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LIBERTY DEVELOPMENT PROJECT

Environmental Report

Prepared by

LGL ALASKA RESEARCH ASSOCIATES, INC.
4175 Tudor Centre Drive, Suite 202
Anchorage, Alaska 99508

WOODWARD-CLYDE CONSULTANTS
3501 Denali Street, Suite 101
Anchorage, Alaska 99503

APPLIED SOCIOCULTURAL RESEARCH
P.O. Box 101352
Anchorage, Alaska 99510-1352

Prepared for

BP EXPLORATION (ALASKA) INC.
P.O. Box 196612
Anchorage, Alaska 99519-6612

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1. INTRODUCTION

1.1 PURPOSE

The purpose of this Environmental Report is to evaluate a proposal by BP Exploration (Alaska) Inc. (BPXA) to develop the Liberty oil field in the Beaufort Sea for production and transport of sales quality oil to the Trans-Alaska Pipeline System. The field will be developed from a gravel island constructed on federal Outer Continental Shelf (OCS) oil and gas lease OCS-Y-1650 (Sale 144) in Foggy Island Bay.

The Liberty oil field, which is located approximately 5 miles offshore the coast of Foggy Island Bay, is about midway between Point Brower to the west and Tigvariak Island to the east (Figure 1-1). The proposed island site is located in federal waters between the McClure Islands and the coast in water depths of about 22 feet. The lead permitting agency will be the U.S. Minerals Management Service (MMS) because the island is located in federal waters and because MMS has jurisdiction over nearly the entire scope of the development, including construction, drilling, and operation. Other Federal, State, and local agencies will also review and approve aspects of the project. The proposed transportation corridors linking Liberty to existing infrastructure will cross State of Alaska (State) lands, and thus will require State and North Slope Borough (NSB) authorizations. In addition, some supporting infrastructure will be constructed onshore, also requiring State and NSB approvals.

The proposed Liberty Development includes the following elements:

- Construction of a new gravel island approximately 1.5 miles west of Tern Island in Foggy Island Bay.
- Placement of drilling, infrastructure, and processing facilities on the island.
- Production of sales quality oil for export.
- Potential production of product for export.
- Disposal of drilling and other wastes on the island via permitted injection wells.
- Transportation of sales quality oil from the production island via a buried subsea pipeline to a land-based connection with the Badami Sales Oil Pipeline.
- Transportation of product via a buried subsea pipeline to a land-based connection with the Badami Products Pipeline.

- Material and personnel necessary to construct and operate the Liberty Development Project.
- Development of a gravel mine site.

1.2 NEED

Development of this resource will increase domestic energy supplies and will provide economic benefits to BPXA, the NSB, the State of Alaska, and the United States of America (U.S.). The Liberty hydrocarbon reservoir is currently estimated to contain potential recoverable reserves of up to 120 million barrels of oil and up to 100 billion cubic feet of natural gas. Therefore, the field represents a significant addition to national energy reserves. While relatively small by Alaska North Slope standards, Liberty is a major field in continental U.S. terms. The State of Alaska stands to benefit directly by infusion of new capital expenditures into the economy and by creation of jobs. Over the life of the project, additional benefits will also accrue to the State through the State's share of the federal royalty, income tax, and *ad valorem* tax, some of which will accrue to the NSB. This benefit will occur at a time when State revenue, heavily dependent on production from the large North Slope oil fields, such as Prudhoe Bay, Kuparuk, and Endicott, is declining. The Liberty Development Project will not by itself offset these declines, but it will help mitigate the severity of the decline to the State of Alaska and to the nation.

1.3 PROJECT MILESTONES

The major milestones of the Liberty Development Project are described in Table 1-1 and shown on Figure 1-2. BPXA's goal is to have the Liberty Development Project in production by the end of 2000. For that to occur, many aspects of engineering, environmental work, facility construction, permit application, and logistics began in 1997 and will continue expeditiously until the target date.

1.4 PERMITS AND APPROVALS

At this time, BPXA is applying for all the major construction and land use approvals required for the Liberty Development Project as listed in Table 1-2.

The permit application packages will address information needs identified by agencies in consultation and meetings during the pre-application process. The major areas of interest and concern to be addressed include:

TABLE 1-1

MAJOR MILESTONES
LIBERTY DEVELOPMENT PROJECT

MILESTONE	TIME FRAME	DESCRIPTION
Exploration Well, Conceptual Engineering	Winter 1996-97	BPXA drilled an exploration well (Liberty #1) at the Tern Island site in Foggy Island Bay to further assess the reservoir and determine whether the field was economically viable. Conceptual engineering proceeded based on assumed well results to develop a "test case."
Well Results	May 1997	BPXA announced estimated recoverable reserves of 120 million barrels at Liberty.
Geotechnical Studies and Route Survey	1997	A geotechnical (soils) drilling program, which included sediment and water sampling, was conducted during the winter of 1997. Shallow hazards and sidescan and multibeam sonar work was completed in the summer of 1997.
Additional Environmental Studies	Summer 1997	The results of environmental studies conducted in this region are summarized in Section 4 of this document. An additional survey of the Boulder Patch was conducted during the summer of 1997 to confirm the feasibility of constructing an island and routing a subsea pipeline through the area with minimal environmental impact. An archaeological survey of the onshore pipeline corridor was completed. Seal surveys were conducted during May and June of 1997, and underwater acoustic studies were conducted July-September 1997.
Geotechnical Studies	Winter 1998	Geotechnical soils drilling program.
ROV surveys	Winter 1998	Visual "ground-truthing" of sea floor conditions at island site and along pipeline route to confirm results of summer 1997 side-scan sonar surveys.
Detailed Engineering	End-1998	Detailed engineering will commence in mid-1997. This will provide the necessary information for the major operational permits (see Section 1.6).
Gravel Construction	Winter 1999-2000	Gravel construction will commence in late 1999 utilizing equipment mobilized over ice roads. Most gravel work at the Liberty field development will be done in a single winter season, with gravel obtained from one of several existing sites or a new mine site.
Pipeline Construction	Winter 1999-2000	Pipeline construction will commence in winter 1999-2000 and is expected to be complete by May 2000.
Sealift	Summer 2000	Modules for process and living facilities will be brought into Liberty by sealift in the summer of 2000 and offloaded on the island.
Development Well Drilling	Fall 2000	Development drilling will commence using a single rig as soon as the rig can be mobilized to the site via a barge in the fall of 2000.
Production	Late 2000	Production from Liberty will commence at the end of 2000 and build to peak rates of up to 65,000 barrels per day.

TABLE 1-2

PERMITS AND APPROVALS REQUIRED FOR LIBERTY DEVELOPMENT

FEDERAL AGENCIES

AGENCY	PERMIT / APPROVAL	ACTIVITY / COMMENTS
Federal Agencies	NEPA Compliance	NEPA review required before Federal permits can be issued
U.S. Army Corps of Engineers	Section 404 / 10	Island construction, pipeline construction in State waters and lands, onshore pad construction, mine site development
Environmental Protection Agency	National Pollutant Discharge Elimination System (NPDES) Individual	Point waste water discharges
Environmental Protection Agency	NPDES (General Stormwater Construction/Industrial Activity)	Stormwater drainage – onshore construction and operations
U.S. Army Corps of Engineers/Environmental Protection Agency	Ocean Dumping Permit (Section 103 of Marine Protection, Research, and Sanctuaries Act)	Transportation of and discharge of dredged sediments on ocean floor
Minerals Management Service	Development and Production Plan	Construction, drilling, and operations
Minerals Management Service	Pipeline Application	Pipeline in federal waters
Minerals Management Service	Permit to Drill	All wells, including waste injection well
Environmental Protection Agency	Part 55 Air Permit	Emissions from island construction and operation, including vessel traffic
National Marine Fisheries Service	Incidental Harassment of Marine Mammals (whale and seal)	Marine construction
National Marine Fisheries Service	Letter of Authorization for Incidental Take of Marine Mammals (whale and seal)	Drilling and production operations
U.S. Fish and Wildlife Service	Letter of Authorization for Incidental Take of Marine Mammals (polar bear and Pacific walrus)	Construction and operations
U.S. Coast Guard	Oil Discharge Prevention and Contingency Plan	Construction, drilling, operations (fuel transfer)

TABLE 1-2 (cont.)

