments originally expected in the Fairbanks North Star Borough, since most incoming pipeline workers were either single or left their families in their home states. Consequently, the present decrease in school enrollments is not as great as estimates for the decrease in total borough populations would otherwise suggest.

The Fairbanks area, along with other areas along TAPS, has undergone noticeable changes in socioeconomic structure as a result of construction of TAPS. The "boom" of the boom-bust cycle associated with such a project has already taken place. However, there is a hesitancy to describe the present economic situation in Fairbanks as a "bust" trend, although the economy has slowed down significantly. 1/

1/ State of Alaska, Department of Labor, Research and Analysis Section, Alaska Economic Trends (January 1979), p. 7.

Unemployment levels in Fairbanks declined to 16.2 percent for the period ending December 1978, but they still remain higher than the state-wide jobless rate of 11.4 percent. Despite this general downturn in the Fairbanks economy, employment remains substantially above prepipeline levels. The present outlook is for slow growth in the Fairbanks area and rising employment levels caused by some increase in tourism and preparation for construction of the ANGTS.

The construction and operation of the SGCF in the Fairbanks-North Pole area would result in an influx of employees into this area. Most of these workers would be moving into the area from the surrounding locality and from outside Alaska. Some of these personnel may bring their families, but most construction workers are usually single or leave their families in their home states. Additional construction workers beyond the 1,000 for the proposed Prudhoe Bay site would be required to build the alternate site at North Pole. The size of the modular units might be smaller since the mode of transportation would be limited to air, rail, or truck into the Fairbanks area, as opposed to larger-sized modules on barges. Smaller module sizes would necessitate increased numbers of units, therefore requiring greater numbers of workers for transporting and assembling these facilities.

Construction of the SGCF at the North Pole alternative site would help remedy the present decline in construction- and transportation-related employment in the Fairbanks area. Most of the new permanent jobs would probably require at least semiskilled workers. Since very few unskilled workers will be employed by the SGCF, this industry would probably have little significant direct effect on unemployment rates in the area, unless the facility operator is committed to a training program for Alaskans.

Temporary employment for construction personnel and the permanent operation and maintenance jobs resulting from the construction and operation of the SGCF would also increase the number of employees that would be hired by supportive facilities and service industries necessary to serve the additional people. The job opportunities created by these support and service facilities might favorably affect unemployment rates. In addition, all of these facilities, including the SGCF, would generate additional tax revenues for the area.

The demands of the approximately 200 permanently employed SGCF personnel and their families on the services and facilities of Fairbanks and the borough would be adequately met with minimal impact. However, if all 200 persons and their families decided to reside in North Pole, the impacts on some of the city's existing facilities and services would be substantial. The largest problem would be the city's past inability to provide sewer and water services to new residential developments.

Construction of the SGCF at the North Pole industrial site could potentially have significant impact on the housing market in the area. It might or might not require construction of a workcamp. If a workcamp were constructed, there would not be a severe strain on the local housing situation. However, if a construction camp were not constructed, a greater demand would again be placed on both rental housing and new housing. Such a demand would increase rents, which until recently had dropped an average of 20 percent since the height of the pipeline boom. New housing starts, which decreased 45 percent during a 6-month construction season in 1978, might be stimulated again. It may be possible to house construction crews on the north side of Fort Wainwright in the same buildings used for the TAPS crews.

If most of the SGCF employees live in Fairbanks and commute to North Pole, there would be a "leakage" of wages to areas outside the North Pole community. If the leakage is great, it could evolve into a critical problem. The city of North Pole would be burdened with accommodating the needs of new industry without the means to do so. The community might have to pay for the necessary public services while losing spending to other areas.

Temporary construction personnel moving into the area might again create the boom economy in the Fairbanks area that occurred during TAPS construction. Fewer temporary construction workers would be required than during peak TAPS construction, but these SGCF construction workers would be primarily concentrated in the Fairbanks-North Pole area for the duration of the construction. Personnel required for ANGTS construction may be moving into the Fairbanks area at about the same time, creating cumulative impacts to the local economy. Following construction of the SGCF and the ANGTS, the Fairbanks area might again experience a downturn in the economy similar to what is presently occurring in the area. However, approximately 200 permanent long-term jobs would have been created at the SGCF in North Pole. This could lessen the downturn by stimulating the local economy, as would the increased tax base the SGCF would provide.

Recreation and Aesthetics

Existing camping and picnic areas include the Chena River Wayside, the Harding Lake Recreation Area (located 64-65 km. from Fairbanks), the Salcha River Picnic Wayside, Growden Memorial Park, and the North Pole City Park. A few other recreational facilities are presently being considered for development in the area (e.g., hiking or bicycle trail routes), and these new developments should help to minimize the demand on existing facilities.

The city of Fairbanks maintains numerous parks for day activities. Additionally, the surrounding area is valued recreationally for its "back country" terrain and character. Recreational activities such as backpacking, skiing, snowmobiling, hunting, fishing, and boating are enjoyed outside the confines of urban areas such as Fairbanks.

The influx of people associated with the construction and operation of the SGCF, both directly and indirectly, would intensify use of existing recreation areas in the vicinity of North Pole and Fairbanks. The increased population of temporary construction personnel would intensify the shortage of informal park areas and recreational facilities needed for organized sports. The existing recreational facilities would be more frequently used by visitors than by residents of the area, especially during the summer.

Increased recreational activity, such as boating, hiking, skiing, and snowmobiling, would all increase disturbance to local wildlife and possibly damage the environment. Such activities would impact to some degree the fish and wildlife of the area and their habitats and would affect local subsistence hunting and fishing.

The combustion products from the power generation system associated with the SGCF could aggravate the existing air quality problems in the Fairbanks area. The gas processing itself, or its power generation system, would not add significantly to the ice fog problem in this area. However, the operation of the process area space heaters associated with the operation of the facility and the secondary effects of the construction and operation of the facility (i.e., increased auto use, people, power requirements, etc.) would significantly add to the ice fog problem. The continual occurrence of such air quality events would create aesthetic problems and annoyance to the people seeking the pristine nature of the surrounding countryside.

Cultural Resources

Records of archaeological sites from surveys of TAPS 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 gas pipeline and gas processing plant depends, of course, on how closely the facilities follow the TAPS right-of-way.

The southern half of the pipeline corridor in Alaska crosses one of the most favorable areas for continuous human occupation. This provides an ideal situation for recovering new information on the developmental sequences of society in the area. The orientations of tribal units to major river arteries suggest that archaeological sites within the pipeline corridor could reveal valuable information on earlier economic patterns and social systems.

The Alaskan interior contains numerous historic sites of the Gold Rush era, including dredges, steamboat relics, saloons, and courthouses. Particularly south of Fairbanks, historical resources are abundant along the route. Roadhouses sprang up along all major travel routes in Alaska, offering services to travelers in the primitive and harsh country. Depending upon the precise placement of the gas processing facility, such sites might be directly impacted if identification and salvage operations are not carried out in advance. See page 735 of DOI-FEIS, Alaska Volume, for more detailed historical information for Fairbanks area. Page 753 of the same volume discusses general impacts to historical resources.

Part of the North Pole alternative site has been surveyed for archaeological resources. The survey archaeologist has indicated that a complete survey would not be productive.

ii. Yukon River Crossing

The TAPS crossing of the Yukon River is located about 6 km. upstream from the Ray River, about 40 km. downstream from Stevens Village, and about 160 km. northwest of Fairbanks. The Yukon River flows westward in an incised channel past the TAPS crossing. Looking downstream, the left (south) bank is steep and high with no floodplains. The right (north) bank is a fairly level floodplain about 800 meters wide. The channel width ranges from about 600 meters at the TAPS crossing to 900 meters near the Ray River mouth. (See figure 26.) The land south of the Yukon TAPS crossing is generally high rolling hills, whereas the land on the north side of the river is somewhat flatter.

Since the river is a navigable stream, it is possible that barging construction modules to the site from the lower 48 would be economically feasible. If not, the river at or near the alternate site would have to be dredged to the proper depth. Because the modules would be quite large, it would be difficult if not impossible to move them over uneven ground. This means that only the relatively flat terrain to the north could be used as a potential site for the gas conditioning facility. However, this area is subject to flooding at undetermined intervals. This might be mitigated by locating the facility on slightly higher ground. The only other location for a SGCF at the Yukon River crossing would be the old TAPS construction camp located on the high rolling hills just north of the Yukon River. However, this site would also be inadequate because it would be difficult if not impossible to move the large modules over uneven terrain. If the gas conditioning facility could not use modular construction techniques, it would not be economically feasible at this site.

The Yukon River crossing would offer advantages similar to the Fairbanks alternative, except that barging modules to the proposed site might be economically feasible; this would make the Yukon Crossing alternative consistent with the

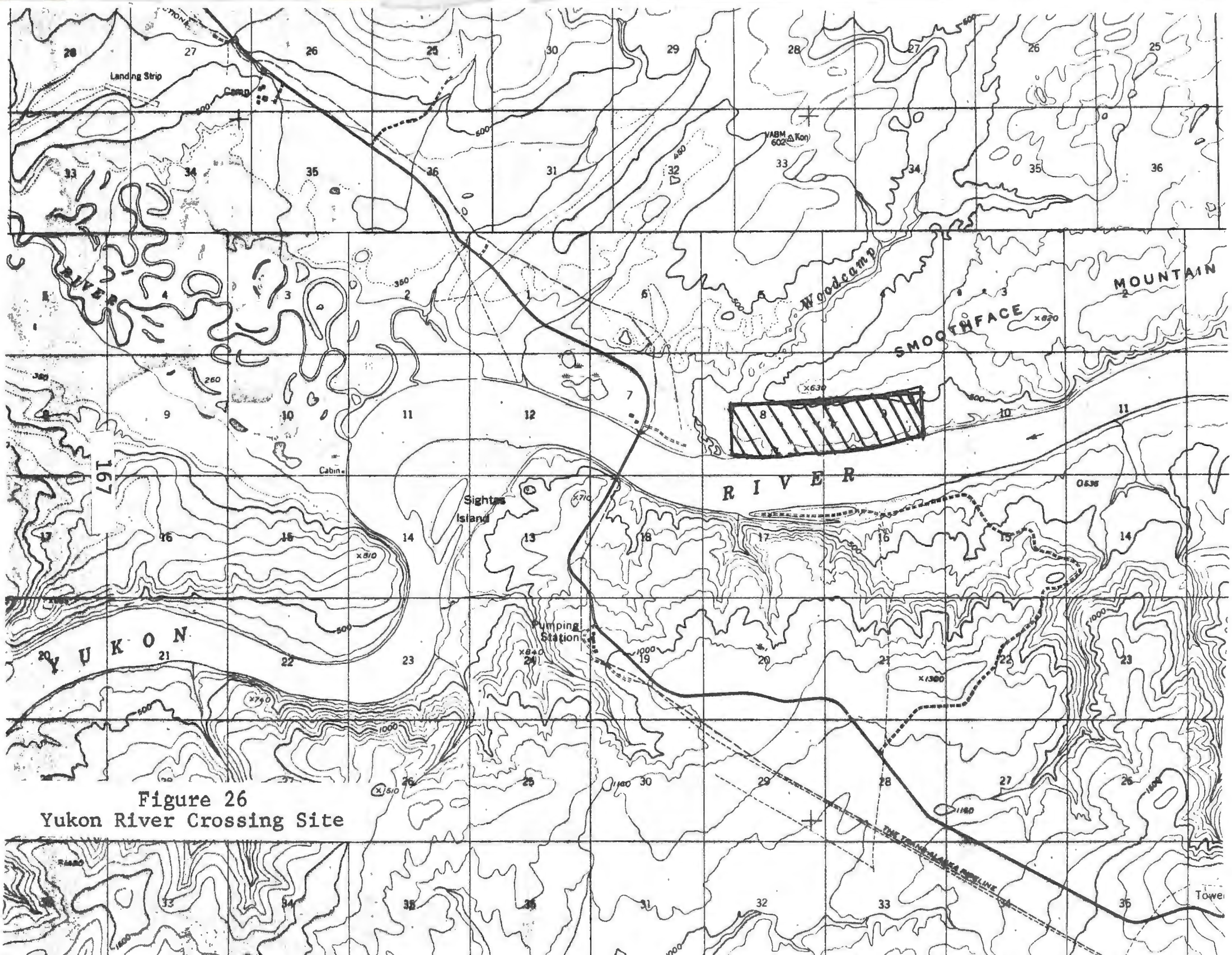


Figure 26
Yukon River Crossing Site

Prudhoe Bay cost estimates. The major disadvantage would be the required construction of at least a 1,680-psig dense-phase high-pressure pipeline to the proposed site, as well as additional pipeline(s) to transport conditioned hydrocarbons from the Yukon site to a present or future customer in or in the general vicinity of Fairbanks.

Climate

There are no climatological data available for this site. However, many comparisons can be drawn between the Fairbanks alternative site and the Yukon River alternative site:

- They are only 120 km. (75 miles) apart; the Yukon River site is northwest of the Fairbanks site.
- They both have a continental climate.
- Their topography is similar.

Based on these similarities, it can be assumed that the existing conditions at the Yukon River site are similar to those at the Fairbanks site.

It can also be assumed that the impacts projected for the Fairbanks site are valid for this site, with the exception of the ice fog phenomenon. Because this site is more remote than the Fairbanks site, there is little "man-made" ice fog. Therefore, the proposed facility would not add to an existing problem, nor would it impact any significant population.

Topography, Geology, and Soils

The Yukon River alternative site is on the north bank of the river and east of the TAPS crossing. This part of the river is within the Kokrine-Hodzana highlands section of the Intermontane Uplands and Lowlands. Although the highland is generally comprised of rounded ridges of 600 to 1,200 meters in elevation (mean sea level), near the river and, in particular, near this site, the elevation is generally below 600 meters.

The alternative site ranges between elevations of 180 meters and about 60 meters, the elevation of the river, with most of the site between 90 and 150 meters. Most of the surface of the site slopes to the south and west at about 56 meters per kilometer.

Extensive modification of the topography would be required for this site. Not only would permafrost conditions require foundation preparation similar to that proposed at Prudhoe Bay, but an unknown amount of cut and fill would be required in preparation for module erection. Finally, and probably most significantly, a haul road would have to be constructed between the dock and the site. Such a road would have to be a minimum of 12.2 meters wide with up to 3 meters of clearance on each side and would be approximately 600 meters long.

No water supply reservoir or waste water disposal lagoon are likely to be needed at this site.

Surficial deposits at the site are predominantly wind-blown silts (loess) which cover the bedrock to depths of up to 30 meters. The bedrock consists of dark mafic igneous rocks, with some related sediments ranging in age from 200 to 300 million years. Bedrock does not outcrop on the site.

This site is within the northern portion of the zone of discontinuous permafrost. The maximum depth to the base of permafrost is about 100 meters, with the top of the permafrost about 1 meter deep. The ice content of the permafrost is highly variable, with locally occurring ice wedges up to 10 meters thick.

The Yukon River site is within the highly seismic area of central Alaska. The largest recorded event in the area occurred in October 1968 and registered 7.1 on the Richter scale. Earthquakes of this size can be expected to occur every 80 years, with a maximum projected Modified Mercalli Intensity of about IX, which corresponds to considerable damage in specially designed structures.

Evidence of faulting was observed in excavations for the Yukon River bridge. No evidence of Holocene faulting was observed. The Kaltag fault, a major strike-slip feature, follows the Yukon River southwest of the site but has not been shown to extend in the direction of the site. It has been suggested that it is a continuation of the Tintina fault system, which is mapped southeast of the site; however, this does not necessarily alter its importance to the site. Of more concern is the Mintook Creek fault, which is associated with a high level of seismicity and which passes less than about 10 km. west of the site.

Substantial amounts of gravel, probably in excess of those required at Prudhoe Bay, would be needed at this site. The only readily available source is the Yukon River, and the quantity available is unknown. Impact on this resource would be appreciable.

Permafrost would be a major, and perhaps the most significant, onsite construction problem. In addition to probable loss of soil-bearing capacity after thawing, downhill flow--either solifluction (slow movement) or mudflows--would be a serious potential problem. Thermokarst pits would be another problem here. These pits form when ice masses within the soil melt, leaving cavities whose tops then cave in.

Another potential problem relating to permafrost at this site is icing. If construction measures to avoid permafrost degradation caused the permafrost table to rise, a localized block to groundwater flow could form within the active layer. This obstacle would force the water to flow to the surface and over the site in the summer, causing messy conditions at best and, at worst, aggravating slope stability problems. In the winter, this flow would continue until the active layer had completely frozen, so the site, or a portion of it, would be covered with a sheet of ice.

No detailed soil surveys are available for the area of this site; however, regional exploratory surveys have been conducted. Soils to be expected on this site are predominantly silt loams, which are moderately well to poorly drained. They may be covered with a peaty layer. Erosion potential of the unprotected mineral soil is moderate to severe. Permafrost is generally within 1 meter of the surface, and deeply buried ice masses may be present in some soils. The properties of these soils impose moderate to severe limitations for construction of low buildings. Detailed studies would be required to outline the areas suitable for construction. In general, the soils have a low bearing capacity and, where ice masses exist, may be susceptible to the formation of deep pits if these masses melt.

Soils within the area affected by construction would be destroyed. This area would be larger than at Prudhoe Bay or North Pole because the land surface is more irregular, requiring more cut and fill. In addition, construction of a haul road would affect about 2 acres. Agricultural use of these areas would be precluded during the life of the facilities and for an extended period thereafter because topsoil would have to be replaced after removal of the facilities.

Since the erosion potential of the site soil is moderate to severe and significant grading of the land would be required, there would be erosion on the site. Some siltation would occur in Woodcamp Creek. Additional sediment load in the Yukon River would be insignificant compared to its normal load.

Hydrology

The Yukon River lies entirely within the Yukon River Drainage Basin, bounded by the Brooks Range to the north and the Alaska Range to the south. The Yukon River site is within the Upper Yukon subregion. The Yukon River at Rampart (approximately 64 km. (40 miles) downstream of the site location) has a drainage area of 199,400 square miles. Average flow over a 12-year period of record (1956-1967) was 128,500 cfs.

The streams in the Upper Yukon subregion typically begin to freeze over by late September. Flow is diminished to practically nothing by April. At Rampart, the minimum discharge over a 12-year period was 9,000 cfs. In May, the ice in the rivers is broken up by the higher flows of runoff from snowmelt. The relatively short summers concentrate the major portion of the annual runoff into less than 5 months. On the larger streams, the peak flow for the year usually occurs within 1 or 2 weeks of the breakup. Throughout the rest of the summer, rains usually sustain a relatively high discharge. Because of underlying permafrost, infiltration losses are minimal, and severe flooding can occur from June through September. In August 1967, a maximum flow for the 1956-1967 period of 950,000 cfs was recorded at Rampart. This flood caused almost $100 million in damages in east-central Alaska, even though the area is very sparsely inhabited. Extensive severe flooding can also occur during spring breakup between May and early July. When spring flow begins, it overflows the massive ice that is still frozen to the channel bed. Ice jams increase the height of the floodwater.

At the site, mean annual runoff is approximately 0.5 cfsm. Mean annual low monthly runoff is approximately 0.1 cfsm. The chemical quality of surface water in the subregion is good. All of the waters are of the calcium bicarbonate type. During the summer, the Yukon transports a suspended sediment concentration ranging from 200 to 400 mg/1, 70 to 80 percent of which is finer than 0.062 millimeter.

At the Yukon River site, groundwater would be expected to be available along the riverbank, where the warming effect of the river influences the thickness of permafrost. Alluvium is thought to be unfrozen beneath the riverbed along the entire course of the Yukon River. However, thin permafrost occurs in the floodplain alluvium adjacent to the river and is thought to thicken farther away from the river.

The chemical quality of groundwater in the upper Yukon area varies widely. Shallow wells near the larger rivers, such as the one at Fort Yukon near the Yukon River, probably receive water mainly by infiltration from the river. Consequently, these well waters are relatively low in dissolved solids content. Because of low population, very little development of surface water or groundwater has taken place in the upper Yukon area.

The impact on water resources of operating the proposed SGCF at the Yukon River site would be expected to be minimal. Extensive experience has been gained in wastewater treatment practices for isolated, arctic construction camps during the TAPS project, and it is likely that this experience will be utilized during construction of the SGCF project. Thirty construction camps were built during the TAPS project, each with its own wastewater treatment system. Because the type of construction camp envisioned for the SGCF should be similar in most respects to those on the TAPS project, it should be possible to extrapolate the data and operational characteristics of those plants to the SGCF study. Three types of camp wastewater treatment systems were utilized: two types of physical-chemical (P/C) plants (units A & B) and biological, extended aeration, activated sludge plants. All three types were housed and operated indoors.

Based on a 1978 summary study by Eggener and Tomlinson, the per capita wastewater generation rate was approximately 70 gallons per capita per day (gpcpd). (This rate generally was independent of the total camp population.) A composite sample of effluent wastewater, collected weekly for 17 months at 20 camps, contained 456 mg/1 BOD_5, 1,078 mg/1 chemical oxygen demand (COD), and 491 mg/1 suspended solids. Numerous startup and shakedown problems were encountered, but once these were alleviated, the average effluent characteristics (for the same period) were:

	BOD_5 (mg/1)	COD (mg/1)
Unit A	23.3	57.5
Unit B	33.4	58.8

The concentration of suspended solids was consistently 5 mg/1 or less. All wastewater sludge was incinerated at the site. Over the 2-year period, the percentage of BOD_5 removal improved steadily because of operational refinements, operator training, and other factors. For the last 6 months of the project, the removal was 95.6 and 97.5 percent for units A and B, respectively. If this shakedown improvement experience were to be used by the gas conditioning plant camp, it is possible that these levels could be achieved at the beginning of the project.

The major pertinent conclusion of this study was that "after the initial startup period, the biological, extended aeration plants performed at least as well as the P/C units in terms of BOD_5 removal." The concentrations of suspended effluent solids generally were higher for these plants than for the P/C units, but seldom exceeded 30 mg/1. Another conclusion that can be drawn is that the adverse conditions of the arctic environment do not present obstacles that cannot be overcome to allow an excellent degree of wastewater treatment. The proposed method of wastewater treatment for the SGCF construction camp will be a biological treatment plant that can be described as follows:

> The sewage treatment system will have the capability for treating high BOD domestic sewage at flow rates up to 150,000 gpd. The system will utilize the activated biofilter process followed by tertiary filtration and standby physical and chemical processing. The system

> will be conservatively designed and will meet all existing State and Federal regulations. Sludge will be processed by centrifuge, filter press, and incineration. The effluent will be chlorinated. A discharge pumping station is provided. (Parsons)

Although there is no arctic camp experience with this specific type of unit, these conclusions can be extended to imply that any type of well-established conventional treatment that can be operated indoors can be operated to achieve the same degree of treatment that it could in a less severe environment. The presence of a standby unit ensures that acceptable treatment would be performed in the event that an upset or breakdown would occur on the primary unit. At an estimated generation rate of 70 gpcpd, the 1,176-person construction camp could be expected to produce 82,000 gpd of wastewater. Thus, the proposed 150,000-gpd capacity plant will be capable of handling these wastewater volumes.

It is very likely that the wastewater disposal for the camp will be governed by the same stipulations that applied to most of the pipeline camps, and specifically by those presented in the waste disposal permit for the Five Mile Camp. These effluent limits, imposed by the Alaska Department of Environmental Conservation (DEC) are:

> The treated liquid waste discharge for any month shall not be permitted to exceed the following limitations:

Final Effluent Characteristic	30 Consecutive Day Average	7 Consecutive Day Average	Daily Maximum
Biochemical Oxygen Demand	30 mg/1	45 mg/1	60 mg/1
Suspended Solids	30 mg/1	45 mg/1	60 mg/1
Oils and Greases	8 mg/1	10 mg/1	15 mg/1
Fecal Coliform Bacteria	200/100 ml	400/100 ml	800/100 ml

- Permittee shall operate and maintain the treatment plant to not exceed the limitations above or to remove not less than 85 percent of the biochemical oxygen demand and suspended solids from the plant influent prior to discharge to the flow control management.

- The pH of the effluent shall not be less than 6.0 standard units nor greater than 9.0 standard units.

- The chlorine residual of the physical-chemical treatment plant effluent shall be greater than 1.0 mg/1 and less than 2.0 mg/1.

- There shall be no discharge of visible floating solids or visible foam.

- Sludge from treatment facilities will not be discharged to waters of the state.

- The method of disposal of sludge shall be incineration or other method approved by the Department.

Surface disposal of treated wastewater was allowable under the following conditions:

> During the period beginning on the effective date and lasting through the expiration date or termination date, the permittee may, after receipt of written permission from the Department, on a case-by-case basis, be authorized to transfer treated liquid waste to the land or surface waters of the State. Not less than 30 days prior to a planned disposal of treated liquid waste permittee shall submit an engineering plan, sealed by a professional civil engineer registered in the State of Alaska, for surface waste disposal, to include recent waste analyses, quantities, proposed locations, proposed frequency of discharge monitoring, and methods of waste disposal to minimize receiving environment impacts.

Based upon the experience of the TAPS project, the impacts of wastewater treatment and disposal on the environment in isolated areas, such as the Yukon River site, are limited. It is assumed that the treatment facilities will meet all state and Federal regulations and thus will impact the environment only as far as the regulatory agencies allow. Although no groundwater monitoring was performed during the TAPS project, there have been known instances where groundwater contamination has occurred from the use of percolation lagoons for properly treated wastewater. The most permanent environmental impact associated with the treatment facilities would be associated with the construction of the large percolation lagoons. Due to the lengthy period required for regrowth of vegetation in the arctic, these lagoons have been characterized as permanent solutions to temporary problems. Another possible impact of this type of disposal would be the thawing of the permafrost by the warm wastewater, with subsequent erosion problems. Again, experience from the TAPS project indicates that this theoretical concern has not been supported by any field observations. The DEC is now in the process of assimilating its monitoring information and is considering the elimination of percolation lagoons as an unnecessary requirement in favor of land application or stream discharge. Thus, percolation lagoons may not be required at the SGCF construction camp. If discharge to a stream is allowed for the treated wastewater, the Yukon River would be the likely receiving stream. The impact of 70,000 gpd (0.1 cfs) of highly treated wastewater on even the minimum flow of 9,000 cfs would be negligible.

Sufficient quantities of water of suitable quality would be available year-round for domestic purposes.

Construction of the proposed facilities could potentially cause more significant impacts. Any spills or leaks of petroleum products associated with construction which entered surface watercourses would adversely affect water quality. Local alterations of surface drainage patterns which might occur at the Prudhoe Bay site from the proposed construction would also result here.

Although no information is currently available, it is anticipated that dredging within the Yukon River would be necessary to accommodate unloading module barges. Yukon River sediments in the vicinity of the Yukon River site are composed of silty sands and, as a consequence, dredging would result in significant turbidity levels.

Air Quality

There are no ambient air quality data available for the Yukon River/TAPS site. It is assumed, however, that the general air quality is good and that state and Federal air quality standards are currently not violated. There are only three sources of air pollutants located within a 48-km. (30-mile) radius of the proposed alternative site: the Five Mile Camp and pumping station associated with TAPS and the haul road. The emission characteristics of the Five Mile Camp are insignificant compared to the emission characteristics for the existing development at North Slope and are not expected to affect the air quality in the region significantly. The haul road is used infrequently and is not a significant source of air pollutants.

The impacts that might result from construction of the SGCF at the Yukon River alternative site would not differ significantly from the impacts predicted for the construction of the proposed facility at Prudhoe Bay. This expectation is based on several assumptions:

- The SELEXOL process would be used at this site.
- The modules would be transported to the site by barges.
- The module size will not differ from those proposed.

No significant differences are anticipated between the construction impacts associated with the Yukon River site and those associated with the Prudhoe Bay site. The same three operations required at the Prudhoe Bay site (i.e., gravel extraction and placement, module unloading, and support equipment, would be required at the Yukon River site. Therefore, the number, type, and use of vehicles would be similar for both sites. Furthermore, the time restrictions on the construction schedules for both sites are similar. Finally, the Five Mile Camp would be used as the construction base camp. Therefore, no new housing facilities would need to be built.

It is expected that the operational impacts of the SGCF at the Yukon River alternative site would not differ significantly from those for operation of the proposed facility at Prudhoe Bay, with the exception of ice fog.

This expectation is based on the assumption that the SGCF to be constructed on the Yukon River alternate site would be the same as the facility built at Prudhoe Bay. The emissions from the significant sources (the gas turbines and the space and process heaters) would be the same for both sites. The operational modes for the SGCF would be the same for both sites. The features of the surrounding terrain would affect the dispersion characteristics of the gas turbines plumes only minimally, and only under adverse meteorological conditions.

As mentioned previously, ice fog formation resulting from the operation of the SGCF would be a problem at this site. Both this alternative site and the Fairbanks alternative site are topographically and meteorologically prone to ice-fog episodes. The gas turbine units associated with the SGCF should not contribute significantly to the problem. The space and process heaters, with their poor dispersion characteristics, probably would be major contributors to any ice fog episodes that might occur. If this site receives serious consideration as the preferred site, an in-depth study should be undertaken to more adequately determine the potential impacts.

Noise Quality

Ambient noise levels have not been monitored at the Yukon River alternative site, but they are estimated to be about 30 dBA. This estimate is based on the general characteristics of the area, which is completely rural. The haul road, TAPS, and the Five Mile Camp are the only areas of human activity within a 16-km.(10-mile) radius of the site.

If the SGCF built on this site were an exact replica of the facility proposed for the Prudhoe Bay site, the noise impacts that would result from construction would not differ significantly from construction impacts at the Prudhoe Bay site. The noise level generated by construction is estimated to be 98 dBA at 15 meters from the construction site. It also is estimated that this noise will be audible at a distance of 3 km.

The noise levels generated during construction would have no impact on human populations in the vicinity because there are no residents in the area.

Noise impacts that would result from the operation of the facility on this site would not differ significantly from those at the Prudhoe Bay site. The noise level associated with the operation of the facility is expected to be 63 dBA at 0.8 km., an increase of 6 dBA above the existing noise level.

There are no humans living in the area, and thus no residents would be affected by the noise levels associated with operation of the proposed facility.

Terrestrial and Aquatic Communities

The alternate site would be located in an area described as an upland spruce-hardwood forest. These forests consist of tall to moderately tall closed forests of white and black spruce, paper birch, aspen, and balsam poplar. White spruce with scattered birch or aspen is commonly found on moderate south-facing slopes, while black spruce is found on northern exposures and poorly drained flat areas. The understory within the upland spruce-hardwood forest consists of spongy moss and low brush on the cool moist slopes, grasses on dry slopes, and willow and alder with dwarf birch in the high open forests near the timberline.

Some of the lowest relief terrain in this area along the Yukon River may be characteristic of a floodplain thicket which forms on newly exposed alluvial deposits that are periodically flooded. The main dominant shrub types include willows and occasionally alders, with a number of lower shrubs under the canopy.

Numerous species of birds are found along the Yukon River in this area, but waterfowl--ducks and geese--are the most conspicuous. Ducks include the American wigeon, lesser scaup, pintail, green-winged teal, white-winged scoters, northern shovelers, and canvasbacks. Geese include Canadian geese, white-fronted geese, and trumpeter swans. Additional waterfowl include lesser sandhill cranes, Arctic loons, and horned and red-necked grebes. Seabirds also occurring on the flats include herring, mew, Bonaparte's gulls, Arctic terns, and long-tailed jaegers; shorebirds such as golden plovers and spotted sandpipers are also found in this area.

Twenty species of raptors occur in the Yukon Basin, and 18 are known or suspected to breed there. Bald eagles nest in small numbers along or near the Yukon River in the lowlands, while a few golden eagles may nest on ledges. Other raptors found in this area include ospreys, goshawks, red-tailed hawks, and great-horned owls, and America's largest falcon, the gyr falcon. The peregrine falcon, an endangered species, is abundant along the Yukon, nesting on bluff faces. The birds may use a nest site repeatedly, though it is common for a pair to utilize several sites.

Muskrats, mink, and river otters occur throughout the region. Beavers may be found wherever there are slow-flowing or still waters and sufficient food. Moose, frequently seen throughout the region, spend much of their time in lakes, feeding on tuberous lily roots in relative freedom from fly and mosquito attacks.

The most widely distributed fish in the Yukon River basin are several species of whitefish, Arctic grayling, slimy sculpin, burbot, Arctic lamprey, and three species of salmon--chum, king, and silver. Inconnu, which are widespread in the Yukon River drainage, are known to spawn in the Yukon River in this area. A small commercial fishery for chum and king salmon exists in the mainstem of the Yukon River. Minor subsistence fisheries also exist for whitefish, inconnu, northern pike, and burbot. The Ray River nearby is a major spawning area for summer and fall run chum salmon.

The noise levels generated during the construction and operation of an SGCF at this site would have some impact on the wildlife populations residing in the vicinity, especially the more sensitive species. It is anticipated that these sensitive species will migrate from the affected area, possibly resulting in a loss of some of these individuals.

A potential of approximately 200 acres of brush and forest would be destroyed by constructing the SGCF at the Yukon River alternate site. Additional but unknown acreage would be disturbed to construct connecting roads and dock facilities. Areas of floodplain thicket that are cleared might be replaced by plant species better adapted to drier soils. Clearing large numbers of trees along the Yukon might result in soil erosion and increased runoff and sediment problems in the Yukon River.

The construction, operation, and maintenance of the Yukon alternative SGCF would reduce wildlife populations of local and regional significance by directly or indirectly destroying their habitats. The reduction would be caused by direct and indirect harassment during critical periods of an animal's life cycle and/or destruction of wildlife because of the introduction of pollutants to the ecosystem and the inability of certain species to adapt to human presence.

Construction of the SGCF at the Yukon River alternative would destroy moose habitat, while operation of the facility might change moose behavior patterns enough so that moose shift to less desirable range.