PERMITS AND APPROVALS REQUIRED FOR LIBERTY DEVELOPMENT

STATE AGENCIES

AGENCY	PERMIT / APPROVAL	ACTIVITY / COMMENTS
Department of Natural Resources, State Pipeline Coordinator's Office	Right-of-Way Lease	Pipeline construction and operations in State waters and lands
Department of Natural Resources, Division of Lands	Material Sales Contract	Gravel mining and purchase
Department of Natural Resources, Division of Lands	Miscellaneous Land Use (ice roads)	Construction and operations
Department of Environmental Conservation	Oil Discharge Prevention and Contingency Plan	Pipeline operations
Department of Environmental Conservation	Section 401 Water Quality Certification	All construction under Corps Section 404 permit (certification)
Department of Fish and Game	Title 16 Fish Habitat	Mine site development
Division of Governmental Coordination	Coastal Zone Consistency	Construction and operations (certification on all Federal and State permits)

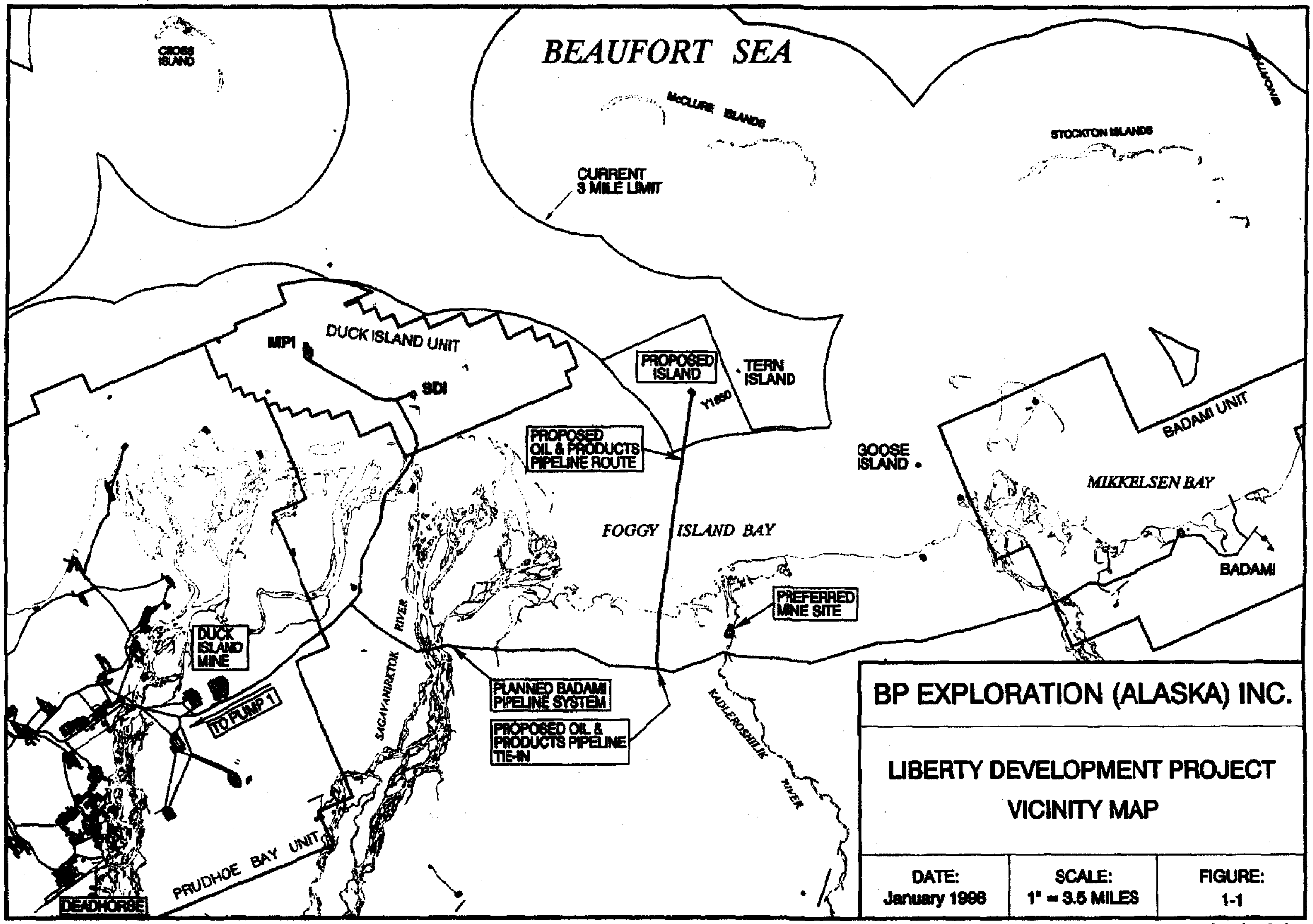
LOCAL AGENCIES

AGENCY	PERMIT / APPROVAL	ACTIVITY / COMMENTS
North Slope Borough	Rezoning - Conservation District to Resource Development District	Construction and operations

- The alternatives considered and rejected for the major project components (e.g., pipeline routes, facility requirements, site access, island design and location).
- The design and geotechnical and thermal performance of a buried pipeline and pipeline leak detection.
- Spill prevention and spill response.
- Potential impacts on the Boulder Patch.
- Potential impacts on subsistence resources and use of those resources.

1.5 SCOPE OF ENVIRONMENTAL REPORT

This Environmental Report is designed to provide the necessary information to support agency decision making for permits listed in Table 1-2. Alternatives to the proposed action that were considered are analyzed in Section 2 as a basis for the alternatives evaluation required by the National Environmental Policy Act (NEPA) (40 CFR 1502.14); regulations of the MMS (30 CFR 250.34(b)(12)); regulations of the U.S. Army Corps of Engineers (33 CFR 325-Appendix B); and the U.S. Environmental Protection Agency 404(b)(1) Guidelines (40 CFR 230). The major project components and activities that constitute the proposed action are summarized in Section 3. (Note that this information is a summary of the more detailed description of the project provided in the Development and Production Plan.) Sections 4 and 5 are intended to provide information to the MMS to assist in satisfying the NEPA requirements at 33 CFR Part 230.34. Mitigation measures incorporated into project design are detailed in Section 6, which is intended to establish the basis for regulatory review for conformance with the requirements to the Section 404 (b)(1) Guidelines. Compliance with Lease Sale 144 stipulations, as required by 30 CFR 250.34, is also addressed in Section 6. Agency, public, and third-party consultations that have been conducted by BPXA as an integral part of the planning process are listed in Section 7.


BEAUFORT SEA
CROSS ISLAND
McCLURE ISLANDS
STOCKTON ISLANDS
CURRENT 3 MILE LIMIT
DUCK ISLAND UNIT
MPI
SDI
PROPOSED ISLAND
TERN ISLAND
Y1650
PROPOSED OIL & PRODUCTS PIPELINE ROUTE
GOOSE ISLAND
BADAMI UNIT
MIKKELSEN BAY
FOGGY ISLAND BAY
BADAMI
PREFERRED MINE SITE
DUCK ISLAND MINE
TO PUMP 1
SAGAVANIRKTOK RIVER
PLANNED BADAMI PIPELINE SYSTEM
PROPOSED OIL & PRODUCTS PIPELINE TIE-IN
KADLEROSHILIK RIVER
PRUDHOE BAY UNIT
DEADHORSE
BP EXPLORATION (ALASKA) INC.
LIBERTY DEVELOPMENT PROJECT
VICINITY MAP
DATE: January 1998
SCALE: 1" = 3.5 MILES
FIGURE: 1-1