Bird populations in the Yukon River region would probably suffer the most significant impact of any wildlife species in the area. Potential conflicts between construction and operation of the SGCF at the Yukon site and bird populations could occur from disturbance, habitat destruction, pollution, and direct mortality. Although the Yukon River alternative site is downriver from the comparatively more productive Yukon Flats, construction and operation could increase stress and alter normal bird behavior patterns during critical phases such as spring migration, nesting, molting, or fall migration staging. Such disturbances could decrease reproductive success or cause the birds to desert traditional molting areas or nesting sites. The degree of impact of disturbance to 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 sound, the distribution pattern of the bird, and the species' sensitivity to disturbance.

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 peregrine falcon, an endangered species, nests in the steep cliff and canyon areas of the Yukon River near the Canadian border and also at Franklin Bluffs. From what is known of the species, any disturbance during nesting could result in nest abandonment or even cannibalism of young. Displacement of peregrine falcons from hunting areas is not considered a long-term impact, but because of low population numbers of this species of bird, any population loss is significant.

The primary impacts of SGCF construction and operation on fish would be adverse, arising from increases in suspended particles, reduction in dissolved oxygen, and introduction of pollutants. The effects of these impacts on fish populations would be similar to those described for the proposed Prudhoe Bay site and the alternate site at North Pole.

The Yukon River at or near the SGCF site location would have to be navigable or dredged to the proper depth for barge transportation. Such dredging operations would modify or destroy aquatic habitats and result in a long-term loss of fish. This would be more damaging to most fish species than any short-term environmental degradation.

Land Use and Solid Waste Disposal

The Yukon River alternate site is in an uninhabited, undeveloped area. The site would be located on classified lands designated by the Bureau of Land Management for retention in Federal ownership as the Arctic Transportation and Utilities Corridor. It includes the northern part of TAPS and the proposed route for the ANGTS. This area is used intermittently for recreation, sport hunting and fishing, subsistence, seasonal residences, and resource exploration.

To the northeast of the site, the Yukon Flats area has been proposed as a National Wildlife Refuge to protect the high density wetland waterfowl habitats and adjoining upland wildlife habitats. The Rampart section of the Yukon River, which includes the Yukon River at the alternate site, is also recommended for potential scenic river designation pending clarification of land status in the area and after further study and classification of surrounding land or uses of the river have been completed.

There has been increasing interest in Alaska's interior forests and the possible development of a forest industry. Most of this potential commercial or subcommercial timber operation is projected for the upper sections of the Yukon River, in the general area of the Porcupine River. However, several small scattered sawmills are operating in the area and are producing, when in operation, about 5,000 board feet per day. Two proposed hydroelectric projects (Rampart and Porcupine) have been identified in the area, but there is currently no significant demand for the potential power, flood control, or water storage to be derived from such projects.

The Yukon River is presently navigable by shallow draft barge up to 4 months of the year over most of its length. Existing roads in the area consist of a road from Livengood to the Yukon River and thence along TAPS. However, air is the principal mode of transportation in the area, with the main service from Fairbanks. The TAPS Five Mile Camp airport, approximately 10 km northwest of the alternate site, is a privately owned airport with a gravel runway.

Because of this area's designation as a utility corridor, the existing TAPS right-of-way and the proposed route of the ANGTS are also included in this region. However, construction of the SGCF at the Yukon River alternate site would have significant impacts on present land use.

These lands are now largely undisturbed wilderness used mostly as habitat for wildlife species which depend on extensive areas for their well-being. The wildlife, in turn, provide the base for the subsistence hunting and trapping economy unique to rural Alaska. Subsistence hunting and/or fishing opportunities would be reduced as a result of construction and operation of the SGCF at the Yukon River alternative site. If a part of the TAPS Five Mile Camp could be used for construction workers, some land use impacts would be lessened. However, construction of the SGCF along the Yukon River would probably influence the river's potential scenic river designation.

Alyeska Pipeline Service Company was issued a permit by the DEC to operate a solid waste disposal site (designated as MS 79-1) for Five Mile Camp. Pump Station No. 6, located south of the Yukon River, utilized this same solid waste disposal site. Although the Alyeska permit has expired, the disposal site is still open and operational. Should the Yukon River site be selected for this project, ample capacity is available. DEC officials describe operation of the site as acceptable and usually in conformance with the strict requirements included in the permit. The requirements on the operation of this site (which probably would apply if it were used during the SGCF project) were that all papers, cardboards, and putrescible solid wastes be incinerated before disposal. The only other wastes disposed of were scrap wood (generally disposed of simply by burning), nonsalvageable scrap metals, and foam insulation. Compacted cover was put over the cells weekly, and a final cover was put on when the cells became full.

It is likely that this same disposal site would be utilized by any future construction camps located in this area. The DEC encourages the use of a single site rather than scattered smaller ones. However, if it were not possible to use this site, another suitable site could easily be located. Groundwater depth and preference for already disturbed lands would be the major considerations in selecting a new site. Any new site would probably be required to comply with the same DEC permit stipulations.

With TAPS now complete, the impact of the existing solid waste disposal site on the existing environment is minimal. The DEC has estimated that the rate of generation of solid wastes from a pipeline construction camp would be 8 pounds/capita/day, which would be a total of 4 tons/day for a 1,000-worker camp. Although it is not possible to estimate the volume and weight reduction achieved by prior incineration because of the limited data available, the reduction would be quite large.

Socioeconomics

The nearest named inhabited place to the alternate site is Stevens Village. Stevens Village, located approximately 32 km. from the site, is representative of a Native subsistence community. In 1970, Stevens Village had a Native population of 72 out of a total population of 84 and was declared eligible for village land selection under the Alaska Native Land Claims Settlement Act in 1971.

The people of Stevens Village live primarily by subsistence hunting and fishing. The annual average subsistence harvest for the years 1969-1973 had an estimated gross weight of 88,370 pounds. Fish, principally salmon, grayling, whitefish, and pike, made up 83.3 percent of the total; mammals, principally black and grizzly bear, muskrat, and hares, 13.9 percent; birds, principally ducks, 1.1 percent; berries, 1.1 percent; and garden produce, 0.6 percent.

In the 1970 census, 19 of the 24 villagers (79 percent) in the local employment survey were listed as unemployed on a cash-economy basis.

Construction of the SGCF at the alternative Yukon River site would result in impact to local Native communities. Construction would bring permanent facilities and concentrate human activities in areas that have been valuable for subsistence uses in the past. Annual subsistence harvests by nearby Native villages would be affected if construction and operation of the SGCF caused impact to wildlife populations in the area that are used for subsistence needs.

Small villages such as Stevens Village would not be able to provide housing, public services, or other amenities required for workers involved in construction, operation, and maintenance. Housing for both temporary construction workers and permanent SGCF employees may be provided by construction of a new work camp or possible utilization of the TAPS Work Camp 5. Most of the trade and service necessities required by workers would probably be provided by the Fairbanks area, the major distribution center for this northern area of Alaska. Only a few residents of the isolated villages in the area would probably be employed in either construction or operation of the proposed facilities at the Yukon River alternate site.

As with any development, there would be potential for significant changes in the existing way of life for the local communities. Any changes in lifestyle would likely be long-lasting. The changes affecting the Native residents in the Yukon River area would be similar to those described for the Native residents at the proposed Prudhoe Bay site.

Revenues to the state and local governments would increase as a result of construction of the SGCF at the Yukon River alternative. However, these increased returns would be accompanied by increased costs for services as more people move into remote and uninhabited regions of Alaska. It is not known whether Native communities in the area would forego economic development to retain cultural and social values.

Recreation and Aesthetics

Alaska has a diversity of landscapes, from broad low wetlands to high mountains and lake-dotted coastal plains to rugged, rain-drenched coastlines. The Yukon River, which traverses many of these types of landscapes, has remained largely unaltered from its natural state. It provides recreation, primarily boating and fishing in the summer and early fall. Swimming is not a major activity. During winter, the frozen Yukon provides a thoroughfare for recreational travel by foot, dogsled, or snowmobiles. Travel is severely curtailed during spring and fall when ice on the Yukon is unsafe and snow is insufficient or soft.

Scenic features along the Yukon River for boaters or hikers may include colorful bluffs, canyons, rock outcroppings, mountains, rapids, falls, or a variety of vegetation. Wildlife observation opportunities also occur along much of the Yukon drainage, and this river possesses prehistoric, geological, and paleontological values as well.

If construction of the SGCF at the Yukon River alternate site improved the access to this region, either by better airports, roads, or water navigability, then recreational use would increase. Because dredging would be required in certain areas of the river in order to offload the modules to the site, increased recreational boating and larger vessels would be expected to occur on the river.

Clearing brush and forest for the existing TAPS right-of-way, the additional right-of-way for the proposed ANGTS, and the construction of the SGCF at the Yukon River site would combine to significantly alter the natural environment and would consequently degrade the region's aesthetic values. The major aesthetic impact would be the sight of those facilities that catch the eye from roads, trails, or from boats on the river. Construction of the SGCF at this site would contribute to the continual deterioration of this area as a wilderness environment in interior Alaska.

Cultural Resources

There is a good probability that the Yukon River alternative site is an archaeologically sensitive location. Although no sites were found at the TAPS crossing, the river has been an important transportation corridor for prehistoric and historic peoples and a major caribou hunting area. The Iroquois Research Institute study also notes that confluences of streams, rivers, and bluffs on river basins--the conditions at this site--are zones of high archaeological potential. Most sites in the area are hunting lookouts and chipping stations. An intensive site survey would be necessary before construction at this site.

4. Alternate Pipeline Pressure Design Considerations

The options that presently exist for the segment of the Northwest Alaskan pipeline system north of Whitehorse are: (1) a 48-inch diameter, 1,260-psig system, (2) a 42-inch diameter, 1,680-psig system, (3) a 48-inch diameter, 1,440-psig system, and (4) a 42-inch diameter, 2,160-psig system. The AGPO must recommend to the Commission the maximum operating pressure for the Alaskan leg of the Northwest Alaskan pipeline system. After hearings conducted with applicants, the Canadian government, and the State of Alaska and an internal study, the AGPO has decided ("System Design Inquiry," February 1978) to recommend to the Commission a 1,260-psig, 48-inch diameter pipeline system that can be upgraded to a 1,440-psig system if necessary. (See Transcript of Proceedings, Systems Design Inquiry, December 15, 1978.)

The choice of pipeline must also take into consideration the possible modes of transporting the various hydrocarbons produced from the gas conditioning facility. These possibilities are:

(1) Transportation through TAPS or a new NGL pipeline;

(2) Transportation through the ANGTS;

(3) Use within field as fuel for production, processing, and conditioning facilities;

(4) Use as fuel for flow stations on TAPS and fuel for compressor stations on ANGTS;

(5) Transportation in a 1,680-psig, dense-phase pipeline;

(6) Reinjection; and

(7) Some combination of these procedures.

The possible methods of using hydrocarbons will be determined by the pressure selected for the Northwest Alaskan pipeline; however, the hydrocarbon dewpoint will dictate the amount of hydrocarbons that can be blended into the oil and gas transmission lines for transportation to a present or future customer. The staff used hydrocarbon dewpoint data supplied by Arco, Exxon, and SOHIO in its analysis of alternative systems design.

a) Arco's Position

Arco states that all of the gas may be transported at 2,160 psig without any prior conditioning, while at 1,680 psig, the pipeline could carry all of the propanes and lighter hydrocarbons and 50 to 98 percent of the butanes. The remainder of the butanes and the heavier molecular weight hydrocarbons would have to be removed during the initial processing. At a pipeline pressure of 1,260 psig, all of the propanes and lighter hydrocarbons could be transported as a gas, along with 25 to 60 percent of the butanes. Additional quantities of butanes and heavier molecular weight hydrocarbons would be transported by TAPS. Carbon dioxide, which enhances hydrocarbon-carrying capacity, need not be removed prior to conditioning or pipeline transportation, because it would not corrode the pipeline.

Arco's main concern is that additional cooling of the oil pipeline, required to maintain a constant vapor pressure within the pipeline so that additional quantities of butane can be transported, may lead to wax formations within the pipeline.

b) SOHIO's Position

SOHIO claims that the total volume of gas may be transported at 1,680 psig, provided no CO_2 is removed. This would be compatible with the specifications of a dense-phase pipeline, since dewpoint curves indicate that the maximum dewpoint pressure of natural gas, NGL's, and CO_2 blended in the pipeline is approximately 1,360 psig. However, SOHIO states that upset conditions for the 1,680-psig pipeline would occur at 1,300 psig and -23°C. While the gas would still remain in a single phase at this pressure, there could be little variation in temperature before fallout occurred, damaging the pipeline system and causing system shutdown. A slight increase in temperature to -21°C. would cause some of the gas to condense, resulting in a two-phase flow inside the gas pipeline.

SOHIO also claims that approximately 62 to 75 percent of the butanes can be transported through a 1,260-psig gas pipeline. However, heavier molecular weight hydrocarbons would have to be moved through the oil pipeline.

When oil production increases from 1.2 million barrels a day to 1.5 million barrels per day, some additional cooling of the oil pipeline would be required. Because constructing and operating cooling facilities would cost less than increasing pipeline compression to 1,680 psig, transporting the butanes in the oil pipeline would be cost effective.

c) Exxon's Position

Exxon, like Arco, claims that the gas may be transported at a pressure of 2,160 psig without prior conditioning. However, it states that the 12 percent by volume of CO_2 presents some risk of corrosion. In an apparent contradiction, Exxon has stated that there may be some difficulty in obtaining financing for a lower pressure, 1,680-psig pipeline because design and construction of such a large-diameter, high-pressure pipeline would require new technology and present greater risks.

The company has stated that a 1,440-psig pipeline would be feasible but not economical. A 1,260-psig pipeline would be more economical at a low flow rate, while the 1,680-psig pipeline would be more economical at high flow rates (above 3.8 Bcfd). The 1,440-psig pipeline would be more economical only in the 3.6 to 3.8 Bcfd range.

In summary, there appears to be disagreement as to the need to remove the pentane plus heavier hydrocarbons at a pipeline pressure of 1,680 psig. The staff specifically requests comments on this issue.

d) Additional Design Considerations

Present specifications dictate that the conditioned gas will contain 1 percent by volume CO_2. The common CO_2 volumetric standard for pipeline quality gas is approximately 3 percent. If a 3-percent standard is adopted, an additional 165 trillion Btu's of natural gas would be delivered to the ANGTS over the life of the project than if a 1-percent CO_2 standard is in effect. Increasing the CO_2 in the gas pipeline would serve two additional functions: the cost of conditioning the feed gas would be reduced substantially, and since CO_2 acts as a carrying agent for the NGL's, more NGL's could be blended into the pipeline.

The applicants have expressed concern about the additional safety hazards associated with a higher pressure system, which would increase the likelihood of damage to the oil pipeline if the gas pipeline ruptured. To minimize this danger, crack arresters would be required for the 1,680-psig and 1,440-psig systems, but they might not be required for the 1,260-psig system.

Tentative calculations indicate that if a 1,260-psig Alaskan pipeline merges with the contemplated 56-inch diameter, 1,080-psig Canadian pipeline below the permafrost region so that a "hot" pipeline operation is permissible, no hydrocarbon dewpoint problems should be encountered. If a 1,680-psig Alaskan pipeline were constructed and the heavier hydrocarbons (pentanes plus) not removed at Prudhoe Bay, difficulties might be encountered where the higher pressure operation joined the lower pressure operation and also at the highest crossing in the Canadian mountain range. These problems would probably necessitate in the removal of the heavier hydrocarbons prior to the Canadian segment.

5. Process Alternatives

To deliver an acceptable sales gas to the pipeline, the SGCF must remove most of the carbon dioxide present and a portion of the heavier hydrocarbons. Consideration of the vapor pressures of the hydrocarbons involved shows that after the carbon dioxide is removed, the ethane and propane can be left in the gas without exceeding the $-10^{\circ}F$ at 1,100 psi hydrocarbon dewpoint specification, but at least a portion of the butanes and almost all of the pentanes-plus fractions must be removed to meet the specifications.

Removal of acid gases, such as carbon dioxide and hydrogen sulfide, is often required in the treatment of natural gas, and a variety of processes have been developed for this purpose. These processes are based on contacting the raw gas with either a liquid that physically dissolves the gas to be removed or with an alkaline solution that chemically reacts with and absorbs the undesired gas. Both types of processes are used widely in gas treatment, and both could be applicable at the proposed SGCF.

a) Chemical Absorbent Processes

These processes involve the formation of weakly-bound chemical reaction products between the carbon dioxide and an amine in water solution. The amines used are typically monoethanol amine, diethanol amine, diisopropyl amine, etc. The solution containing the weak carbon dioxide-amine compound is heated in a recovery vessel to drive off the carbon dioxide and to recover the amine, which is cooled and recirculated through the process. These amine processes have certain characteristics in common that bear on their performance:

- A relatively large amount of heat is required in the desorption step. Design calculations in Perry's Chemical Engineer's Handbook (1978) give a direct-fired heater requirement of 2,500 million Btu/hr for a 2,600 million cfd high-load diethanol amine (DEA) process, with air-cooled heat exchangers to handle 1,625 million Btu/hr.

- The absorbing solutions require the presence of water, with potential problems of freezing and corrosion.

- A relatively pure carbon dioxide stream (over 95 percent) is produced.

- There is little absorption of hydrocarbons, and further treatment may be required to meet the hydrocarbon dewpoint specification.

- The required circulation of the absorbent solution is a function of the amount of acid gas to be removed, so the processing train becomes larger as the amount of carbon dioxide in the raw gas increases.

b) Physical Absorbent Processes

Carbon dioxide is quite soluble in a number of organic solvents. The solubility is a direct function of pressure, and physical absorbent processes depend on reducing the pressure to desorb the carbon dioxide. This method consumes less energy than desorption by increasing temperature, as must be done in the chemical absorption processes. These solvents also absorb considerable amounts of methane and other hydrocarbons, so the desorption is done by reducing the pressure in several steps. The earlier stage flash gases, which contain most of the absorbed methane, are recycled to the beginning of the process. Because the solubility of the carbon dioxide is increased by high pressure and low temperature, the processes normally are operated under these conditions. The higher hydrocarbons are more soluble and, thus, are removed effectively. The higher hydrocarbons, such as the C_6 fraction, may be absorbed so effectively by some solvents that they are not readily removed by stripping, and a distillation process may be required.

There are a variety of solvents that have been used in various proprietary processes, as follows:

Process	Vendor	Solvent
Rectisol	Lotepro	Methanol and others
SELEXOL	Allied	Dimethyl ether of polyethylene glycol
Propylene Carbonate	Fluor	Propylene carbonate
Purisol	Lurgi	N-methyl-2-pyrrolidone
Sulfinol	Shell	Tetrahydrothiophene-1, 1-dioxide*

* The Sulfinol process usually includes an alkanolamine and thus is a combination chemical/physical solvent process.

Processes using these and other solvents have been proposed or used for gas treatment, all operating at temperatures near ambient or below and at pressures of from a few hundred to about 1,000 psi, with desorption by pressure release. Major differences between the processes relate to the different properties of the solvents and to the differences in the process arrangements to conserve energy by using expanding gases to drive turbines and provide the desorption step. The general similarities of the physical solvent processes are:

- Less heating and heat exchange surface are required because the desorption takes place by pressure release rather than by raising the temperature. This generally results in an energy savings.

- The absorbing solutions do not contain water, reducing corrosion and freezing problems.

- The removal of carbon dioxide usually is less complete, and the purity of the high-carbon dioxide stream is less than with the chemical solvent processes.

- The removal of high hydrocarbons is much larger than with the chemical processes.

- The concentration of carbon dioxide in the solvent is a function of the pressure, inverse temperature, and the concentration in the raw gas. Thus, the removal becomes more efficient the larger the concentration of carbon dioxide in the feed gas.

- By varying the pressures, temperatures, and flash steps, there is a considerable degree of flexibility available for choice of product streams and purities.

c) Process Alternatives Environmental Factors

Out of the several alternative processes initially studied by the team composed of sponsors of the original SGCF study, only two physical solvent processes (SELEXOL and Fluor's propylene carbonate) and one physical/chemical process (Sulfinol) were selected for further investigation. The discussion that follows thus concentrates on these three processes.

i. Waste Liquid Discharges

The feed gas delivered to the SGCF would be at less than the water dewpoint, so no water would be removed from the gas during processing. Because of potential freezing problems, air-cooling would be used to dissipate heat, and no cooling water would be used. Thus, there are no wastewater discharges from the absorber process during normal operation from any of the three processes that are process-dependent, and hence the choice of absorber process does not affect the waste liquid discharges.

During emergencies, water may be used to fight or reduce the danger of fire. All of the three processes operate at similar pressures. The two physical processes, SELEXOL and Fluor, have more rotary turbines and compressors, with attendant leak potential, whereas the physical/chemical process, Sulfinol, has more pieces of equipment and more potential corrosion problems, thus increasing its leak potential. The potential for major breaks or accidents would appear to be approximately similar for all three processes, so that the choice of process does not appear to be a major factor in the possibility of emergency waste liquid discharges.

ii. Waste Hydrocarbon Discharges

There is a significant difference between the physical and the physical/chemical processes in terms of waste hydrocarbon discharges. In the physical/chemical process, Sulfinol, the separation of CO_2 is quite good, resulting in a stream that is 98+ percent CO_2, which could be discharged to the atmosphere or could be injected back into the formation, if desired. In the physical processes, the CO_2-rich streams are less pure--in the 90-percent range--and would be disposed of by using them as fuel in the process and at the base camp. However, the demand for fuel is expected to be less than the amount of this high-CO_2 stream at times, and the excess would have to be disposed of in an alternate way. Injection into the formation is planned for this disposal, since the hydrocarbon content is too high to permit discharge to the atmosphere without incineration.

iii. Solid Wastes

There are no process-dependent solid wastes from the three processes.

iv. Air Emissions

The air emissions from the operation of the three alternative processes differ widely. The preferred process, SELEXOL, has been analyzed in depth, and the results of this analysis can be reviewed in section C of this EIS. Therefore, the SELEXOL process has been used as a "base-case." From this analysis, it was determined that the emissions from the space and process heaters are the major area of concern. They are not only the major potential source of ice fog during the winter months, but they also are the major source of ground-level NO_2 concentrations. The predicted maximum ground-level concentrations for NO_2 was the only concentration for a criteria pollutant that exceeded the Minimum Significant Levels.

Based on Btu requirements of the three alternative processes, the Fluor process requires approximately 35 percent more Btu's for space and process heat, and the Sulfinol process requires over 400 percent more Btu's for space and process heat than the SELEXOL process. Based on the assumption that an increase in Btu's yields a proportional increase in total emissions, the SELEXOL process would produce the lowest NO_2 ground-level concentrations.

The SELEXOL and Fluor processes produce a 90-percent CO_2 content fuel for use in the heaters and turbine. The Sulfinol process produces only a 26-percent CO_2 fuel for use in the heaters and turbines. Addition of CO_2 to the fuel results in a lower burning temperature, therefore lower NO_x emissions. The result of this situation is an additional increase of NO_2 generation from the Sulfinol process over and above the 400-percent increase due to higher Btu demands. Total CO_2 emissions attributable to the processes are:

SELEXOL	7.3 million tons/year
Fluor	6.4
Sulfinol	8.6

An increase of 1 ppm of ambient CO_2 concentration could be expected from an emission rate of 7.5 million tons/year of CO_2. Because the atmosphere normally contains over 300 ppm of CO_2, the environmental effects of any of the processes would be negligible in this regard.

v. Construction Impacts

All three processes require the same general types of equipment and plant design, and construction impacts will be qualitatively similar. One of the major factors leading to the selection of the SELEXOL process was the fact that it required fewer process trains and major equipment items; the Sulfinol process required the most. Thus, the plant area for the Sulfinol process would probably be the largest, and the SELEXOL plant would use the least area. Quantitative comparisons are not possible, since only the SELEXOL plant has been subjected to preliminary design.

vi. Butane Fraction Disposal

A considerable quantity of butanes enter the processes with the feed gases. It is planned to combine most of the butanes with the sales gas, up to the point permissible by the dewpoint specification. A typical distribution of the butanes is as follows:

Into process with feed gas	291,000 pounds/hour
To sales gas	160,000
To local and field fuels	35,000
To crude line with C_5's	9,000
Excess	87,000

If the excess is added to the crude, the total butanes added to the crude will be 96,000 pounds/hour, or about 11,000 bbl/day. This will be about 0.8 percent when added to a crude flow of 1.4 million bbl/day.

California regulations limit the true vapor pressure of a crude to 11 psia unless vapor control measures are taken during storage and use. Calculations indicate that the amount of added butanes will raise the vapor pressure by less than 1.5 psi from the original 9 psia vapor pressure of the crude at a storage temperature of 100°F., so that the 11 psia maximum will not be exceeded. However, if the pipeline is flowing at less than the 1.4 million bbl/day rate used in the above calculations, the vapor pressure increase will be higher, and the 11 psia limit could be exceeded. Problems could also be caused in meeting the TAPS pressure specifications, and it might be necessary to provide chilling of the crude if the butanes were to be added. Alternatively, it may be possible to add a larger amount of the butanes to the sales gas than used in the example above and still meet the hydrocarbon dewpoint; this will reduce the excess butanes which must be blended into the crude or disposed of in some other way. The Parsons report indicates that it may be possible to add almost the entire butane fraction to the sales gas.

If it is determined that adding the excess butanes to TAPS will cause problems, alternate disposal methods must be considered. With the Sulfinol process, the 87,000 pounds/hr of butanes, equivalent to about 1,700 million Btu/hr, could be used for heater fuel, replacing high-methane content gas which could increase sales gas delivery. This would not be possible with the SELEXOL or Fluor processes, where heater fuel needs are smaller and are met by the high-CO_2 gas stream, which is present in excess of needs, so that a portion of it has to be reinjected. Incineration or reinjection of the excess butanes are alternate disposal techniques.

Another available alternative is to increase the sales gas CO_2 specification from 1 to 3 percent. This would decrease the hydrocarbon dewpoint and allow the incorporation of more butanes. Experimental evaluation would be required to determine how much more butanes could be added to the sales gas and the effect this would have on the heat value of the sales gas.

vii. Noise Impacts

The noise impacts from the process alternatives are not expected to vary significantly from those predicted for the preferred alternative. Refer to section C.5 for a detailed discussion regarding predicted impacts from the preferred SELEXOL alternative.

I. CONCLUSIONS AND RECOMMENDATIONS

The environmental staff finds that the proposed Prudhoe Bay site is acceptable. While the staff considers the North Pole alternative site to be acceptable as well, it believes that the site is not sufficiently superior to the Prudhoe Bay site to warrant its selection. The alternative Yukon River site has been found to be less acceptable than either the proposed Prudhoe Bay site or the alternative North Pole site.

There are several advantages in locating the SGCF at Prudhoe Bay. The site is close to the source of gas and adjacent to the Beaufort Sea, which would provide a convenient means for delivering construction materials to the site. The site has a foundation of adequate stability, few topographic irregularities, minimal slope, is not in a seismically active area, and would not be subject to tsunamis, storm tides, or river flooding. The land in the general vicinity of the site has already undergone significant development by the petroleum industry, and the site would be included in an area which the North Slope Borough has proposed as a zone of preferred industrial development. Neither air emissions or noise would be expected to exceed acceptable levels, though air emissions would require further review. Climatological conditions at the Prudhoe Bay site are not ideal, but this is also true of the Yukon River and North Pole alternatives.

The potential for some adverse impact because of construction and operation of the proposed facilities at Prudhoe Bay does exist. Significant impact to the marine environment could occur because of potential dock construction. Additionally, transportation of materials to construct docking and onshore facilities would increase barge traffic along the North Slope of Alaska and within the Prudhoe Bay area. Barge routes might be similar to the migratory route of the endangered bowhead and gray whales, and the endangered peregrine falcon in northern Alaska may utilize the Beaufort Sea coast. The FERC staff is currently preparing biological assessments on the bowhead and gray whales to be submitted to the National Marine Fisheries Service and on the peregrine falcon to be submitted to the United States Fish and Wildlife Service. The assessments will describe the type of effect that may occur to these species as a result of the proposed action.

Potentially less significant impact would also occur at the proposed site because of permafrost degradation, gravel extraction, drainage alterations, water use, and topographical alterations.

The North Pole alternative site offers many of the same advantages as the Prudhoe Bay site but with three significant exceptions. It is within the highly seismic area of central Alaska. It is also located in an EPA non-quality nonattainment area for CO. Costly reduction of emissions produced by other facilities would be required before the SGCF could be placed in operation. A last resort would be to relocate the SGCF outside the nonattainment area. In conjunction with the climatological conditions that cause the CO problems, ice fog in the North Pole area is anticipated to be a greater problem than at the Yukon River or Prudhoe Bay sites. Finally, while adverse socioeconomic impact could occur to both Fairbanks/North Pole and North Slope Borough communities, the boom/bust cycle experienced in the Fairbanks community is of particular concern. Construction of the conditioning facilities at North Pole would mitigate the current bust portion of the cycle. However, it could also contribute significantly to an even more serious bust following the completion of construction.

Little or no significant adverse impact on aquatic communities, hydrology, topography, or geology is anticipated at the North Pole site because of construction and operation. Impact to soils, terrestrial communities, recreation and aesthetics, and cultural resources should be relatively minor at both the North Pole and Prudhoe Bay sites.

Cut and fill operations at the Yukon River alternative site would extensively modify the topography. The foundation stability of the site is poor, and the site is located in an area of high seismic activity. Construction at the site would cause significant adverse impact to the topography, geology, soils, hydrology, aquatic community, and, potentially, to archaeological resources. Additionally, while the site would be located on lands designated by the Bureau of Land Management for retention in Federal ownership as the Arctic Transportation and Utilities Corridor, the Rampart section of the Yukon River, which includes the Yukon River alternative site, may be recommended for scenic river designation. Construction of the SGCF along the Yukon River would probably influence the decision on this recommendation.

Although the environmental staff concludes that the environmental impact associated with the construction and operation of the SGCF at Prudhoe Bay as proposed would be acceptable, it recommends that the following procedures be implemented to further mitigate potential environmental impact from the proposal: 1/

1. Because of the rate of unemployment and percentage of families with incomes below the poverty level in the area, the applicant shall use local Alaskan and Native Alaskan workers as much as possible during construction and operation of the project. Particular emphasis shall be given to training local Alaskans and Native Alaskans for the 200 permanent operating positions proposed for the SGCF.

2. Existing module fabrication sites shall be used to the maximum possible extent.

3. Existing facilities at Prudhoe Bay shall be used to the maximum extent possible, including but not limited to wastewater systems, incinerators, water supply systems, and living quarters.

4. The applicant shall conduct and submit to the staff a study analyzing the feasibility of using waste heat produced by gas turbine units. One such use to be studied is space heating.

5. The applicant shall conduct and submit to the staff a detailed study identifying the environmental impact associated with the existing and future wastewater and water storage systems.

6. Water withdrawn from the Put River for both water supply replenishment and daily use shall be limited to the months of June and July.

1/ Further recommendations may result from the biological opinion issued by the National Marine Fisheries Service or U.S. Fish and Wildlife Service on the endangered species.

7. All construction and facilities shall be scheduled and/or designed to maintain free movement and safe passage of fish, birds, and mammals, both onshore and offshore. The adequacy of the design will be determined by Alaska Department of Fish and Game (ADFG).

8. Construction and other operations associated with the proposal shall be conducted so as to avoid or minimize degradation of fish and wildlife breeding, staging, molting, nesting, spawning, overwintering, calving, and rearing areas designated by ADFG.

9. Water use and other activities which alter natural hydrologic conditions in a manner which is detrimental to overwintering, migration, spawning, survival, or habitat of fish, seabirds, or waterfowl are prohibited unless approved by the ADFG.

10. Transportation shall be scheduled and conducted to minimize disturbance of ground cover and to minimize adverse impact on fish and wildlife. Transportation corridors must be routed around biologically sensitive areas during sensitive periods.

11. Fixed-wing aircraft and helicopters shall avoid low-level flights over areas sensitive to wildlife disturbance.

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APPENDIX A

Is this necessary?

PROPERTIES OF OIL FORMATIONS

Oil reserves are complicated systems whose physical properties, fluid contents, and latent energies within the reservoir fluids dictate the degree of ease or difficulty which the producer will experience in tapping the hydrocarbons trapped below the surface of the ground.

A petroleum reservoir consists of a porous stratum of rock which is capped with an impervious layer of rock. The shape of the structure must be such that the oil (or gas) can accumulate in the porous zone. The cap rock prevents further upward migration of the contents. The most common type of reservoir is a dome-shaped structure or "anticline." In some instances, the dome may be almost hemispherical; in other cases, it may be narrow and elongated.

Porous rocks normally contain three fluids within their pores --oil, gas, and water. Since the fluids have different densities, the force of gravity tends to cause the fluids to segregate, with any gas, being lightest, on top, oil and water on the bottom. Where the rock stratum is flat, any gas or oil present will flow to the top of the porous rock formation. When the porous formation is tilted, gravity will cause the oil or gas to move in an updip direction until they meet some restriction, such as a fold in the formation. When oil is trapped in an anticline or other type trap, water will commonly exist downdip on the flanks of the structure. If the porous formation is quite thick, water may also exist directly underneath the oil.

The nature of reservoir rock is extremely important, because the oil is stored in the small spaces or pores which separate the individual rock grains. The porisity of a rock is the volume of all the pores and openings expressed as a percentage of the total volume of reservoir rock. If the oil is to enter or leave the rock, there must be a free connection between one pore and the next. The ability of the rock to allow passage of fluids through interstices depends on the size of the connecting channels which exist between one pore space and the next (permeability).

For oil to move through the pores of the reservoir rock and into the bottom of a well, the pressure under which the oil exists in the reservoir must be greater than the pressure at the bottom of the well. As long as this differential pressure can be maintained, the oil and its associated dissolved gas will continue to flow into the producing well.

The following paragraphs summarize natural production mechanisms.