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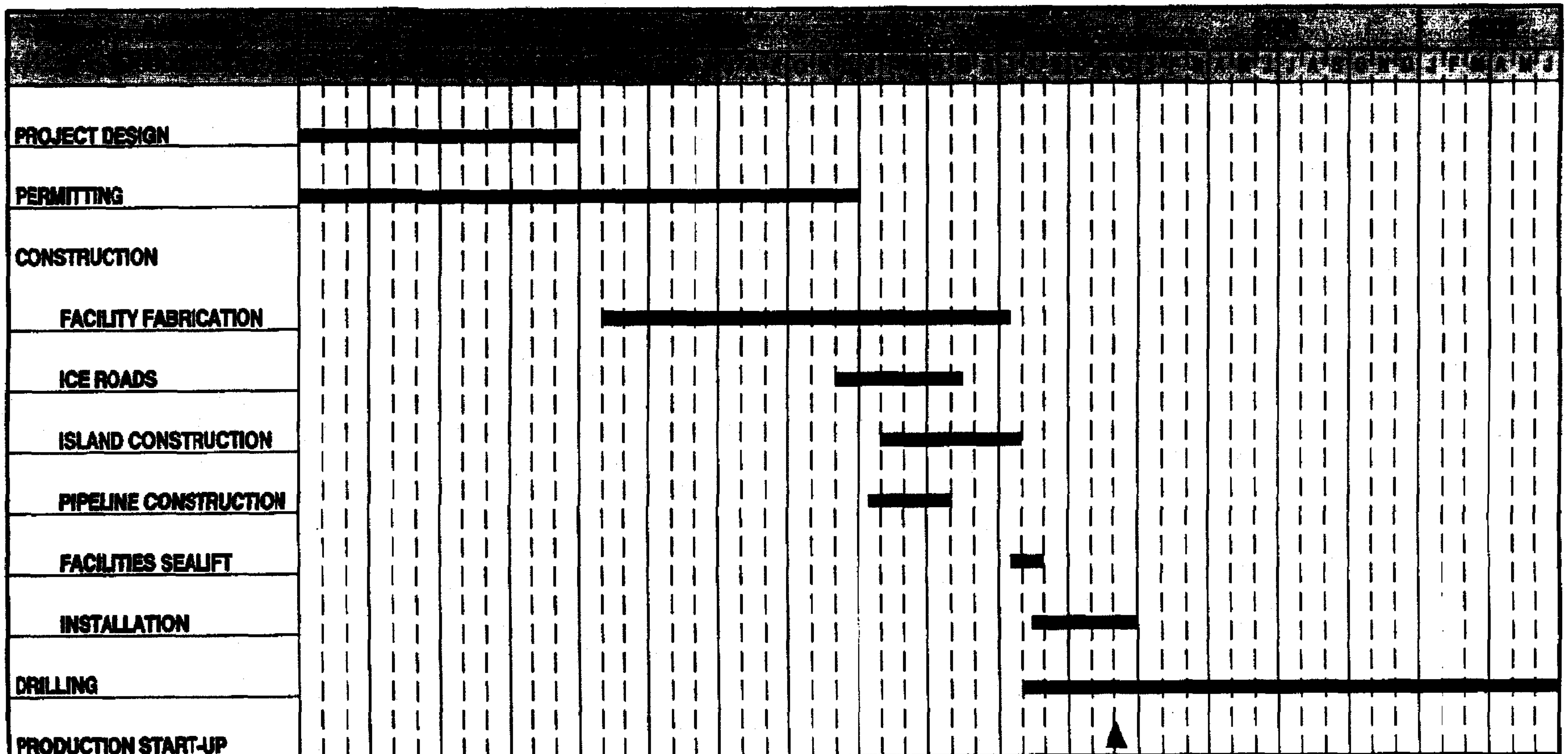


BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT SCHEDULE

DATE:	SCALE:	FIGURE:
January 1998	N/A	1-2

2. DEVELOPMENT ALTERNATIVES

2.1 INTRODUCTION

As part of conceptual and preliminary project planning, BPXA has evaluated a series of alternatives for design, construction, and operation of the Liberty Development Project. The proposed project was formulated based on a balance of environmental, technical, economic, and logistical considerations. As a result of this analysis, a proposed Liberty project has been identified. The overall project includes a gravel island, stand-alone processing facilities on the island, associated infrastructure, a pipeline system south to a tie-in with the Badami pipeline system, an onshore gravel mine site, and ice roads. The proposed project, as developed on the basis of this alternatives analysis, is summarized in Section 3 and described in detail in the Development and Production Plan. This section describes the analysis of alternatives and options to the proposed project, including the No Action Alternative, and the rationale for selection of the proposed project based on current information. The proposed project components are briefly described here as evaluated against other options.

Alternatives were identified for the following project components:

- Island
- Facilities
- Pipeline
- Mine site
- Construction timing

In the process of analyzing alternatives, options for each component were evaluated independently, as well as in connection with one another. For example, island construction options were identified and analyzed, then also evaluated against facilities layout options. Table 2-1 summarizes the field development alternatives considered for this project.

2.2 ISLAND

The Liberty reservoir cannot be developed from an onshore location or existing gravel causeways with existing extended reach drilling technology. Thus, some form of offshore island is the only feasible approach to the development. The following offshore island alternatives were evaluated:

TABLE 2-1

LIBERTY DEVELOPMENT PROJECT ALTERNATIVES

PROJECT OPTION	FEASIBILITY	STATUS
FIELD DEVELOPMENT		
Offshore Drilling and Full Processing Facilities Island	Feasible	Proposed Project
Offshore Drilling and Partial Processing Facilities Island	Feasible	Rejected
Offshore Drilling/Onshore Processing at Endicott	Feasible	Rejected
Offshore Drilling/Onshore Processing at Badami	Feasible	Rejected
Onshore Drilling and Processing Pad	Not feasible with current drilling technology	Rejected
Offshore Drilling Platform	Not feasible due to water depth	Rejected
ISLAND DESIGN		
Conventional Gravel Island	Feasible	Proposed Project
Custom Built Barge/Gravel Island Combination	Feasible	Rejected
Converted Barge/Gravel Island Combination	Feasible	Rejected
Caisson Retained Island (CRI)/Gravel Island Combination	CRI space limits number of wells	Rejected
EXPORT PIPELINE		
12" Stabilized Crude to Badami Tie-in (Western Route)	Feasible	Proposed Project
12" Stabilized Crude to Badami Tie-in (Eastern Route)	Feasible	Alternative
26" (36" outer pipe) 3-phase Unprocessed to Endicott	Feasible	Rejected
24" (30" outer pipe) 3-phase Unprocessed to Endicott	Feasible	Rejected
12" Live Crude to Endicott	Feasible	Rejected
26" (30" outer pipe) 3-phase Unprocessed to Badami	Feasible	Rejected
12" Live Crude to Badami	Feasible	Rejected

- Conventional gravel island (proposed project).
- Conventional gravel island with adjacent custom-built grounded barge containing process facilities/support infrastructure.
- Conventional gravel island with an embedded converted barge containing process facilities/support infrastructure.
- Combination Caisson Retained Island (drilling) and conventional gravel island (process/support infrastructure).
- Offshore drilling platform

2.2.1 Options

Conventional Gravel Island (Proposed Project)

This proposed structure is a gravel island with dimensions of 680 feet by 345 feet, requiring approximately 650,000 to 825,000 cubic yards of gravel (see Section 3 for further details). Access to the site will be by marine vessels in the summer and by ice road in the winter. During freezeup and breakup the site will be accessed by helicopter only. Location and access will be the same for each of the alternatives considered. Location of this island was selected based on optimal reservoir development and avoidance of the Boulder Patch.

Custom Built Barge/Gravel Island Combination

In this option, the island would be rectangular, with sufficient room for drilling operations and storage of drilling supplies. The island would allow grounding a large purpose-built barge, carrying the process facilities/camp, along the south side of the island. The dock would be incorporated into the barge and all of the major production facilities would be integral with the barge structure (see Figures 2-1 and 2-2).

The total island size would be 500 feet by 400 feet, comprising both the gravel section and the barge. The barge would be 100 feet by 500 feet with a 30-foot side shell. This would yield an island perimeter of 1,800 feet, requiring approximately 310,000 cubic yards of gravel. Slope protection of the gravel island would be a combination of concrete blocks and gravel filled bags.

The barge facilities would include a heliport, dock for island access during open water, and water intake structure with protective sheet piles as required.

Construction would start during early 2000 and would be completed during the 2000 open water season. The ice would be cut and removed to a location near the island site. The fill material would be placed through the open hole to form the working surface of the island. All fill would be placed by the end of March 2000. Slope protection work would begin at that time. A slot would be left in the island to receive the barge and the process facilities. The bottom of the slot would be prepared to receive and safely set-down the barge. The barge would arrive in the open water season of 2000 and would be floated into position in the slot. The barge would then be ballasted down into the final location ready for facility/well hook-up. The final fill would be placed to complete the island and slope protection finalized.

Converted Barge/Gravel Island Combination

In this option, the island would be shaped in a key configuration, with drilling located at the enlarged end. A large converted barge carrying the process facilities/camp would be grounded in the core of the island. A protective gravel outer berm would extend around the perimeter of the barge (see Figures 2-3 and 2-4).

The island size would be 400 feet by 200 feet for drilling and 300 feet by 500 feet for the enclosed barge. A 300-foot by 100-foot dock would be built after grounding the barge in the island. This would yield an island perimeter of 2,100 feet requiring approximately 387,000 cubic yards of gravel. Slope protection of the gravel island would be a combination of concrete blocks and gravel filled bags.

Additional surface features which would form part of the barge facilities include: heliport, dock for island access during open water, and water intake structure with protective sheet piles as required. The island would support all of the process, drilling and camp infrastructure for the project.

Construction would commence with placement of material for the drilling section of the island and protective gravel outer berm in early 2000. Material would be hauled to the site and placed using techniques described in the Custom Built Barge Option. By midsummer, the island would be complete and ready for placement of the barge in the slot during the 2000 open water season. This work would take place during late August, and the island would be closed and finished by October 2000. Pile installation for the dock area would take place during October 2000, at which stage the island would be complete.

Caisson Retained Island/Gravel Island Combination

The Caisson Retained Island (CRI) option would use an existing steel caisson constructed and currently deployed in the Canadian Arctic. The structure is an outer octagonal steel ring 334 feet in diameter which would be ballasted into place. The interior would then be filled with select gravel fill to form a working surface. The CRI would be deployed as the drilling surface and a gravel island extension would abut the structure to support the facilities and other activities.