1. Water drive: When a porous formation covers an area much larger than the area of the entrapped oil, the reduction in the reservoir pressure causes the water under pressure in the porous formation (called an aquifer) to flow into the oil reservoir. The amount of energy obtained from expansion of a barrel of water under pressure as the pressure is reduced is quite small. However, in a large aquifer, the amount of water may greatly exceed the amount of oil trapped within local areas of the aquifer. If the aquifer is large enough and has a high enough permeability, the energy provided by expansion of water in the aquifer may be sufficient to cause water to move into the oil reservoir to replace all oil withdrawn. Such an oil reservoir would be said to possess an "active water drive."

If the aquifer is smaller relative to the oil reservoir or if the permeability isn't high enough to allow water to flow up to the oil reservoir fast enough to replace the oil withdrawn, a field may have a "partial water drive." This provides little of the energy necessary to produce the oil or a large portion of it. A field with a partial water drive at one producing rate might have an active water drive at a lower rate.

Under some conditions, a water drive may be the most effective mechanism to recover oil. In order to utilize the energy from a water drive most effectively, it may be necessary to limit the rate of oil production so that the aquifer water can enter the vacated section of the oil-bearing zone as the oil is extracted. If the oil production rate exceeds the rate of water entering the reservoir, pressure will decline and consequently reduce the energy available for oil production.

2. Solution gas drive: Gas is soluble in oil. In most reservoirs, considerable gas is dissolved in the oil under pressure. As oil is produced and the pressure declines, gas is released from solution in the oil. The gas, having a high expansion ability, expands to replace the oil.

In the absence of a water drive that maintains the reservoir pressure use at a high level, a portion of the energy required to produce the oil will be provided by expansion of the released solution gas. In reservoirs with no water drive, essentially all the energy may be provided by expanding gas. Far more energy is available in the gas than is required to move all the oil to the well bore in most reservoirs. Unfortunately, gas is much more mobile than oil, and as its saturation builds, it flows to the well bore in increasing amounts and is produced with the oil. Thus, much of the energy needed to produce the oil is dissipated. Consequently, a solution gas drive is generally less efficient than other recovery mechanisms.

3. Gas cap drive: When more gas is present than can be dissolved in the oil at the reservoir pressure, the free gas will collect at the highest portion of the structure (trap) above the oil. As oil is withdrawn and the reservoir pressure declines, the gas in the gas cap will expand to displace the oil and maintain reservoir pressure. A gas cap drive may be extremely efficient, exceeding the potential recovery from water drive reservoirs, or extremely inefficient, approaching recovery from a solution gas drive reservoir. The problem is that the gas cap gas, because of its high mobility (low velocity), tends to finger through the oil rather than displace it or overrun the oil along the top of the reservoir and come into the producing oil wells. Thus, it is often difficult to prevent producing the gas cap gas and dissipating its energy. In reservoirs with steep dips or thick oil columns, it is sometimes possible to minimize gas cap production, and oil recoveries may be quite high.

4. Gravity drainage or gravity segregation: The force of gravity, which resulted in the oil and gas being trapped initially, may also be used in the recovery of oil. Gravity represents an inexhaustable source of energy. The problem is that the amount available is quite small. Consequently, unless the porous rock has a high permeability, allowing oil to flow with a low energy expenditure, gravity may

provide only a small fraction of the energy required. However, in reservoirs with a necessary combination of steep formation dips, thick oil columns, and high permeability, the forces of gravity may be utilized to yield extremely high recoveries. As an example, the force of gravity opposes those forces which tend to cause gas cap gas to finger through the oil or overrun the oil and cone into producing oil wells. In reservoirs with high permeabilities where pressure into producing well bores is low (or where producing rates are low), gravity may minimize dissipation of the gas cap gas and allow high oil recoveries.

Even in reservoirs with no gas cap, gravity may be important. If the permeability is high enough to produce low pressure gradients, gravity will cause much of the gas to flow to the top of the trap and form a secondary gas cap (a secondary gas cap is formed from solution gas after oil production starts). This allows the energy present in the solution gas to be conserved rather than dissipated, as in most solution gas drive reservoirs, and can allow high oil recoveries.

The Sadlerochet reservoir at Prudhoe Bay has a large primary gas cap, a thick oil column, a high permeability, and a large aquifer to the west. The large aquifer would suggest the possibility of an active water drive. However, the permeability of the aquifer decreases away from the reservoir, and as a consequence, most reservoir engineers and geologists expect only limited water ice flux into the reservoir.

The thick oil column and relatively high permeability suggest that gravity forces will be useful in oil recovery. The operators plan to allow the primary gas cap to expand to displace oil. Producing rates and oil withdrawal points will be controlled to minimize gas fingering, overrunning, or coning. To the extent possible, they will allow the oil to drain into producing oil wells, utilizing gravity, rather than allowing active displacement (pushing) by an expanding gas cap. Initially, they will produce at rates exceeding drainage rates, and there will be some active displacement of oil by gas. Eventually, however, they will reduce oil producing rates to the drainage rate. In its later stages, therefore, the Sadlerochet reservoir will produce by a gravity drainage mechanism.

PLANT AND PROCESS ECONOMICS

It has been roughly estimated that increasing the level of carbon dioxide (CO_2) from 1 percent to 3 percent by volume would reduce the gas conditioning plant capital cost in 1978 dollars by $100 million and operating cost by $5 million per year. Lowering the CO_2 content in the gas stream would provide the following cost-reduction advantages:

1. The SELEXOL solvent stripping unit (solvent regenerator) along with associated equipment (expanders and compressors) could be eliminated. Solvent regeneration would be handled by successive differential pressure flash drums already present in final process design.

2. It would reduce the SELEXOL solvent circulation rate through the absorption column.

3. The deethanizer duty could possibly be performed by an enlarged gas fractionating unit, thus eliminating the cost of a deethanizer and associated equipment.

Taking greater advantage of the low ambient temperatures which exist for a substantial portion of the year could substantially reduce fuel costs. The refrigeration system has necessarily been designed to cope with an ambient temperature of 22°C, which is exceeded only a few hours of the year at Prudhoe Bay. However, about 75 percent of the time, the ambient temperature is below -1°C. Sales gas chilling loads could be eliminated by providing adequate ventilation to all heat exchangers during winter operations. Utilizing pumps rather than differential pressure to move the propane refrigerant through the system would allow all power recovery equipment (economizers) to be located at the lowest practical pressure levels. This would make maximum benefit of the horsepower and fuel saving potential of economizers. Additional fuel and NGL savings could be realized by heating fractionater reboilers with waste heat from turbine exhaust. It has been roughly estimated that this system would result in an operating cost savings of $8 million per year ($2.00/million Btu), as well as a potential capital cost savings, by eliminating reboiler furnaces and replacing them with heat recovery systems.

Under normal operating conditions, module space heat could be supplied from process waste heat. This would amount to some 300 million Btu per hour (under winter conditions) generated without utilizing NGL's or CO_2-enriched fuel gas.

APPENDIX C

PRUDHOE PROCESS DESCRIPTION

1. Inlet Separation and Field Fuel Gas Facilities

Feed gases originating from the gathering centers and flow stations would enter the proposed SGCF through the existing Central Compressor Plant (CCP) inlet separators. These separators serve as liquid slug catchers and, in conjunction with downstream filter separators, remove and recover any entrained liquids or particulates from the feed gases.

Feed gas for the existing field fuel gas unit is withdrawn downstream from the filter separators. The field fuel gas unit feed is compressed in one of the existing first-stage injection compressors to between 1,700 psig and 1,800 psig. In the field fuel gas unit, the gas is cooled to -40°C. at 850 psig by heat exchange and Joule-Thompson expansion. Cold vapor and condensed liquid are separated, and the net field fuel gas unit conditioned gas is warmed by heat exchange with feed gas and goes to the TAPS fuel line. Cold separator liquid also is warmed by heat exchange with feed gas and is vaporized partially at about 635 psig. The separator vapor returns to the main SGCF feed, and the net separator liquid joins the deethanizer feed stream.

2. NGL Extraction

The feed stream from the inlet separators would flow to the four parallel gas conditioning trains of the NGL extraction and CO_2 removal processes. Each train could condition 33 percent of the total flow, thus effectively providing one spare train. Within each of these trains, the feed gas would be combined with the SELEXOL stripper overhead gas and would be cooled to -34°C. by heat exchange and propane refrigeration. Condensed liquids would be separated from the cooled feed stream in the low-temperature separator and would be pumped through a feed stream in the low-temperature separator and would be pumped through a feed gas heat exchanger where they would be heated to -9°C. A partial demethanization flash would occur in the deethanizer feed flash drum, and the remaining liquid would be heated to about 31°C. by further exchange with feed gas and then would be fed to the deethanizer.

3. CO_2 Removal

The vapor from the low-temperature separator would be heated to about -7°C by exchange with feed gas and would be fed to the SELEXOL absorber along with deethanizer feed flash drum vapor, deethanizer overhead product gas, and SELEXOL recycle flash gas. In the absorber, the feed gas would be contacted countercurrently with lean SELEXOL solvent that would absorb the CO_2, a substantial portion of methane and ethane, most of the propane, and essentially all of the heavier hydrocarbons from the gas. Propane refrigeration cooling would be required in the circulating solvent system to maintain the design operating temperature. The conditioned absorber overhead gas would be warmed by heat exchange with feed gas and then would be routed to the pipeline gas compressors.

4. Pipeline Gas Compression and Chilling

The conditioned gas streams from the four NGL extraction/ CO_2 removal trains would be combined. The propane product and most of the butanes product from fractionation would be vaporized into the combined gas stream at this point. After compression and after-cooling in the CCP equipment, the conditioned gas stream would be chilled to -4°C. for delivery to the gas pipeline.

5. CO_2

The SELEXOL solvent system is a simple recirculating loop. Solvent rich in CO_2 first flows from the absorber through a hydraulic power recovery turbine to a recycle flash drum. In the recycle flash drum, a large percentage of the methane coabsorbed with the CO_2 is vaporized and compressed back to the absorber feed. Rich SELEXOL from the recycle flash drum flows through another hydraulic turbine to an intermediate pressure (IP) flash drum. A large part of the coabsorbed ethane, as well as CO_2 vapors, are released in the intermediate pressure flash. Solvent from the intermediate pressure flash drums is routed to the low-pressure flash drum, where the bulk of the absorbed CO_2

and coabsorbed propane and heavier hydrocarbons are released. The low-pressure flash gases are compressed to a nominal 325 psig level and are routed to the local fuel fractionator. A stripper is required to reduce the CO_2 content of the lean solvent to the level required to condition gas to the 1-percent CO_2 level. Solvent from the low-pressure flash drum is pumped to the SELEXOL stripper, where it contacts a slipstream of treated gas from the absorber. The stripping gas from the absorber is depressurized through two expander stages for power generation and refrigeration recovery. Stripper overhead vapor is compressed back to feed gas pressure and recycled to the feed gas NGL extraction system for recovery of stripped hydrocarbons. Stripped overhead vapor is compressed back to feed gas pressure and recycled to the feed gas NGL extraction system for recovery of stripped hydrocarbons. Stripped lean solvent is pumped from the stripper back to the absorber, thus completing the circuit.

6. NGL Fractionation

The single-train fractionation facilities would consist of the local fuel fractionator, deethanizer, depropanizer, and debutanizer. All of these columns are reboiled by direct-fired heaters. Compressed SELEXOL low-pressure flash gas is fed to the local fuel fractionator to recover the bulk of the propane and the heavier hydrocarbons from the gas. The column would have a refrigerated overhead condenser and is similar to a deethanizer. Separate feed-overhead heat exchangers would be used for the local turbine fuel and for the heater fuel portions of the overhead product. Propane would be added to the turbine fuel portion of the overhead product for enrichment. This propane would be vaporized in the feed-overhead exchanger. Local fuel fractionator bottoms product would be fed to the depropanizer.

The deethanizer feed is made up of deethanizer feed flash liquids and NGL from the field fuel gas unit. The deethanizer operates at a nominal 450 psig with a propane-refrigerated condenser. Deethanizer overhead vapor product is compressed and can go either to field fuel or to the SELEXOL absorber feed. Deethanizer bottoms product is fed to the depropanizer along with local fuel fractionator bottoms.

The depropanizer produces a liquid propane overhead product stream. The low propane content depropanizer bottoms product could be blended directly into crude oil or could be fed to the debutanizer.

The debutanizer produces a liquid butane overhead product and a pentanes-plus bottoms product. The debutanizer overhead product can be almost totally injected into the pipeline gas without exceeding the pipeline gas hydrocarbon dewpoint specification or can be blended into the crude oil up to true vapor pressure limitations.

A system is provided to inject the liquid feed for any column in the fractionation facilities alternatively into the producing formation. Therefore, an upset or equipment failure in the unspared fractionation facilities would not impair either crude oil production or pipeline gas deliveries.

A small sidestream rectifier is utilized on the depropanizer to provide refrigerant-grade propane as makeup for the refrigeration system. This column draws a small ethane-free vapor feed from below the depropanizer feed tray and produces a very pure propane overhead product. The bottoms are pumped back to the depropanizer.

7. Fuel System

The SELEXOL intermediate-pressure flash gas is collected from the CO_2 removal trains and is compressed to a nominal 500 psig for use in the field fuel. Compressor discharge heat is used to vaporize propane. The propane is injected into this stream for heating value control. Field fuel requirements greater than those available from this flash gas stream are met by adding field fuel gas unit conditioned gas (in excess of TAPS requirements), deethanizer overhead vapor, and low temperature separator vapor, in that order. The combined field fuel gas has a relatively high hydrocarbon dewpoint. This gas is heated to 60°C. by exchange with the exhaust gas from the field fuel gas compressor turbine driver to prevent condensation in the insulated field fuel distribution system.

In situations where the field fuel requirement is relatively low, there could be an excess of SELEXOL intermediate-pressure flash gas. At such times, excess field fuel compressor discharge would be bled into the local turbine fuel system.

This, in turn, would create an excess of local fuel fractionator overhead vapor. During this operation, the excess CO_2-rich local fuel fractionator overhead could be compressed and reinjected into the producing formation. If the local fuel fractionator were shut down, the feed to this column would be used for local fuel, and the excess feed would be injected using both CO_2 compressors. Also, during periods of high local fuel demand, field fuel compressor discharge would be used to supplement local fuel fractionator overhead.

8. Plant Yields

In addition to the nominal 2 billion cubic feet per day of pipeline gas conditioned by the SGCF, there are a number of other streams that are separated incidental to the pipeline gas conditioning. These include the high CO_2 NGL. The flash gases would be utilized as fuel at the SGCF and for fuel requirements of the Prudhoe Bay complex. The NGL's which include separate ethane, propane, butane, and pentanes-plus streams, could be blended into the fuel streams (propane) to control heating value, the pipeline gas to the hydrocarbon dewpoint limitation (propane or butane), or into the crude (butane or pentanes-plus) as limited by the vapor pressure specification.

The design anticipates that there would be a significant variation in the fuel requirements at the SGCF between the extremes of summer and winter operation. The demand for fuel by the Prudhoe Bay complex would vary both as a function of season and time as well as oil production rates. The blending of butanes into either pipeline gas or crude is controlled by the pipeline hydrocarbon dewpoint limitation or by economics. These variations have been incorporated in the design. The schemes illustrated represent the maximum and minimum anticipated demand for fuel by the Prudhoe Bay industrial complex and assume no blending of butanes to the pipeline gas.

MODULAR CONSTRUCTION

A generic study was developed on the possible impacts associated with the prefabrication sites required for modular construction in the lower 48 states. The discussion that follows summarizes the study. Copies are available from the FERC or from EPA's regional office in Seattle.

Construction of the SGCF would use modular construction techniques. Preassembled modules that can be assembled easily at the North Slope site would be fabricated in the lower 48 and would be shipped to Alaska by oceangoing barges. Each contained equipment module would contain as complete a system as possible. The only limiting factor for module size is logistics, that is, the physical requirements for loading, transporting, off-loading, and emplacing the modules at the Prudhoe Bay site. The modular construction method would minimize the labor required on the North Slope and would take advantage of the higher productivity of the lower 48. Modules would also reduce potential delays that could result from adverse weather conditions at the Alaskan construction site.

Modular fabrication sites would probably be located on the west coast of the United States adjacent to major deep-draft waterways that could accommodate oceangoing barges. The west coast provides favorable weather conditions, adequate labor forces, and the shortest shipping distance to the North Slope. Four existing or recently operational modular fabrication sites have been identified at Seattle/Tacoma, Washington, and Alameda and Oakland, California. These sites have produced modules, almost exclusively for Alaskan use. The modules for the proposed SGCF would be similar in size and overall construction. Most of the identified sites are located in or near major metropolitan areas, and all are within easy access of large navigable waterways. The proximity of most sites to urban areas permits access to large labor pools, ensures the availability of a wide variety of skills, and minimizes the travel time of the work force.

The four individual modular fabrication projects investigated had land area requirements that ranged from 0.65 acre/module/year to 1.25 acres/module/year. As a general rule, 1 acre per module per year would be sufficient for most modular fabrication. Parsons estimates that the SGCF would require 0.95 acre/module/year. The estimate is based on construction of 200 modules during the first year and 52 modules during the second. The site (or sites) would require the following land area during the first year:

Category	Area (acres)
Erection	102
Closed warehouse	12
Yard storage	28
Field office and parking	6
Craft parking	42
Total	190

Although the same site or sites would be used during the second year of construction, only 78 acres (1.5 acres/module/year) would be required. In comparison to the past and present projects surveyed, such a site would be one of the largest sites on the west coast, if all activities were consolidated on a single 200-acre site. It is unlikely, however, that a suitable site of this size could be located.

Wherever possible, existing fabrication sites should be used for new projects unless the purchaser requires a different location. The use of existing sites eliminates the need to acquire or lease a new site and also limits the number of site improvements required for a particular project. Several of the existing sites investigated did not have all of the facilities indicated in the Parsons Report. As a result, some limited new construction may be necessary if an existing site(s) were used; only limited new construction would be required. The required construction materials should be available readily in any major metropolitan area.

Module construction does not require raw materials as typically defined, because most components of the module are processed material. Many of the components would be available only from particular suppliers that may be located beyond the local area. The amount of materials, components, and other supplies to be used for the Prudhoe Bay modules cannot be quantified because no specific engineering plans for the modules are available.

The labor requirements for this workload under either the phased start (1982/1983) or the full capacity start (1983) are indicated in table D-1. Under either alternative, a relatively large peak labor force would be required, consisting almost entirely of construction occupations. The requirements for certain specialized skills in module fabrication exceed the number of workers available in the metropolitan areas of the

TABLE D-1

ESTIMATED MAXIMUM LABOR FORCE REQUIREMENTS FOR THE MODULAR FABRICATION OF THE PRUDHOE BAY SGCF

Labor type	1983 Full Startup	1982-83 Phased Startup
Pipefitters	1,066	1,600
Ironworkers	467	700
Electricians	467	700
Laborers	200	300
Carpenters	200	300
Sheetmetal workers	200	300
Painters	200	300
Operating engineers	200	300
Total	3,000	4,500

Source: Parsons, 1978.

selected fabrication sites. However, only a portion of the requirements are for highly qualified master craftsmen, and many of the positions could be filled by new entrants to the labor force if adequate apprentice programs were available. Also, improved job opportunities in certain occupations would cause some workers to shift occupations, either permanently or for the duration of the shortage. In general, the wages of pipefitters, electricians, and iron workers would rise relative to the wages of other workers in the area and relative to wages elsewhere. This would induce trained workers to move into the area, new workers to become trained in those occupations, and existing workers in closely related fields to switch occupations. Employers probably would economize on highly skilled workers by substituting less skilled workers requiring more supervision.

The Parsons report and the survey of existing fabrication firms indicate that the use of multiple sites for the module fabrication facilities required for the Prudhoe Bay project is both advantageous and necessary. The foremost reason is that no single existing or potential module fabrication site would be available to construct all the modules required for the first-year sealift (183 for full startup; 243 for phased startup). In addition, no major metropolitan area with adequate port facilities is likely to have available the large labor force required for this fabrication operation. Consequently, multiple sites located in different cities would probably be required.

If existing fabrication sites could be utilized, the additional costs of multiple sites would be minimal compared to the benefits of more efficient operations. Existing sites would require only limited new facilities, permitting construction to be completed more quickly. In addition, multiple sites would disperse the limited environmental impact over two or more locations.

The four sites investigated indicate that the demographic characteristics of a location are not particularly important to that area's ability to support modular fabrication operations. Although the location must have a diversity of labor skills and the typical characteristics of a major metropolitan area, other criteria such as adequate port facilities, waterway access, land availability, and shipping distance are more important. As a result, it is likely that any major west coast port including San Diego, Los Angeles, Long Beach, or Vancouver, Canada, could provide a suitable location for modular fabrication. Several of these locations were identified in the initial survey of existing fabrication sites, and the other locations might have been identified had the survey included all existing west coast fabrication sites. The following impacts were observed at the sites studied:

- No process emissions were found at any module fabrication site, because no industrial process is performed onsite.

- Sanitary wastewater generated at the sites usually was in relatively small quantities and would require no special considerations.

- The only potentially significant amount of wastewater is from the hydrostatic pressure testing of the modules, which on occasion requires that certain substances such as glycol be mixed with the testing water. However, in all of the projects surveyed, this wastewater was collected and treated off-site.

- Module fabrication operations were relatively large producers of solid waste, but this waste normally included no toxic or hazardous materials.

- Potential air pollutant emissions from a module fabrication site would result from the operation of construction and loading equipment and commuter and service vehicles. However, even under "worst case" conditions, it is unlikely that the emissions at the site would affect air quality significantly.

- Noise is not likely to be a significant problem.

In general, module fabrication sites were found to be similar to typical industrial construction sites. The only exception is that when construction is completed at a modular fabrication site, the module is removed from the site and relocated. The construction is not water- or material-intensive, and there are no significant environmental impacts or process wastes. The entire operation can be characterized as a clean construction activity that is a labor-intensive stimulus to the local economy.

Based on the Parsons report, several conclusions on the module fabrication facilities required for the Prudhoe Bay SGCF were made. They include:

- The relatively large first-year size of the project (approximately 200 modules) would require at least two separate sites and possibly as many as three or four sites. Although the multiple sites would create additional costs for management and facilities, these costs would be at least partially offset by more efficient operations that will ensure that the modules would be ready for the first-year sealift.

- The multiple-site approach is likely to require fabrication sites in several different geographical locations. This would allow a larger and more diverse labor pool to be used and would place a smaller burden on metropolitan services and facilities.

- Although the environmental impacts from the modular fabrication operations are not anticipated to be significant, multiple sites would serve to disperse them, further reducing their importance.

- Because existing module fabrication sites are expected to be used for the Prudhoe Bay project, no new construction of module fabrication sites is likely. As a result, no new impacts on environmentally sensitive or critical areas (floodplains, wetlands, critical habitats) are anticipated.

- The final location(s) selected for fabrication would experience short-term economic gains, but no significant expansion of the economic base is expected.

The overall conclusion of this analysis is that the module fabrication operations required for the Prudhoe Bay SGCF would not result in any significant environmental problems, if existing prefabrication sites are utilized to the maximum extent possible.

APPENDIX E

AMBIENT GROUND-LEVEL CONCENTRATIONS FROM THE CONSTRUCTION OF THE SGCF AND ITS ANCILLARY FACILITIES

Construction of the SGCF and its ancillary facilities will produce airborne pollutants that could adversely affect air quality in the surrounding area. To quantify the impact of construction on air quality, the staff estimated emissions from equipment used during the major construction activities. The emissions then were evaluated collectively to determine their impact on the ambient pollutant concentrations. This appendix presents the methodologies and assumptions used in estimating total pollutant emissions from all construction activities and the resulting ground-level increases in pollutant concentrations. Pollutant emissions from all construction equipment are shown in table E-1.

TABLE E-1

ESTIMATED TOTAL POLLUTANT EMISSIONS (TONS/YEAR) FROM THE EQUIPMENT REQUIRED FOR ALL CONSTRUCTION

Construction Operation	Particulates	Total Estimated Exhaust Emissions SO_2	CO	HC	NO_2
Gravel extraction, transportation, and placement operations	18.5	32.0	94.80	30.70	531.5
Module unloading, transportation, and placement	1.67	2.43	40.19	6.37	41.64
Other support functions	2.98	2.20	1,475	94.4	36.50
Total Emissions	22.65	36.63	1,609.99	131.47	1609.64

1. Gravel Extraction, Transportation, and Placement

To estimate the emissions (tons/year) from the construction equipment required for gravel extraction, transportation, and placement operations, it was necessary to know the type and amount of equipment that would be used, the emission rates of the equipment, and the amount of time that the equipment would be used. The equipment to be used and the emission rates are presented in table E-2. The amount of time that the equipment will be used was determined by estimating how much

TABLE E-2

TOTAL ESTIMATED EXHAUST EMISSIONS RATES (GRAMS/HR) FOR THE CONSTRUCTION EQUIPMENT REQUIRED FOR GRAVEL EXTRACTION, TRANSPORTATION, AND PLACEMENT 1/

Equipment	Quantity	Carbon Monoxide (CO)	Exhaust Hydrocarbons (HC)	Nitrogen Oxides (NO_x as NO_2)	Sulfur Oxides (SO_x as SO_2)	Particulates (TSP)
Motor grader	1	97.7	24.7	478	39.0	27.7
Track-laying tractors	2	175.0	50.1	665	62.3	50.7
Wheeled loaders	3	251.0	84.7	1,090	82.5	77.9
Off-highway trucks (bellydumps)	40	610.0	198.0	3,460	206.0	11.6

1/ Source for emission rates: EPA, 1977.
Source for equipment requirements: Parsons, 1978.

gravel could be moved per day, knowing that approximately 1.3 million cubic meters are needed. The following assumptions were made:

1) 1,278,315 cubic meters (M^3) of gravel are needed.

2) Each bellydump holds 15.3 cubic meters.

3) Each bellydump makes 15 trips per day from the gravel extraction site to the plant site.

4) All equipment is used 24 hours a day.

Determination of how many hours each piece of equipment will operate to move 1,278,315 M^3 of gravel:

15.3 M^3/trip x 15 trips/day

= 229 M^3/day for each bellydump

x 40 belly dumps

= 9,180 M^3/day

1,278,315 M^3/9,180 M^3/day

= 140 days (i.e. approximately 140 days (around the the clock) to provide the gravel needed for pads and access roads.)

140 days x 24 hrs/day = 3,360 hours (i.e., each piece of equipment is used 3,360 hours).

Determination of total emissions:

g/hr x 3,360 hours x 2.205 x 10^{-3} lbs/g x 1 ton/2000 lbs

= tons/year x no. of each type of equipment = total emissions (tons/year)

Sample calculation:

- motor grader -

Determination of carbon monoxide emissions in tons per year, given an emission rate of 97.7 g/hr and assumptions 1 through 4:

$$= 97.7 \text{ g/hr} \times 3360 \text{ hours/year} \times 2.205 \times 10^{-3} \text{ lbs/g}$$

$$\times 1 \text{ ton/2000 lbs} = 3.62 \times 10^{-1} \text{ tons/year}$$

The results of this analysis are presented in table E-3.

TABLE E-3

ESTIMATED POLLUTANT EMISSIONS (TONS/YEAR) FOR CONSTRUCTION EQUIPMENT REQUIRED FOR GRAVEL EXTRACTION, TRANSPORTATION, AND PLACEMENT OPERATIONS

Equipment	Quantity	Total Estimated Exhaust Emissions				
		Particulates	SO_2	CO	HC	NO_2
Motor grader	1	0.103	0.144	0.362	0.091	1.77
Track-laying tractor	2	0.376	0.462	1.29	0.371	4.93
Wheeled loader	3	0.866	0.917	2.78	0.941	12.11
Off-highway truck (belly dump)	40	17.2	30.5	90.4	29.3	512.7
Total Emissions		18.5	32.0	94.8	30.7	531.5

2. Module Unloading, Transportation and Placement

To estimate the emissions (tons/year) from equipment required for module unloading, transportation, and placement, it was necessary to know the type and amount of equipment that would be used, the emission rates of the equipment, and the amount of time that the equipment would be used. The equipment to be used and the emission rates are presented in table E-4. Total emissions were estimated using the following assumptions:

TABLE E-4

TOTAL ESTIMATED EXHAUST EMISSION RATES (GRAMS/HOUR) FOR EQUIPMENT REQUIRED FOR MODULE UNLOADING, TRANSPORTATION, AND PLACEMENT

Equipment	Quantity	Particulates	SO_2	CO	Exhaust HC	NO_2
Crawler transporters 1 pair - 1000 ton 1 pair - 800 ton 1 pair - 700 ton	3 pairs	a	a	a	a	a
200-ton capacity crawler cranes,[b] 160 ft. boom	2	63.2	64.7	188	71.4	1030
250-ton capacity lowboy tractor-trailers[b]	3	116	206	610	198	3460
Fuel truck[c]	1	--	--	30.52	3.65	2.53
Lube truck[c]	1	--	--	30.52	3.65	2.53
Mechanics' van - outfitted[c]	1	--	--	30.52	3.65	2.53
Gear van[c] - outfitted including rigging gear	2	--	--	30.52	3.65	2.53
50-ton hydraulic truck crane[b]	1	63.2	64.7	188	71.4	1030
Portable 365 cfm air compressors[d]	2	0.44	0.39	250	15.2	4.97
30 kw generators[d]	3	0.44	0.39	250	15.2	4.97
40-ton tractor trailer[b]	1	116	206	610	198	3460
3/4-ton pickups[c]	16	--	--	30.52	3.65	2.53
10-ton loader[b]	2	77.9	82.5	251	84.7	1090
1200-ton capacity pneumatic tire vehicles	2	a	a	a	a	a
Burning van[c] with oxyacetylene equipment	1	--	--	30.52	3.65	2.53
Crew buses[c]	3	--	--	30.52	3.65	2.53

[a] Emission rates not available.

[b] Emission rates reported in grams/hour (EPA 1977).

[c] Emission rates reported in grams/mile (EPA 1977).

[d] Emission rates reported in grams/hp-hour (EPA 1977).

1) Heavy-duty equipment would be used 24 hrs/day for 77 days (module unloading, transportation, and placement time).

2) Emission rates for light vehicles (e.g., pickups and vans) were computed using EPA's MOBILE 1 program, assuming:

- 1981 model year vehicles would be used.
- Operation would be at -1°C.
- Operation would be at an average speed of 48.3 km/hr.
- Cold-start emissions would be negligible.
- Each vehicle would be used 32,180 km/yr.
- Particulate and SO_2 emissions would be negligible.

3) Emission rates for nonvehicular equipment (e.g. generators and compressors) were converted from grams per horsepower - hour (EPA 1977) to tons per year, assuming:

- Small utility four-stroke gasoline engines would be used.
- Average horsepower of the equipment would be 5 hp.
- Equipment would be used 16 hours per day for 6 months.

Sample calculation:

- cranes -

Determination of carbon monoxide emissions in tons/year, given an emission rate of 63.2 g/hr and assumptions 1 through 3.

= 188 g/hr x 24 hrs/day x 77 days/year

x 2.205 x 10^{-3} lbs/g x 1 ton/2000 lbs

= 0.383 tons/year

x 2 cranes = 0.766 total tons/year

The results of this analysis are presented in table E-5.

TABLE E-5

ESTIMATED POLLUTANT EMISSIONS (TONS/YEAR) FOR EQUIPMENT REQUIRED FOR MODULE UNLOADING, TRANSPORTATION, AND PLACEMENT

Equipment	Quantity	Total Estimated Exhaust Emissions: Particulates	SO_2	CO	HC	NO_2
Crawler transporters 1 pair - 1000 ton 1 pair - 800 ton 1 pair - 700 ton	3 pairs	a	a	a	a	a
200-ton capacity crawler cranes,[b] 160 ft. boom	2	0.258	0.269	0.766	0.29	4.20
250-ton capacity lowboy tractor-trailers[b]	3	0.709	1.26	3.73	1.21	21.15
Fuel truck[c]	1	--	--	0.813	0.128	0.098
Lube truck[c]	1	--	--	0.813	0.128	0.098
Mechanics' van-outfitted[c]	1	--	--	0.813	0.128	0.098
Gear van-outfitted including rigging gear	2	--	--	1.63	0.256	0.196
50-ton hydraulic truck crane[b]	1	0.129	0.132	0.383	0.145	2.10
Portable 365 cfm air compressors[d]	2	0.009	0.008	5.09	0.310	0.101
30 kw generators[d]	3	0.013	0.012	7.64	0.464	0.152
40-ton tractor trailer[b]	1	0.236	0.420	1.24	0.403	7.05
3/4-ton pickups[c]	16	--	--	13.0	2.05	1.57
10-ton loader[b]	2	0.317	0.336	1.02	0.345	4.44
1200-ton capacity pneumatic tire vehicles	2	a	a	a	a	a
Burning van[c] with oxy-acetylene equipment	1	--	--	0.813	0.128	0.098
Crew buses[c]	3	--	--	2.44	0.384	0.294
TOTAL EMISSIONS		1.67	2.43	40.19	6.37	41.64

[a] Not available.

[b] Emission rates obtained from EPA, 1977.

[c] Emission rates obtained using EPA model MOBILE I 1979.

[d] Five-hp gasoline four-stroke engine. EPA, 1977.

3. Support Equipment

In addition to the support equipment required for module unloading, transportation, and placement, approximately 135 light vehicles and 350 nonvehicular items would be used in a support function during other construction activities. Sample calculations to estimate emissions are presented below:

- light vehicle -

Determination of carbon monoxide emissions in tons/year, given an emission rate of 21.38 g/vehicle-mile and the operational assumptions:

$= 21.38$ g/vehicle-mile x 20,000 miles/year x 2.205×10^{-3} lbs/g

x 1 ton/2000 lbs = 4.71×10^{-1} tons/year-vehicle

x 135 vehicles = 63.64 total tons/year of CO.

- nonvehicular item -

Determination of carbon monoxide emissions in tons/year, given an emission rate of 250 g/hp-hr and the operational assumptions:

= 250 g/hp-hr x 5 hp x 16 hrs/day x 183 days/year

x 2.205×10^{-3} lbs/g x 1 ton/2000 lbs

= 403 tons/year (per item)

x 350 items

= 1412 total tons/year of CO.