The gravel island section would measure 165 feet by 110 feet, with the CRI embedded in one corner of the structure. The entire integrated structure would be approximately 465 feet by 410 feet. Side slopes of the gravel extension would be 3:1, with concrete block slope protection from sea level to the toe of the island, and with gravel filled bags above that point. The island would support all of the process, drilling and camp infrastructure for the project.

Construction would commence during summer 2000 with installation of the CRI, and would be completed during winter and summer 2001. The gravel extension would be placed in the winter and the slopes protected as the gravel placement is completed. The final slope protection would be installed during the open water season in 2001. Fill material for the CRI would be hauled from the gravel source, transferred onto barges at the Endicott dock, and transported to the site.

The gravel island extension would be constructed in the winter. The ice would be cut and removed to a location near the island site on grounded ice. The fill material would be placed through the open hole to form the working surface of the island. All fill would be placed by the end of March in 2001 and slope protection work would begin at that time. Summer work would be limited to the minor adjustments required to finish the island prior to arrival of the sealifted facilities.

Offshore Drilling Platform

Use of an offshore drilling platform in Foggy Island Bay was considered but found to be not feasible for this project. Offshore drilling platforms such as those used in Cook Inlet require water depths of at least 30 feet; water depths in Foggy Island Bay do not exceed 22-25 feet, and water depth at the optimal location for reservoir development is only 22 feet.

Re-Use of Tern Island

BPXA considered reuse of Tern Island, which lies approximately 1.5 miles east of the proposed island location. Drilling from the Tern Island location would not allow optimal reservoir development.

Tern Island was built in 1981 and abandoned in 1991. Based on BPXA estimates used in design of the gravel/ice structure built on Tern Island for the Liberty #1 Exploration Well, there are approximately 238,000 cubic yards of gravel remaining, approximately 7,000 cubic yards of this above sea level. Use of this island for planned Liberty development would involve expansion of the island, requiring about 325,000 to 400,000 additional cubic yards of gravel and installation of slope protection. While the total volume of new gravel to be placed as fill in this location would be reduced, overall impacts of the gravel construction activity would be similar to construction of a new island.

2.2.2 Analysis

The range of structures considered varied from hybrid islands to simple gravel islands. Analysis showed that minimal cost savings or schedule benefits can be derived from use of the hybrid solutions. Generally, the island-barge combinations concepts are more expensive, and fabrication requirements increase risk due to delivery and ship yard space availability.

Hybrid designs employing the barge mounted facilities were considered as a solution to the problem of functional checkouts prior to North Slope installation of the production facilities. With these designs, all of the production facilities would be installed and functionally commissioned at the fabrication yard, then sealifted to the North Slope. Estimates revealed that there is only a small advantage in the design, while the risks associated with the delivery of the barge were overshadowing. Therefore these alternatives were considered to be less desirable.

The CRI hybrid would provide an early start for drilling operations. After schedules were constructed for the entire project, it was clear that there was no significant advantage to have the drilling start this early. Also, the CRI has space constraints which could restrict the number of wells which could ultimately be drilled from its surface. On this basis the CRI option was rejected.

After eliminating the hybrid options, BPXA focused on simple gravel island design as the preferred option for providing a working base for Liberty drilling and process facilities. The gravel island concept is proven for this type of location, water depth and for this type of service. The risk associated with construction and performance are quantifiable and known with documented service histories. While the proposed project requires a larger footprint than the hybrid options, the hybrid options also involve gravel placement, with essentially similar impacts. In addition, except for re-use of Tern Island, these island alternatives would also require gravel placement during summer, which increase potential impacts (see Section 5.1).

Re-use of Tern Island would be less costly than construction of a new island, but increased drilling costs would essentially offset the construction savings. In addition, this location would not allow optimal development of the reservoir. Impacts from reconstruction of Tern Island would be similar to impacts of the proposed action.

2.3 ISLAND SLOPE PROTECTION

Based on selection of a conventional gravel island, slope protection systems were also analyzed. Island slope protection is required to assure the integrity of the gravel island by protecting it from the erosive forces of waves, ice ride-up, and currents. In addition, by reducing the risk of erosion and associated introduction of sediment into the water column, slope protection offers a means to protect water quality.

Based on nearly 20 years of operating experience with exploration islands and the Endicott development in the Beaufort Sea, several slope protection systems were evaluated, including:

- sacrificial gravel buffer
- sheet pile walls
- slope armor (concrete mats, gravel bags, other materials)

The sacrificial gravel buffer concept was rejected because it is inappropriate for long term use. An island structure contained entirely within sheet-pile driven walls was also rejected as uneconomical. Other design options were evaluated on the basis of performance, cost, and environmental effects, as described below.

2.3.1 Options

Sheet Pile/Concrete Mat/Gravel Berm

This hybrid option has been proposed for Northstar Island construction, and was analyzed for suitability at the Liberty Island location. In the Northstar design, the slope armor of the island incorporates a steel sheet pile perimeter wall to surround the work surface completely. A shallow concrete mat bench surrounds the perimeter wall to dissipate wave and ice forces. Island side slopes are also covered with a concrete mat to about the 20-foot water depth. A submerged gravel berm surrounds the north, east and west sides of the island. The berm functions to prevent thick multi-year ice floes and ridge features from contacting the concrete mat slope armor and to dissipate wave energy.

Gravel Bag Slope Protection

This option would involve only use of gravel bags to provide slope protection at Liberty. This type of design was used at Tern Island, which has subsequently been abandoned. Experience indicates relatively high maintenance costs for this design, due to the potential for bags to be damaged by ice and waves.

Other Materials

Conventional slope armor materials that are frequently used in warmer climates (quarrystone, large concrete armor units) are not appropriate for the North Slope area due to lack of availability and poor stability against large ice forces.

2.3.2 Analysis

The proposed Liberty slope protection design incorporates island side slopes and a bench protected with concrete mat slope armor, with a system of overlapping gravel filled bags at the top of the bench. The entire slope protection system is underlain by filter fabric that will prevent leaching of sediment into the water column. The bench and the gravel bags dissipate wave energy and limit ice ride-up potential. The position of the bags does not allow frequent exposure to damaging waves and ice, and loss of gravel bag fabric debris is expected to be negligible.

This design was developed on the basis of optimizing cost, performance, and minimizing environmental effects. BPXA has experience with the performance of the design through long-term experience of a nearly identical system at Endicott. This slope protection option is considered most appropriate given the environmental conditions (waves, ice, currents, proximity to Boulder Patch) at this location. After construction, the system is expected to provide a stable island structure by preventing erosion. Given the limited erosion potential and the use of filter fabric, no release of sediment to the water column (that could affect Boulder Patch habitats in Foggy Island Bay) is expected.

The proposed Northstar Island would be constructed in deeper water than Liberty, and in a location subject to more severe ice and wave forces. Thus, the gravel berm which is appropriate at Northstar is not needed at Liberty. Likewise, the sheet pile protection around the island perimeter is not required in Liberty's more quiescent environment.

2.4 FACILITIES

A number of processing alternatives for the Liberty prospect were considered (Table 2-2). This section describes and evaluates the following processing alternatives:

- Stand-alone full processing facility (proposed project)
- Partial processing at Liberty Island with export of live crude to Endicott
- No processing at Liberty Island with three-phase export to Endicott
- – Gas lift case
- – Electrical submersible pump case

For the purposes of this analysis, facilities options were compared assuming use of a conventional gravel island. As discussed in Section 2.2, each of the island options could accommodate full processing, and therefore could accommodate processing options requiring less space. For processing at Badami, Liberty Island facilities would be identical to those for the Endicott processing options and are therefore not discussed separately.

TABLE 2-2

PROCESSING ALTERNATIVES

PROJECT OPTION	POWER SUPPLY	WATERFLOOD SUPPLY	GAS LIFT SUPPLY	CONVENTIONAL ISLAND SIZE	NORMALLY MANNED
Full Processing at Liberty Island	Local	Local	Local	680' x 345'	Yes
Partial Processing at Liberty Island	Local	Local	Local	680' x 345'	Yes
No Processing at Liberty (Gas Lift)	Endicott (~0.5 MW)	10" Pipeline from Endicott	8" from Endicott	320' x 450'	No
No Processing at Liberty (Electrical Submersible Pumps)	Endicott (~6.0 MW)	10" Pipeline from Endicott	None	320' x 450'	No

2.4.1 Options

Full Processing (Proposed Project)

The proposed project is a stand-alone full processing facility delivering pipeline quality crude oil. Produced water will be treated and re-injected to the producing formation. Produced gas will be dried and compressed for re-injection to the producing formation. Seawater will be treated, combined with the produced water stream, and injected into the producing formation as a secondary means of oil recovery. See Section 3 for further details.