The results of this analysis are presented in table E-6.

4. Groundlevel Concentrations

To estimate the maximum downwind ground-level increases in pollutant concentration ($\mu g/m^3$) resulting from the equipment

TABLE E-6

ESTIMATED POLLUTANT EMISSIONS (TONS/YEAR) FOR CONSTRUCTION EQUIPMENT TO BE USED IN A SUPPORT FUNCTION

Equipment	Quantity	Total Estimated Exhaust Emissions				
		Particulates	SO_2	CO	HC	NO_2
Light vehicles[a]	135	-	-	63.6	8.7	8.4
Nonvehicular items[b]	350	2.48	2.20	1412	85.5	28.1
Total Emissions		2.48	2.20	1475	94.4	36.5

[a] Light vehicles include pickups and crew buses. Emission rates were obtained using EPA model MOBILE 1 (1979).

[b] Nonvehicular items include generators, compressors, and space heaters. Emission rates were obtained from EPA, 1977.

required for all construction activities, a "box model" was used. This box model takes into account emission rate, wind speed, mixing height, and area. The box model gives an estimate of increases in pollutant concentrations using the formula

$$x = \frac{Q}{ULA^{0.5}} \times 10^6 \ \mu g/g$$

Where:

- X is the increase in concentration in $\mu g/m^3$ (dependent variable)
- Q is total emission rate in g/sec
- U is the average wind speed in m/sec for May through October; u = 12.2 mph = 5.45 m/sec
- L is the average mixing height in meters; L = 500 m
- A is the area in square meters;

  $A = 16.25 \text{ miles}^2 = 4.21 \times 10^7 \text{ m}^2$
- Long-term refers to annual; short-term refers to 24 hours.

Sample calculation for carbon monoxide:

$$X_{[CO]} \text{ long-term} = \frac{46.31 \text{ g/sec}}{5.45 \text{ m/sec} \times 500\text{m} \times (4.21 \times 10^7 \text{m}^2)^{0.5}} \times 10^6 \ \mu g/g$$

$$X_{[CO]} \text{ short-term} = X_{[CO]} \text{ long-term} \times \left(\frac{8760 \text{ hr}}{24 \text{ hr}}\right)^{0.5}$$

$$= 2.6 \ \mu g/m^3 \times \left(\frac{8760}{24}\right)^{0.5}$$

$$= 49.67 \ \mu g/m^3$$

The results of this analysis are presented in table E-7.

TABLE E-7

COMPARISON OF NAAQ'S AND ESTIMATED MAXIMUM DOWNWIND GROUND-LEVEL INCREASES IN POLLUTANT CONCENTRATIONS RESULTING FROM CONSTRUCTION EQUIPMENT

Pollutant	Time of Average	Primary Standard	Secondary Standard	Estimated Maximum Groundlevel Increase in Pollution Concentrations
Particulate matter (TSP)	Annual (geometric mean)	75 ug	60 ug (guideline for 24-hour standard)	0.04 ug/m^3
	24-hour	260 ug[b]	150 ug[b]	0.76 ug/m^3
Sulfur oxides (SO_x) (measured as SO_2)	Annual (arithmetic mean)	80 ug (0.03 ppm)		0.06 ug/m^3
	24-hour	365 ug (0.14 ppm)[b]		1.15 ug/m^3
	3-hour	--	1,300 ug (0.5 ppm)[b]	3.24 ug/m^3
Carbon monoxide (CO)	8-hour	10 mg (9 ppm)[b]	Same as primary	2.6 ug/m^3
	1-hour	40 mg (35 ppm)[b]	Same as primary	49.67 ug/m^3
Hydrocarbons (HC) (nonmethane measured as CH_4)	3-hour (6 A.M. to 9 A.M.)	160 ug (0.24 ppm)[b] (guideline for O_3 standard)	Same as primary	11.35 ug/m^3
Nitrogen dioxide (NO_2)	Annual (arithmetic mean)	100 ug (0.05 ppm)	Same as primary	0.99 ug/m^3
Ozone (O_3)[d]	1-hour	240 ug (0.12 ppm)[b]	Same as primary	--
Lead (Pb^{+2})[e]	Calendar quarter	1.5 ug[c]	Same as primary	--

[a]Concentration in weight per cubic meter (corrected to 25° and 760 mm of Hg).

[b]Concentration not to be exceeded more than once per year.

[c]Concentration not to be exceeded more than one day per year.

[d]Revised 8 February 1979; 44 FR 8220.

APPENDIX F

<u>REPORT ON THE AIR POLLUTION DISPERSION ANALYSIS FOR THE SALES GAS CONDITIONING FACILITY AND ITS ANCILLARY FACILITIES</u>

An air pollution dispersion analysis was performed to predict the maximum ground-level concentrations of air pollutants that would be produced by the SGCF and its ancillary facilities. The significant sources modeled in the effort included the gas turbine units and the space and process heaters. These sources were modeled under worst-case meteorological and operational conditions. The results of this effort were compared to the Prevention of Significant Deterioration (PSD) increments and Minimum Significance Levels.

All major existing and EPA PSD-permitted sources were also modeled. This analysis was performed to predict the air quality background levels of the region. These sources were modeled under "worst-case" meterorological and operational conditions. The results of this analysis were compared to the primary NAAQS.

EPA handles the program for PSD. Construction or modification of most sources (28 catagories of industries and production facilities) of air emissions which have the potential to emit more than 100 tons per year of any air pollutant and other sources which have the potential to emit 250 tons per year of any pollutant require EPA's PSD preconstruction approval. To receive PSD approval, a proposed facility must not violate the PSD air quality increments, meet the best available control technology, and not violate national ambient air quality. At present, only particulates and sulfur dioxide air emissions have increments associated with them. However, other applicable pollutants must meet the latter two conditions.

This study was conducted to:

- Estimate the maximum long- and short-term increases in air pollution concentrations resulting from the operation of the SGCF and its ancillary facilities located at the Prudhoe Bay site. The analysis was performed by combining the emission rates of the significant emission sources associated with the SGCF.

- Determine whether the predicted increases in maximum ground-level concentrations resulting from the operation of the proposed facilities would exceed the PSD increments or would cause the entire oil production operation to violate the NAAQS.

- Predict the air quality background levels of the Prudhoe Bay site by modeling all major existing and EPA PSD-permitted emission sources associated with the major oil production operation.

1. Emissions From the Proposed Facility

There are two significant sources of air pollutants associated with the proposed SGCF--the gas turbine units and the space and process heaters. Emission characteristics for these sources are presented in table F-1.

The gas turbine facility would consist of three 25.9 MWe simple cycle units. Two units will be operated at a partial load, while the third unit will be kept in reserve. For purposes of this study, all three units were assumed to run at 100-percent load 100 percent of the time.

The process heaters would supply process heat to the fractionation portions of the conditioning facility. The space heaters would supply heat to the living, working, and recreational portions of the facility. There will be six process heaters, three 70 x 10^6 BTU/hr. heaters, and three 150 x 10^6 BTU/hr. heaters. One heater of each size would be kept in reserve. There will be three 130 x 10^6 BTU/hr. space heaters. Two of these heaters would be running continuously, and one would be kept in reserve. For the purpose of this study, all nine units were assumed to run at 100-percent load 100 percent of the time.

Emissions data for the existing and EPA PSD-permitted facilities were obtained from ARCO's Prevention of Significant Deterioration Permit Application. The emission characteristics of the existing facilities are presented in table F-2. The emission characteristics of the permitted facilities are presented in table F-3.

The meteorological data used for the analyses were collected at the Barter Island weather station. Barter Island is approximately 190 kilometers east of the Prudhoe Bay site. Barter Island experiences generally the same meteorological and climatological conditions as those experienced at the Prudhoe Bay site.

TABLE F-1. EMISSION CHARACTERISTICS FOR THE PROPOSED SGCF AND ANCILLARY FACILITIES AT THE PRUDHOE BAY OIL FIELD[a]

Source	UTM		TSP		SO_2		NO_x		HC		CO		Stack Parameters[b]			
	(East)	(North)	g/s	t/y	g/s	t/y	g/s	t/y	g/s	t/u	g/s	t/y	HS(m)	DS(m)	Ts(°K)	Vs(m/s)
Gas turbine units (3)	443.7	7802.2	1.794	624	0.078	2.7	52.958	1842	5.348	186	14.663	510	30.0	2.69	755	50
Space and process heater (9)	443.7	7802.2	1.179	41	3.163	110	11.788	410	0.201	17	1.179	41	30.0	0.03	623	10.6

[a] Indicated emissions are gram per sec (g/s) and tons per year (t/y) for maximum, continuous operation.

[b] Indicated stack parameters are stack height (US) in meters (m), stack diameter (DS) in meters (m), stack exit temperature (Ts) in degrees Kelvin (°K), and stack exit velocity (Vs) in meters per second (m/s).

TABLE E-2. EMISSION CHARACTERISTICS OF EXISTING FACILITIES IN THE PRUDHOE BAY OIL FIELD[a]

Facility Description	UTM (East)	UTM (North)	TSP g/s	TSP t/y	SO_2 g/s	SO_2 t/y	NOx g/s	NOx t/y	HC g/s	HC t/y	CO g/s	CO t/y	Stack Parameters[b] HS(m)	DS(m)	Ts(°K)	Vs(m/s)
A.R.Co. Operation Center P-357																
Gas Boilers (4)	449.5	7,794.6	0.019	0.7	0.001	(c)	0.434	15.1	0.006	0.2	0.032	1.1	7.6	1.0	623	10.6
Space Heater	449.5	7,794.6	0.003	0.9	0.001	(c)	0.030	1.1	0.001	(c)	0.004	0.1	22.8(d)	0.3	623	10.6
A.R.Co. Construction Camp Power Plant P-358 COTU Gas Heater (81.8 mm BTU)	448.4	7,794.7	0.117	4.1	0.007	0.2	2.700	93.7	0.035	1.2	0.198	6.9	22.8(d)	1.0	623	10.6
A.R.Co. Crude Oil Topping Unit P-136																
Gas Fired Crude Oil Htrs (3)	449.3	7,794.4	0.116	4.0	0.000	0.0	1.330	46.3	0.170	6.0	0.000	0.0	22.8(d)	1.2	555	10.6
Waste Incinerator and Gas Afterburner	449.3	7,794.4	0.038	1.3	0.113	3.9	0.396	1.4	0.706	24.6	0.940	33.0	10.7	0.9	1,033	6.9
A.R.Co. Flow Station No. 1 P-138																
Gas Turbine Compressors (2)	446.0	7,795.2	0.502	17.5	0.021	0.7	14.800	515.8	1.500	52.4	4.120	143.4	13.1	2.5	644	20.1
Production/Space Htrs (6)	446.0	7,795.2	0.025	0.9	0.000	0.0	2.980	103.7	0.380	13.5	0.000	0.0	22.8(d)	0.3	623	10.6
A.R.Co. Flow Station No. 2 P-381																
Gas Turbines Compressors(2)	449.5	7,795.5	0.502	17.5	0.021	0.7	14.800	515.8	1.500	52.4	4.120	143.4	13.1	2.5	644	20.1
Production/Space Htrs (6)	449.5	7,795.5	0.025	0.9	0.000	0.0	2.980	103.7	0.380	13.5	0.000	0.0	22.8(d)	0.3	623	10.6
A.R.Co. Flow Station No. 3 P-443																
Gas Turbine Compressors (2)	440.7	7,795.7	0.502	17.5	0.021	0.7	14.800	515.8	1.50	52.4	4.120	143.4	13.1	2.5	644	20.1
Production/Space Htrs (6)	440.7	7,795.7	0.025	0.9	0.000	0.0	2.980	103.7	0.38	13.5	0.000	0.0	22.8(d)	0.3	623	10.6
A.R.Co. Field Fuel Gas Unit P-326 Process Htrs (4)	443.7	7,802.2	0.500	1.8	0.000	0.0	0.578	20.1	0.075	2.6	0.000	0.0	16.1	0.9	611	10.6
A.R.Co. Central Compressor Plant P-324																
Reinjector Turb/Comp (12) @ 25,000 hp each	443.7	7,802.2	5.580	194.3	0.239	8.3	164.000	5729.0	16.700	582.0	45.700	1,539.0	26.8	2.4	755	50.6
Combustion Htrs (2)	443.7	7,802.2	0.066	2.3	0.004	0.1	1.530	53.3	0.020	0.7	0.113	3.9	9.1	1.1	519	10.6

Source: Dames and Moore(1978)

TABLE F-2 Continued.

Facility Description	UTM (East)	UTM (North)	TSP g/s	TSP t/y	SO_2 g/s	SO_2 t/y	NO_x g/s	NO_x t/y	HC g/s	HC t/y	CO g/s	CO t/y	Stack Parameters[b] HS(m)	DS(m)	Ts(°K)	Vs(m/s)
Sohio Const. Camp No. 1 P-338																
Trash Incinerator No. 1	435.8	7,799.5	0.176	3.3	0.063	1.2	0.076	1.3	0.076	1.3	0.250	4.4	7.3	0.5	1,088	6.9
Sludge Incinerator No. 2 and Oil Afterburner	435.8	7,799.5	0.160	3.0	0.064	1.2	0.261	4.6	0.032	0.6	0.009	0.2	7.3	0.5	1,088	7.4
Sohio Central Power Plant P-185																
Gas Turbine Generators (6)	437.5	7,792.2	3.700	128.8	0.158	5.5	109.200	3801.8	11.400	397.2	30.300	1,055.0	15.8	2.7	777	50.6
Gas Turbine Generator	437.5	7,792.2	0.690	24.0	0.029	1.0	20.310	707.1	2.120	76.0	5.630	196.3	15.8	2.7	777	50.6
Dowell Div'n Warehouse/ 24-Person Bldg. P-325-A																
Diesel Generators (2)	447.9	7,792.0	0.044	1.5	0.059	2.0	1.250	43.8	0.125	4.4	0.767	26.7	3.7	0.2	721	15.2
Sludge Incinerator and Diesel Afterburner	447.9	7,792.0	0.067	2.3	0.160	0.6	0.078	2.7	0.004	0.2	0.006	0.2	3.7	0.2	721	7.4
NANA/Prudhoe Bay Solid Waste Utility P-413																
Trash Incinerator No. 1	447.3	7,791.0	0.176	6.1	0.375	6.6	2.510	43.8	0.000	0.0	0.000	0.0	15.2	0.9	921	6.9
Trash Incinerator No. 2 and Diesel Afterburner	447.3	7,791.0	0.022	0.8	0.447	7.8	2.660	46.4	0.007	(c)	0.010	(c)	15.2	0.9	921	7.4
Alyeska Pipeline Pump Sta. No. 1 P-289																
Turbines/Pumps (3)	439.0	7,796.0	0.850	29.6	0.036	1.3	25.100	875.1	2.550	89.0	6.990	243.0	13.7	3.3	727	22.8
Turbines/Generators (4)	439.0	7,796.0	0.035	1.2	0.001	0.1	1.040	36.2	0.105	3.7	0.289	10.1	13.7	3.3	727	22.8
Heaters (3)	439.0	7,796.0	0.067	2.4	0.004	0.1	1.560	54.3	0.020	0.7	0.115	4.0	13.7	1.0	623	10.7
Trash Incinerator No. 1	439.0	7,796.0	0.001	(c)	0.014	(c)	0.094	(c)	0.000	0.0	0.000	0.0	7.9	0.4	1,144	6.9
Sludge Incinerator No. 2 and Diesel Afterburner	439.0	7,796.0	0.003	0.1	0.010	0.2	0.062	2.2	0.002	(c)	0.001	0.1	7.9	0.4	1,144	7.4
NANA/Prudhoe Bay Solid Waste Utility																
Diesel Generator (1,850 kw) P-423	444.4	7,789.4	0.690	24.0	0.640	22.3	9.660	336.0	0.770	26.8	2.090	72.7	7.6	0.5	421	18.3
Waste Incinerator P-424	444.4	7,789.4	0.707	24.6	0.113	3.9	0.396	1.4	0.706	24.6	0.904	0.2	10.7	0.9	1,033	6.9
VE Construction P-482																
Diesel Generators 670 kw (2)	446.0	7,791.6	0.500	13.4	0.470	16.4	7.000	243.5	0.560	19.5	1.510	52.5	7.6	0.5	421	15.2
Waste Incinerator	446.0	7,791.6	0.350	12.3	0.055	2.0	0.195	0.7	0.350	12.3	0.470	0.8	10.6	0.9	1,033	6.9
A.R.Co. Operations Center																
Trash Incinerator and Afterburner P-355	449.8	7,794.6	0.047	1.2	0.431	4.6	0.792	9.2	0.397	4.6	0.153	1.6	12.2	1.1	971	6.9
Sludge Incinerator and Afterburner P-356	449.8	7,794.6	0.018	0.5	0.038	0.4	0.249	2.0	0.042	0.4	0.010	0.1	12.2	0.8	1,366	7.4

TABLE F-2 Concluded.