Partial Processing

In this alternative, the Liberty partial processing facilities would include primary stages of production separation, complete gas dehydration, compression, produced water and sea water treating, water injection, power generation and camp facilities. In addition, the Liberty partial processing facility would include a similar level of operating and maintenance staff as a stand-alone facility.

An 11-mile, live-crude pipeline would be routed from Liberty facilities directly to the Endicott Main Production Island (MPI). Liberty production would be pumped from Liberty Island to the production manifold at MPI, where it would be commingled with Endicott production stream. The commingled stream would then be routed to the primary Endicott production separator. This alternative would result in only a minimal reduction in island size from the full processing case.

This option was considered uneconomic due to the limited facility cost savings and the added cost for processing Liberty production through the Endicott facility.

No Processing (Gas Lift)

The facilities on the Liberty Island would be limited to the manifolding necessary to collect three-phase production from approximately 14 production wells, supply gas lift to the production wells, and to distribute water to approximately six water injection wells. This option would utilize gas lift for artificial lift of low pressure production wells.

The island also would have well test facilities, electrical transformer, electrical and instrumentation equipment, pipeline pigging facilities, emergency shelter, and shutdown equipment for all wells and flowlines. The Liberty Island would be normally unmanned, and operations would be controlled remotely from the Endicott control room, via microwave link. The Liberty Island facilities also would have a locally-initiated automatic shutdown system able to shutdown the facility during a process upset.

Approximately 11 miles of subsea flowline would transport three-phase fluids from the Liberty Island to the MPI. The Liberty three-phase flowline would be tied into the production manifold at MPI where fluids would be commingled with the Endicott production stream. The commingled stream would then be routed to the primary Endicott production separator. Liberty would receive treated water for water flood and dried gas for gas lift from the Endicott facilities. Water and lift gas would be supplied to Liberty through two subsea flowlines of approximately 11 miles in length from the Endicott MPI to Liberty Island. Produced gas from the Liberty reservoir would be injected and stored in the Endicott producing formation.

Electrical power (approximately 0.5 megawatts) for the Liberty Island facilities would be supplied by subsea cable from Endicott.

The minimal facilities associated with this no processing option would require an island size of 320 feet by 450 feet, requiring approximately 397,000 cubic yards of gravel (see Figure 2-5).

No Processing (Electric Submersible Pumps)

In this alternative, the facilities on the Liberty Island would be limited to the manifolding necessary to collect three-phase production from approximately 14 production wells and to distribute water to approximately six water injection wells. This option would utilize electrical submersible pumps (ESPs) for artificial lift of low pressure production wells. Use of ESPs would eliminate the need for gas lift and would allow a slightly smaller diameter three-phase flowline to be installed compared to the gas lift alternative (see Section 2.5).

The island also would have well test facilities, electrical transformer, electrical and instrumentation equipment, pipeline pigging facilities, emergency shelter, and shutdown equipment for all wells and flowlines. The Liberty Island would be normally unmanned and operations would be controlled remotely from the Endicott control room, via microwave link. The Liberty Island facilities also would have a locally-initiated automatic shutdown system able to shut down the facility during a process upset.

Approximately 11 miles of subsea flowline would transport three-phase fluids from the Liberty Island to the Endicott MPI. The Liberty three-phase flowline would be tied into the production manifold at the MPI where fluids would be commingled with the Endicott production stream. The commingled stream would then be routed to the primary Endicott production separator. Liberty would receive treated water for water from the Endicott facilities. Water would be supplied to Liberty through a subsea flowline of approximately 11 miles in length from the Endicott MPI to Liberty Island.

Electrical power for the Liberty Island facilities would be supplied by subsea cable from Endicott. Electrical power demand at Liberty would be significantly higher than the gas lift option discussed above (approximately 6.0 megawatts).

The minimal facilities associated with this no processing option would require an island size of 320 feet by 450 feet, requiring approximately 397,000 cubic yards of gravel.

2.4.2 Analysis

A stand-alone full processing facility has been selected as the proposed action based on economics, maximizing reservoir recovery, and the lack of significant environmental impacts (see Section 5.2).

The partial processing alternative, while feasible, did not offer any significant benefits in terms of reduction in island-based processing equipment, support infrastructure or island size.

While the no processing alternatives resulted in a minor reduction in island size, a number of technical and commercial difficulties regarding facility sharing with Endicott would have to be overcome to make this a viable option. In addition, there are several major technical and environmental concerns related to the "no processing" pipeline requirements, as discussed in Section 2.5.

Processing alternatives are summarized in Table 2-2.

2.5 PIPELINE SYSTEM

This section describes and evaluates the various pipeline alternatives considered (Table 2-3 and Figure 2-6). Each option is described as it pertains to the respective facility processing option(s). For the Liberty Development, the following alternatives were considered:

- Tie-in to the Badami line/Full Processing at Liberty
  - Western Route (Proposed Project)
  - Eastern Route
- Tie-in at Endicott Main Production Island
  - Partial Processing at Liberty
  - No Processing at Liberty (Gas Lift)
  - No Processing at Liberty (Electrical Submersible Pumps)
- Tie-in at Badami Central Processing Unit
  - Partial Processing at Liberty
  - No Processing at Liberty

Construction techniques for all cases would be similar. Access to the pipeline construction sites would be in winter, from an ice road, with access to the seafloor through a slot cut in the ice. A trench would be excavated and the material temporarily stored. The pipelines would be welded into one continuous length and lowered into the

TABLE 2-3

PIPELINE ALTERNATIVES

PROJECT OPTION	PIPELINES	NO. OF PIPELINES	LENGTH	BOULDER PATCH DISTURBANCE	STRUDEL SCOUR HAZARD	PIPELINE MODE	RETAIN (Yes/No)
Tie-in to Badami (Western Route)	12" Oil Export 6" Utility	2	~7.6 miles (6.1 subsea)	Unlikely	Medium	Buried (offshore)/VSM's (onshore)	Yes
Tie-in to Badami (Eastern Route)	12" Oil Export 6" Utility	2	~8.6 miles (5.6 subsea)	Unlikely	Medium	Buried (offshore)/VSM's (onshore)	Alternative
Tie-in at Endicott MPI/Partial Processing at Liberty	12" Live Oil Export	1	~11 miles mostly subsea	Yes	Low	Buried (offshore)/VSM's (onshore)	No
Tie-in at Endicott MPI/No Processing at Liberty (Gas Lift)	26" 3-phase export; 10" water import; 8" gas import	3	~11 miles mostly subsea	Yes	Low	Buried (offshore)/VSM's (onshore)	No
Tie-in at Endicott MPI/No Processing at Liberty (Electrical Submersible Pumps)	24" 3-phase export; 10" water import	2	~11 miles mostly subsea	Yes	Low	Buried (offshore)/VSM's (onshore)	No
Tie-in at Badami CPU	24" 3-phase export; 10" water import; 8" gas import	3	~16 miles mostly subsea	Unlikely	Medium/High	Buried (offshore)/VSM's (onshore)	No

trench. The excavated material would be replaced as back-fill in the trench as the pipelines are installed. The pipeline(s) would be buried with adequate cover to prevent ice gouging from damaging the lines.

2.5.1 Options

Badami Tie-in Western Route/Full Processing at Liberty (Proposed Project)

Two pipelines, a 12-inch oil pipeline and a 6-inch products pipeline, will be routed to a tie-in point with the Badami pipeline, south-southwest of the Liberty Island (Figure 1-1). The oil export and products lines will tie in to the Badami Sales Oil Pipeline and Products Pipeline at this point. The Liberty pipeline right-of-way includes an approximately 6.1 miles long buried subsea section, and an approximately 1.5 miles long conventional elevated (VSM supported) overland section to the Badami tie-in.

Badami Tie-in/Full Processing at Liberty (Eastern Route)

In this alternative, pipeline configuration and construction would be similar to the proposed project. However, the pipeline route would run south-southeast from the Liberty Island to a tie-in point with the Badami line east of the Kadleroshilik River. The subsea portion would be slightly shorter (5.6 miles) and elevated portions of the line would be slightly longer (3.0 miles) than the proposed project. Use of drag-reducing agents in the Liberty Sales Oil Pipeline would be required to achieve the project flowrates because of back pressures in the Badami Sales Oil Pipeline.

Endicott Route (Partial Processing Facilities at Liberty)

This would be a direct route from the Liberty Island to the Endicott MPI. Some portions of the Boulder Patch would be affected, as straight line construction would be necessary due to the size of trench and pipeline required. The pipeline corridor would contain one three-phase production flowline carrying Liberty fluids to Endicott for processing. All other utilities would be provided by facilities located on the Liberty Island.

Construction would require a trench with minimum top dimensions of 24 feet +/- wide, and bottom dimensions of 4 feet +/- wide. All excavated material would be used as backfill on the pipe.