Facility Description	UTM (East)	UTM (North)	TSP g/s	TSP t/y	SO_2 g/s	SO_2 t/y	NOx g/s	NOx t/y	HC g/s	HC t/y	CO g/s	CO t/y	Stack Parameters[b] HS(m)	DS(m)	Ts(°K)	Vs(m/s)
Sohio Base Operation Center																
P-191 Sludge Incinerator and Afterburner	435.8	7,799.5	0.020	0.7	0.034	1.1	0.128	2.2	0.008	0.1	0.007	0.1	12.2	0.5	1,366	6.9
Trash Incinerator and Afterburner	435.8	7,799.5	0.002	(c)	0.052	0.1	0.113	0.1	0.404	(c)	0.130	0.1	12.2	0.5	1,088	7.4
Standby Ops. Generator P-266	435.8	7,799.5	0.400	0.3	0.530	0.3	11.400	7.1	1.140	0.7	6.910	4.4	6.7	0.5	660	18.3
Sohio Construction Camp No. 2 Power Plant P-374																
Trash Incinerator	430.0	7,803.5	0.066	2.3	0.047	0.9	0.056	1.0	0.056	0.1	0.187	3.3	12.2	0.5	1,088	6.9
Sludge Incinerator and Afterburner	430.0	7,803.5	0.041	1.4	0.054	0.9	0.214	3.7	0.022	0.4	0.009	0.2	12.2	0.5	1.088	7.4
Deadhorse Airport 3,000 kw Diesel Generation (est)	445.0	7,789.0	1.120	39.0	1.140	39.7	15.670	545.0	1.250	43.5	3.380	117.6	10.7	0.6	428	22.8
Frontier Constr. 1,500 kw Diesel Generator	445.7	7,791.2	0.560	19.5	0.520	18.1	7.830	272.0	0.630	21.9	1.690	58.8	10.7	0.5	428	18.3
Alaska General Constr. 500 kw Diesel Generator	427.0	7,801.8	0.190	6.6	0.170	5.9	2.610	90.8	0.210	7.3	0.560	19.5	10.7	0.3	428	18.3
Downtown Deadhorse Area 2,500 kw Diesel Power Generation (est)	446.5	7,791.2	0.930	32.4	0.870	30.3	13.060	454.3	1,040	36.2	2.820	98.1	10.7	0.6	428	15.2

[a] Developed from the permit files maintained by the Alaska Department of Environmental Conservation, except that emergency generators were not included in this table. Alyeska Pipeline P.S. No. 1 Camp (P-276) and Sohio Fuel Gas Plant Process Vent are no longer in operation and were not included in this table. Short-term and annual emissions do not always compare when the facility operates intermittently.

[b] Indicated emissions are grams/second (g/s) for maximum 1-hour emissions and ton/year (t/y) for annual emissions. All emissions are based on EPA emission factors for combustion sources (AP-42), except where noted.

[c] Less than 0.05 t/y.

[d] Stack height increased over original heights reported by Dames & Moore (1978) to reflect realistic heights.

TABLE F- 3. EMISSION CHARACTERISTICS OF PERMITTED FACILITY ADDITIONS TO THE OIL FIELD[a]

ID	Facility Description	UTM (East)	UTM (North)	TSP g/s	TSP t/y	SO_2 g/s	SO_2 t/y	NO_x g/s	NO_x t/y	NC g/s	NC t/y	CO g/s	CO t/y	Stack Parameters[b] HS(m)	DS(m)	Ts(°K)	Vs(m/s)
P1	ARCO Central Compressor Plant Gas Fired Turbine/Compressors 3 @ 25,000 horsepower (hp) Each	443.7	7802.2	1.395	48.5	0.059	2.1	41.17	1432.0	4.20	145.5	11.42	398.0	26.8	2.43	755	50.6
P2	ARCO Flow Station No. 2 Gas Fired Turbine/Compressors 2 @ 25,000 hp Each	449.5	7795.5	0.920	32.0	0.038	1.4	27.06	945.0	2.77	95.8	7.53	262.0	26.8	2.43	755	50.6
P3	Sohio Central Power Plant Gas Fired Turbine/Generators 2 @ 67,000 hp Each	437.5	7797.2	2.510	87.4	0.107	3.7	73.80	2578.0	7.51	261.9	20.56	716.8	16.7	2.80	755	102.1
P4	Sohio Gathering Center Plant Gas Fired Turbine/Compressors 2 @ 32,500 hp Each	430.0	7801.8	1.196	41.6	0.050	1.8	35.16	1228.0	1.80	124.6	9.78	340.6	16.7	2.69	755	50.0
P5	Sohio Gathering Center No. 3 Gas Fired Turbine/Compressors 2 @ 17,000 hp Each	436.7	7798.5	0.598	20.8	0.024	1.0	17.58	614.0	0.90	62.2	4.90	170.4	16.7	2.69	755	35.0

[a] Indicated emissions are gram per sec (g/s) and tons per year (t/y) for maximum continuous operation.
[b] Indicated stack parameters are stack height (HS) in meters (m), stack diameter (DS) in meters (m), stack exit temperature (Ts) in degrees Kelvin (°K), and stack exit velocity (Vs) in meters per second (m/s).

Source: Dames and Moore (1978)

The meteorological data were obtained from NOAA in the standard STAR format. This format was modified by combining two pairs of stability classes. This modification reduced the number of stability classes to six from eight to make the data acceptable for the computer codes used in the analyses.

The meteorological inputs to the short-term (PTMTP) model included the worst-case mixing height of 900 meters (2952.9 feet) and the average worst-case temperature of 10°C. reported for the area. The meteorological inputs to the long-term (VALLEY) model included the annual average temperature of -13°C. (The average mixing height is set internally by the program to a very large value for stable cases.) The models used are described in the following section.

2. Analyses

The mathematical analyses used for estimating the dispersion of nonreacting pollutants are based on Gaussian plume models. The atmospheric dispersion models employed were the PTMTP and VALLEY models. These models are included in EPA's UNAMAP (User's Network for Applied Modeling of Air Pollution) series of computer programs. The programs were run on a remote terminal used to access a Xerox Sigma Nine-based computer system.

PTMTP is a comprehensive extension of the PTMAX and PTDIS programs. The PTMTP program allows a more thorough estimate of pollutant concentrations for 1- to 24-hour averaging periods.

PTMTP produces hourly concentrations at up to 30 receptors whose locations are specified from up to 25 point sources. Inputs to the program consist of the number of sources to be considered and, for each source, the emission rate, physical stack height, stack gas temperature, volume flow (or stack gas velocity and diameter), and the location (by coordinates). The number of receptors, the coordinates of each, and their heights above ground also are required. Concentrations for a number of hours up to 24 can be estimated, and an average concentration over this time period is calculated. For each hour, the meteorological information required is: wind direction, wind speed, stability class, mixing height, and ambient air temperature.

The VALLEY model is a steady-state, univariate, Gaussian plume dispersion algorithm designed for estimating annual concentrations resulting from emissions from up to 50 (total) point and area sources. Calculations of ground-level pollutant concentrations are made for each frequency designation in an array defined by 6 stabilities, 16 wind directions, and 6 wind speeds for 112 program-designated receptor sites on a radial grid of variable scale. Empirical dispersion coefficients are used, adjusted for plume rise and limited mixing. Plume height is adjusted according to terrain elevations and stability classes. The program requires meteorological data in STAR format (a joint frequency summary of stability, wind speed, and direction), point source emission data, and receptor point distances and elevations relative to the point source. The model uses Gaussian steady state dispersion with the Briggs Plume Rise equation. This model was used with the no terrain option, because the Prudhoe Bay site is flat, treeless tundra with virtually no significant terrain features.

The results obtained from the PTMTP model estimate short-term (1-, 3-, and 24-hour) levels, and the results obtained from the VALLEY model estimate long-term (annual) levels. So that the results would reflect that plume rises from the gas turbines are different than plume rises from other releases, EPA requested that the results of the gas turbine plume rise equation be multiplied by a factor of 0.70. In order to avoid major adjustments in the models that would be required to treat plume rises from turbines differently than those from other releases in the same computer run, all gas turbine exit velocity inputs were multiplied by a factor of 0.24. This resulted in decreases in plume rises of at least 30 percent for all atmospheric conditions (unstable/neutral, stable, and stable/calm). Therefore, under conditions most prevalent in the project area, resulting plume rises were at least 70 percent of the calculated values.

The results of the modeling indicate the receptor locations where pollutant concentrations are highest. The PTMTP model identifies these receptor locations regardless of their direction from the source. Wind directions, therefore, were not required inputs. The receptor distances used were 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0. 7.5, 10.0. 12.5, 15.0, 17.5, 20.0, and 25.0 kilometers from the project site. For the VALLEY model, receptor locations are fixed by the program to include 112 receptor sites. The scale chosen was 1 inch equals 2.5 kilometers.

In addition to predicting the impact of the proposed project, the models were used to estimate background pollutant levels from the existing and EPA PSD-permitted sources in the area. The VALLEY model was utilized similarly to that used for predicting impact. The stack parameters of 46 of the 47 surrounding point sources are used as inputs to the programs. The resulting worst-case background levels then were added to the maximum impact levels (although these two levels do not occur at the same location) to obtain a conservative estimate of the maximum ground-level pollutant concentrations.

The PTMTP model had to be handled in a different manner to estimate background levels. The maximum short-term impact of the proposed facility is predicted to occur 1 kilometer downwind. In order to estimate background levels, existing and permitted facilities located at various distances from the proposed project site were lumped together into clusters and lined up with the proposed facility. The clusters were assumed to be no more distant, in relation to the proposed facility, than the distance between the closest cluster and the proposed facility. The value predicted at 1 kilometer downwind of the proposed site (with the wind blowing from the cluster to the proposed site) was considered the background level for the cluster. The highest value obtained for any cluster for each pollutant was considered the background level.

3. Results

The results of the dispersion analyses performed on the SGCF and its ancillary facilities are presented in table F-4. As can be seen in this table, the predicted maximum ground-level concentrations of the various regulated pollutants are within the Minimum Significance Levels listed in the Emission Offset Interpretative Ruling, with the sole exception of the annual NO_2 predicted increase.

The results of the dispersion analysis performed to estimate the background pollutant levels are presented in table F-5. As can be seen in this table, the maximum background levels do not exceed primary NAAQS.

TABLE F-4

MAXIMUM PREDICTED INCREASES IN GROUNDLEVEL CONCENTRATIONS RESULTING FROM THE OPERATION OF THE SGCF AND ITS ANCILLARY FACILITIES AND MINIMUM SIGNIFICANCE LEVELS
(Values are in $\mu g/m^3$.)

Pollutant	Averaging Time	Maximum Predicted Increase	Minimum Significance Level[a]
NO	Annual[b]	4.2	1.0
	1-hour[c]	84	-e
SO	Annual[b]	0.25	1.0
	24-hour[d]	3.0	5.0
	3-hour[d]	4.3	25
	1-hour[c]	5.2	-f
TSP	Annual[b]	0.2	1.0
	24-hour[d]	2.4	5.0
	1-hour[c]	4.1	-f

[a] Defined by the Emission Offset Interpretative Ruling (Federal Register, Volume 44, Number 11, 16 January 1979).

[b] Annual levels were predicted using the EPA VALLEY computer program. Maximum levels were predicted to occur 5 km. west of the proposed facilities.

[c] One-hour levels were predicted using the EPA PTMTP computer program. Maximum levels were predicted to occur 1 km. from the proposed facilities during C stability conditions with a wind speed of 10 meters per second.

[d] Turner's power law equation was used to correct the 1-hour predicted values to 3-hour and 24-hour values.

[e] No short-term standard, although a standard is expected to be proposed in late 1979. The annual standard is 100 $\mu g/m^3$.

[f] No significance level has been established.

TABLE F-5

MAXIMUM PREDICTED BACKGROUND POLLUTANT LEVELS AND NATIONAL AMBIENT AIR QUALITY STANDARDS
(Values are $\mu g/m^3$)

Pollutant	Averaging Time	Background Level[a]	National Ambient Air Quality Standard[b]
TSP	Annual	1.5	75
	24-hour	21.8	260
	1-hour	37.4	-
SO_2	Annual	0.6	80
	24-hour	19.3	365
	3-hour	27.5	1,300
	1-hour	33.2	-
CO	8-hour	<1[d]	40,000
	1-hour	<1[d]	10,000
NO_2[e]	Annual	24	100

[a] These levels represent ground level concentrations calculated using emissions from the major and approved existing sources in the area. Maximum levels were predicted to occur 1.0 km downwind from the proposed facilities, with the exception of NO_2 which was reported at 2.0 km downwind.

[b] Source: 36 CFR 8996.

[c] Turner's - 0.17 power law equation was used to correct the 1-hour predicted values to 3-hour and 24-hour values.

[d] Based on the low CO emission rates from the major point sources and the small amount of vehicular traffic in the area.

[e] A short-term standard is expected to be proposed late in 1979.

Several assumptions were designed into both dispersion analyses to assure conservative results. They include:

All nitrogen oxide emissions were assumed to be NO_2.

No reduction in NO_x emissions was assumed, although a lower combustion temperature resulting from exhausting waste CO_2 through the gas turbine unit would reduce NO_x emissions.

Exit velocities used for the turbines were multiplied by 0.24 to reduce the plume rise by at least 30 percent for all stability conditions.

The three turbine units were assumed to be operating at 100-percent load 100 percent of the time, although only two units would run while the third would be kept in reserve.

The space and process heaters were assumed to be operating at 100-percent load 100 percent of the time, although two of the process heaters and one space heater would be kept in reserve.

A worst-case mixing height of 900 meters was used to prevent the plume from rising above the mixing boundary layer.

The staff recommends that further analysis be performed when more project and site-specific data are available. The gas turbine data was a conservative approximation of a 32,500-hp unit burning conventional high Btu gas. Emissions data were unavailable for a unit burning a low Btu-high CO_2 gas. It is expected that such a unit would have lower NO_2 emissions. The space and process heater data were obtained from a vendor and were based on the use of diesel fuel, whereas cleaner local natural gas may be used. The meteorological data were obtained from Barter Island, which can be considered generally characteristic of the area, but site-specific differences such as wind direction frequencies are probable. Based on this analysis, the staff believes that further analysis based on site- and project-specific data may affect the level of review required for PSD approval.

AGENCIES AND THEIR JURISDICTIONS

Agency	Jurisdiction, Statutes, Codes
Federal	
Army Corps of Engineers	-Approves construction of dock facilities, dredging, and pipeline crossings of navigable waters. -Receives required certification from states to insure compliance with state plans for land and water use programs for coastal waters and shorelines.
Department of Labor Occupational Safety and Health Administration	-Approves facility if in compliance with OSHA regulations.
Department of Transportation Office of Pipeline Safety	-Approves design and operations of gas pipelines.
Coast Guard	-Approves design and operations of dock facilities; approves vessel operations; regulates safe shipping practices. Issues permits for pipeline crossings of navigable waters; approves design and operations of private aids to navigation; regulates safe shipping practices.
Environmental Protection Agency	-Issues permits for wastewater discharges (NPDES permits) and prevention of significant air quality deterioration. -Reviews project impact on environment, with special attention on air, water, noise, and solid waste impacts. -Reviews New Source Performance Standards applications.
Federal Aviation Administration	-Reviews facility designs to determine if hazard to aviation would be created.

Agency	Jurisdiction, Statutes, Codes
Federal (cont.)	
Federal Communications Commission	-Certifies all communications equipment. Issues permits for radio towers.
Federal Energy Regulatory Commission	-Approves construction or operation of any pipeline or related facility for the transportation of natural gas in interstate commerce.
State of Alaska	
Department of Commerce Division of Occupational Licensing	-Issues electrical licenses and welding certificates.
Department of Environmental Conservation Division of Water and Air Quality Control	-Issues permits for air emissions, open burning, wastewater discharges, road oiling, and solid waste management.
Department of Health and Social Services Division of Public Health	-Issues food service permits.
Department of Natural Resources Division of Land	-Issues permits for lease operations, gravel removal, water appropriations, miscellaneous land use, and special land use.
Department of Public Safety Division of Fire Prevention	-Approves plans.

STANDARDS APPLICABLE TO THE CONSTRUCTION AND OPERATION OF THE PROPOSED SALES GAS CONDITIONING FACILITIES

Alaska Administrative Codes 18, 50, 60, 70

American Concrete Institute (ACI) Standards 318-71 and 347

American Institute of Steel Construction, Inc., Part 5, Section 1.23

American National Standards Institute (ANSI) S1.4-1971, S1.6-1967, S1.11-1966, S.1.20-1962, B31.3, B31.8

American Petroleum Institute (API) Bulletin 1105

API Standards 5LX, 610, 613, 616, 617, 660, 661, 1104

American Society for Testing and Materials (ASTM) Standards C33, C150, A252, C109, C190, C531, E23

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Guide

American Society of Mechanical Engineers (ASME) Section VIII, Div. 1 and 2, Section IX and E-165

American Welding Society

National Ambient Air Quality Standards (NAAQS)

National Electrical Code

National Fire Protection Association (NFPA)

National Plumbing Code

OSHA (Title 29 of CFR)

Tubular Exchanger Manufacturers' Association (TEMA)

Uniform Building Code