The production flowline, carrying the partially processed fluids, would be 12 inches in diameter. The fluids would be processed to allow use of a conventional leak detection system. The flowline would be insulated to prevent wax and/or hydrate formation from occurring.

Design life of the flowline would be such that a line replacement would not be required over the life of the field. This would be achieved either by the use of Corrosion Resistant Alloys (CRA) or an appropriate chemical inhibition strategy.

Endicott Route – No Processing at Liberty (Gas Lift)

The route from the Liberty Island to the Endicott MPI would be direct because of trench and pipeline size considerations. The pipeline corridor would contain one three-phase production flowline carrying production to Endicott to be processed; one gas line carrying gas to the Liberty Island for artificial lift of low pressure production wells; one water line carrying produced/seawater to the Liberty Island to be used for injection into the reservoir; and one power cable that would furnish power to the island from Endicott.

Construction would require a trench with minimum top dimensions of 35 feet +/- wide, and bottom dimensions of 12 feet +/- wide. All excavated material would be used as backfill on the pipe.

The production flowline would be 26 inches in diameter contained in a 36-inch diameter carrier line providing insulation to prevent the formation of wax and/or hydrates. This pipe-in-pipe arrangement would require weighting to counteract buoyancy effects until the backfill material is placed. The water injection line would also be insulated to prevent freezing.

Design life of the flowline would be such that a line replacement would not be required over the life of the field. This would be achieved either by the use of Corrosion Resistant Alloys (CRA) or an appropriate chemical inhibition strategy.

Trench construction and backfill would use similar techniques to those described above. However, the pipe would be welded into one continuous length and pulled into the trench along the sea bottom.

Endicott Route - No Processing at Liberty (Electrical Submersible Pumps)

The route from the Liberty Island to the Endicott MPI would be direct because of trench and pipeline size considerations. The pipeline corridor would contain one three-phase production flowline carrying production to Endicott to be processed; one water line carrying produced/seawater to the Liberty Island to be used for injection into the reservoir; and one power cable that would furnish power to the island from Endicott. The power cable would have to be capable of supplying approximately 6 megawatts of power requiring a cable that would be equivalent in size to an 8-inch diameter pipeline.

Construction would require a trench with minimum top dimensions of 30 feet +/- wide and with bottom dimensions of 10 feet +/- wide. All of this excavated material would be used as backfill on the pipe.

The production flowline for the electrical submersible pump case would be 24 inches in diameter contained in a 30-inch diameter carrier line providing insulation to prevent the formation of wax and/or hydrates. This pipe-in-pipe arrangement would require weighting to counteract buoyancy effects until the backfill material is placed. The water injection line also would be insulated to prevent freezing.

Design life of the flowline would be such that a line replacement would not be required over the life of the field. This would be achieved either by the use of Corrosion Resistant Alloys (CRA) or an appropriate chemical inhibition strategy.

Trench construction and backfill would use the same techniques as those described in the No Processing (Gas Lift) alternative described above.

Badami Central Processing Unit (CPU) Alternative

This alternative would require transport of three-phase or partially processed fluids to the Badami CPU for processing. This option is similar to the Endicott MPI alternative but would require longer pipelines (approximately 16 miles) which would have to cross the Shaviovik River delta. In this case, the pipeline would traverse a larger area with increased potential for strudel scour.

2.5.2 Analysis

A pipeline system running south-southwest from Liberty Island to a tie-in with the Badami pipeline system has been selected for the Liberty Development. On August 8, 1997, BPXA applied to the State of Alaska for a right-of-way for the proposed Western Route. This route is preferred because it is shorter, provides better pipeline hydraulics, and avoids Boulder Patch communities. The pipeline system includes a 12-inch sales oil and a 6-inch products line installed in the same trench.

The Endicott live crude and three-phase flowline alternatives have been rejected as preferred means of fluid export. In each of the cases reviewed, extensive excavation activities in the environmentally sensitive Boulder Patch would be required. Rerouting or avoidance of the Boulder Patch would not be feasible in these cases due to trench and pipeline size constraints. There is an additional technical challenge associated with metering/leak detection in a three-phase flowline. On the basis of minimizing environmental impacts, limiting technical risk, and the lack of any clear economic advantages over the proposed project, export of unprocessed or partly processed fluids to Endicott has been rejected.

The Badami live crude and three-phase flowline alternatives, while avoiding the Boulder Patch, were rejected early in the analysis on the basis of increased cost, increased technical challenges, strudel scour issues, and the likelihood of increased environmental impact.

Pipeline alternatives are summarized in Table 2-3.

2.6 GRAVEL SOURCE ALTERNATIVES

About one million cubic yards of gravel could be required for the Liberty Development Project. For any project, gravel mine site selection is based on locating adequate quantities of suitable material that are within a reasonable distance from the construction area and that can be mined in an economic and environmentally sound manner. For Liberty, several sources of gravel have been considered. These include the:

- Kadleroshilik floodplain island source
- Kadleroshilik floodplain oxbow source
- Re-use of material from Tern or Goose islands
- Existing Duck Island mine
- Abandoned Shaviovik airstrip or other abandoned gravel facilities

During early project planning, use of three of these sources was eliminated from further consideration. The concept of using reclaimed gravel from the abandoned Shaviovik airstrip was discarded because this is a relatively small quantity of gravel about 13 miles distant from the main construction area. In addition, the gravel would have to be tested to ensure that no contamination exists before BPXA would be willing to purchase this resource from the State of Alaska. The same concerns would apply to the use of other abandoned facilities in this region.

Reuse of gravel in the abandoned offshore Tern and Goose islands was evaluated and rejected based on the limited quantities of gravel available from these sources, and inconsistencies with the planned project schedule. Based on a 1996 survey, BPXA estimates that approximately 238,000 cubic yards of gravel remains at Tern Island, and Goose Island is assumed to have about the same quantity of gravel. Combined, these islands do not provide an adequate supply of gravel to support project construction needs, so an additional source would still be required.

In addition, the most practical way to remove this gravel is in the summer using drag-line excavation equipment and barge transport. This summer activity would be more disruptive to wildlife and subsistence users than a winter activity. If permits were not received by August, 1999, this option could delay the project one year, because island construction could not begin until summer 2001. Winter excavation of these islands is impractical due to extensive blasting requirements. In addition, the blasting/hauling process would probably require more time than conventional gravel mining and hauling.

The option of hauling gravel from the Duck Island Mine Site was also considered, but not selected for this project. Gravel could be obtained from this source, but at substantially greater cost. Hauling distance is a major factor in the cost of gravel civil construction on the North Slope, and the Duck Island Mine Site is about three times farther from the island location than the proposed site. Also, dewatering of this pit would be required before this quantity of gravel could be extracted.

BPXA considered two alternative sites in the Kadleroshilik River floodplain in detail: an island site, and a site in a nearby oxbow lake system. A site in the oxbow lake system would involve more disturbance of tundra vegetation, and would be slightly farther from the construction areas than the island site. The oxbow site, after flooding, would create a deep freshwater pool. The island site would create a brackish pool. Based on cost and minimization of impacts, the island site was selected for this project.

2.7 CONSTRUCTION TIMING

In assessing project options, BPXA evaluated summer versus winter construction. Winter construction is standard North Slope practice, and allows mobilization to roadless areas with no impact. In the past, however, many offshore gravel islands were constructed in the summer. While summer construction is not infeasible for this project, winter construction is preferred for several reasons. Gravel hauling and placement, installation of island slope protection, installation of modules, and mobilization of the drilling rig would not be possible in a single open water season. Island construction in the open water season would likely require mobilization of ocean-going barges from the lower 48 states. Gravel haul would involve a two stage operation with trucks transferring to barges at West Dock or other locations. This would incur a cost and schedule premium to the island construction.

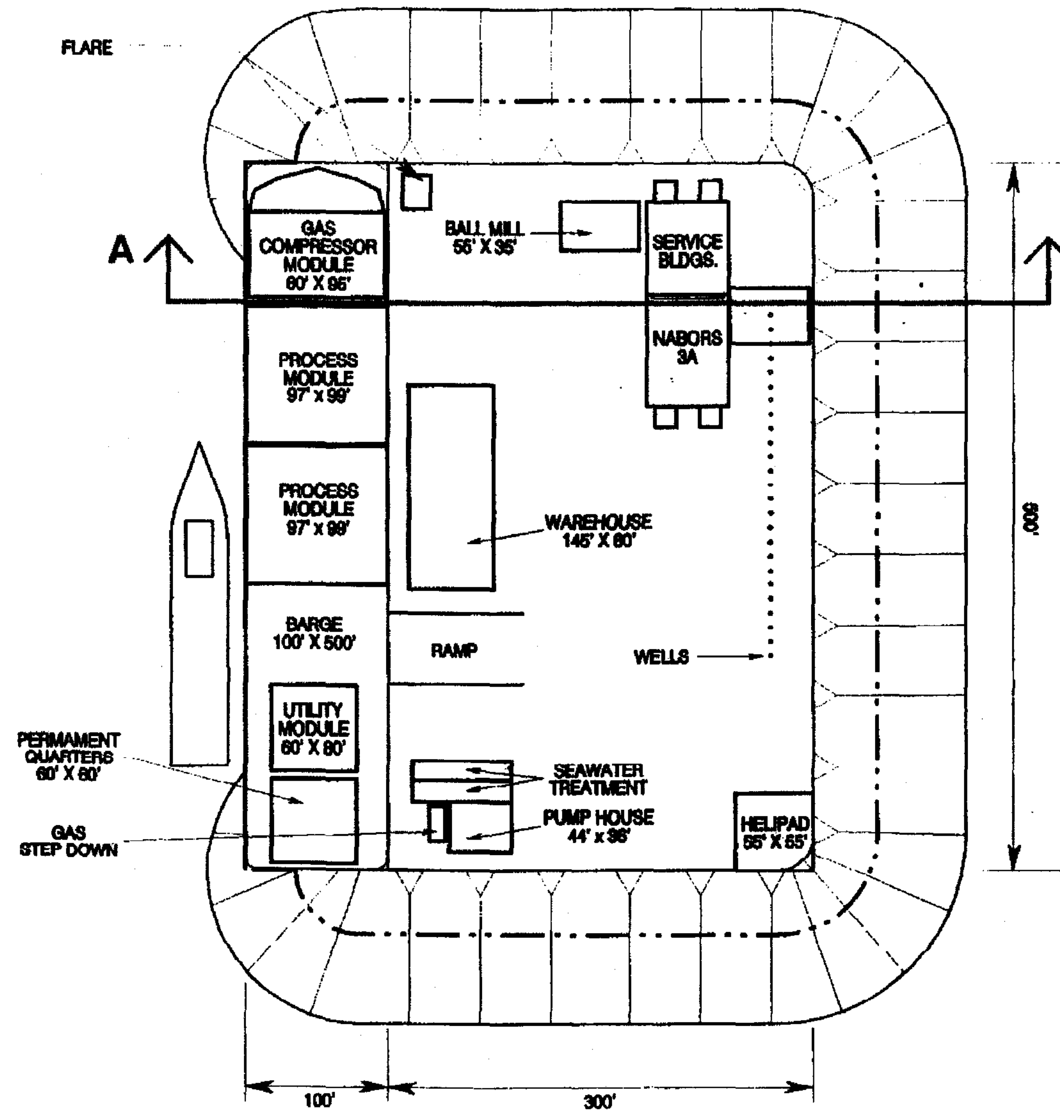
Marine pipeline installation would also require mobilization of equipment from the lower 48 states or from overseas, requiring transit into the Beaufort Sea during the open water season. Because of the mobilization distance and limited access season to the Beaufort Sea, marine (open-water) construction commits equipment for up to a year with a cost premium. Also, laying the pipelines in the shallow open water area would require extensive seabed excavation due to the draft of the marine vessels.

For both the island and the pipeline, winter construction would generally involve fewer environmental impacts than summer construction, including the ability to access nearby onshore areas without tundra damage, less disturbance to wildlife, and less potential for conflicts with subsistence users.

2.8 NO ACTION ALTERNATIVE

A no action decision would result if MMS or other agencies deny the permits necessary for the Liberty Development Project. BPXA would then have the option of canceling the project, redesigning it, or pursuing some other course of action that may or may not require a federal permit.

Adverse environmental impacts on oceanographic processes and biological resources would be eliminated with the No Action alternative. Directional drilling from an onshore site or drilling from an existing gravel island are not currently feasible alternatives for development of the Liberty reservoir. No oil would be recovered under a No Action alternative. This would eliminate potentially increased revenues to federal, state, and local governments, loss of national energy reserves, and potentially increased dependence upon imported oil. In addition, exploratory drilling in other OCS lease sites might not be pursued.

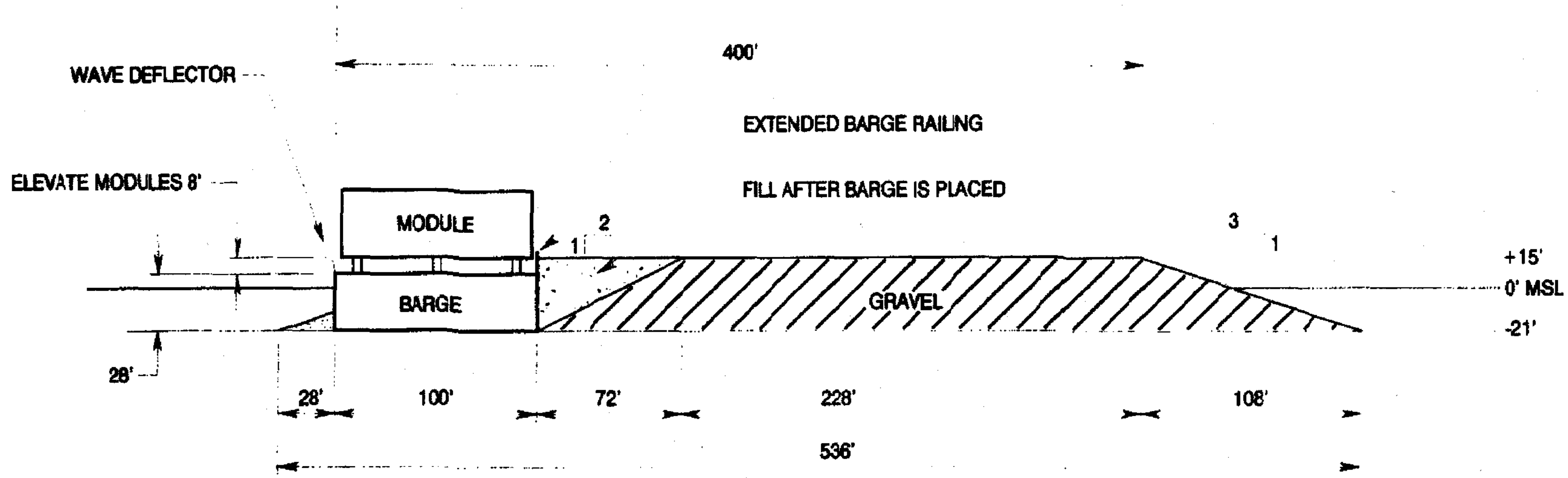


BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
CUSTOM BUILT BARGE ISLAND CONCEPT
PLAN VIEW

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	2-1

lib198.dgn



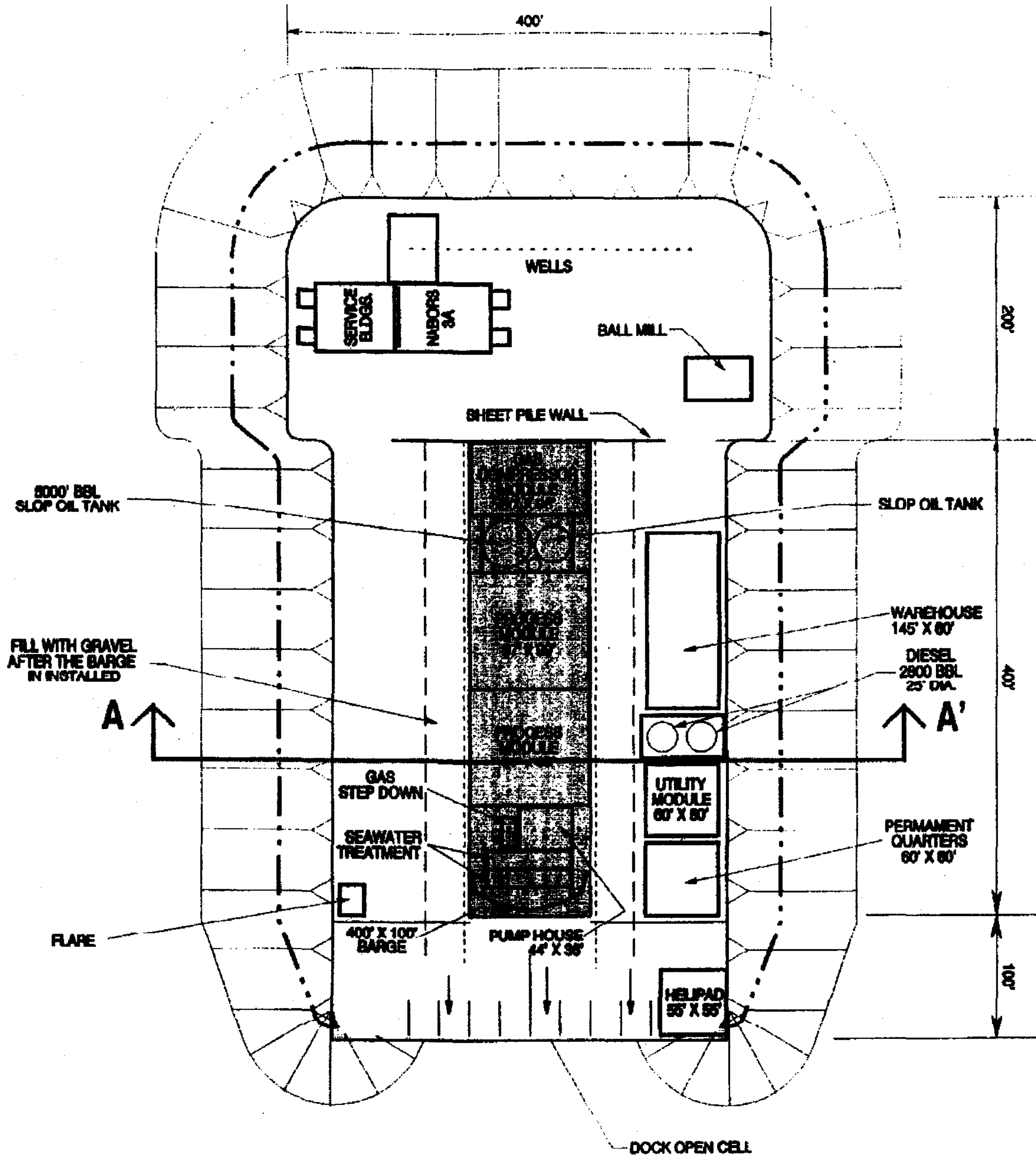
CROSS - SECTION A-A'

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
CUSTOM BUILT ISLAND CONCEPT
CROSS - SECTION

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	2-2

lib108.dgn



BP EXPLORATION (ALASKA) INC.		
LIBERTY DEVELOPMENT PROJECT CONVERTED BARGE - ISLAND CONCEPT PLAN VIEW		
DATE: January 1998	SCALE: NOT TO SCALE	FIGURE: 2-3

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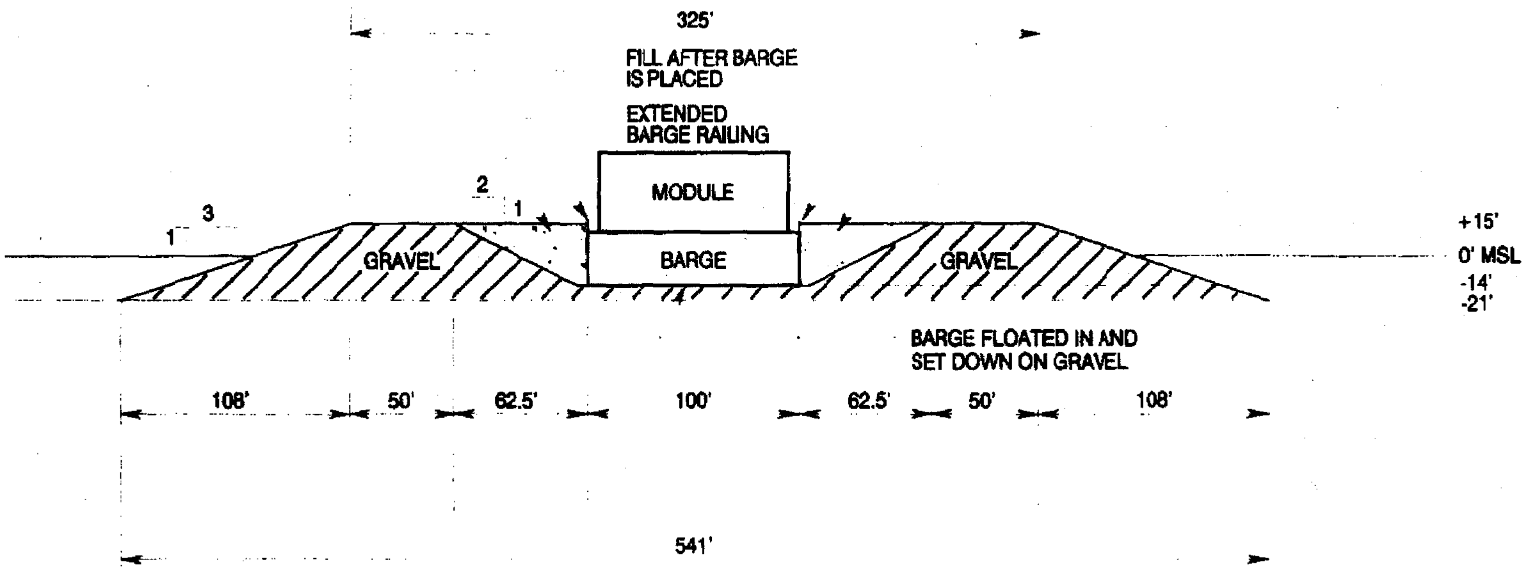


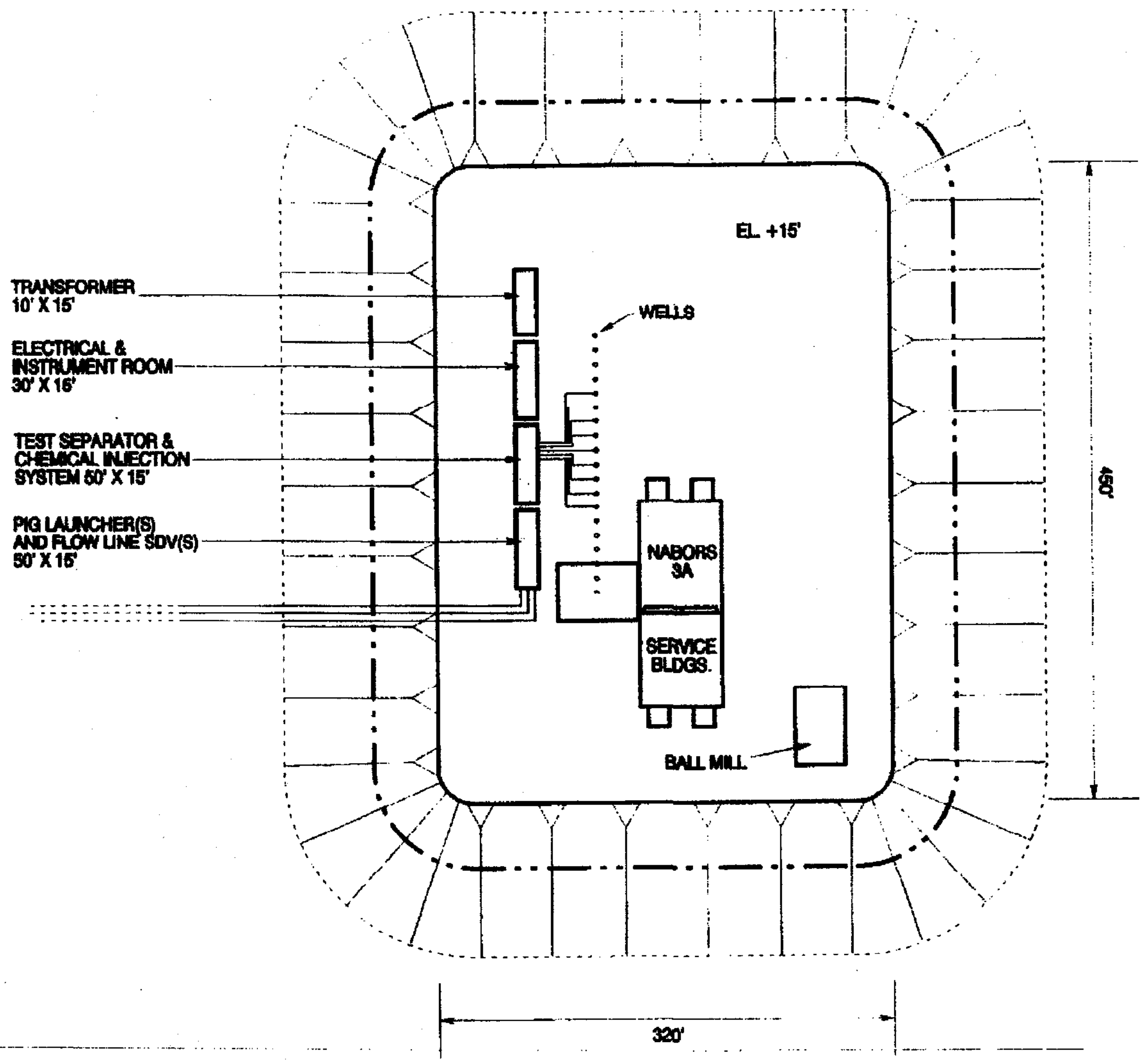
CROSS - SECTION A-A'

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
CONVERTED BARGE - ISLAND CONCEPT
CROSS - SECTION

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	2-4

lib109.dgn

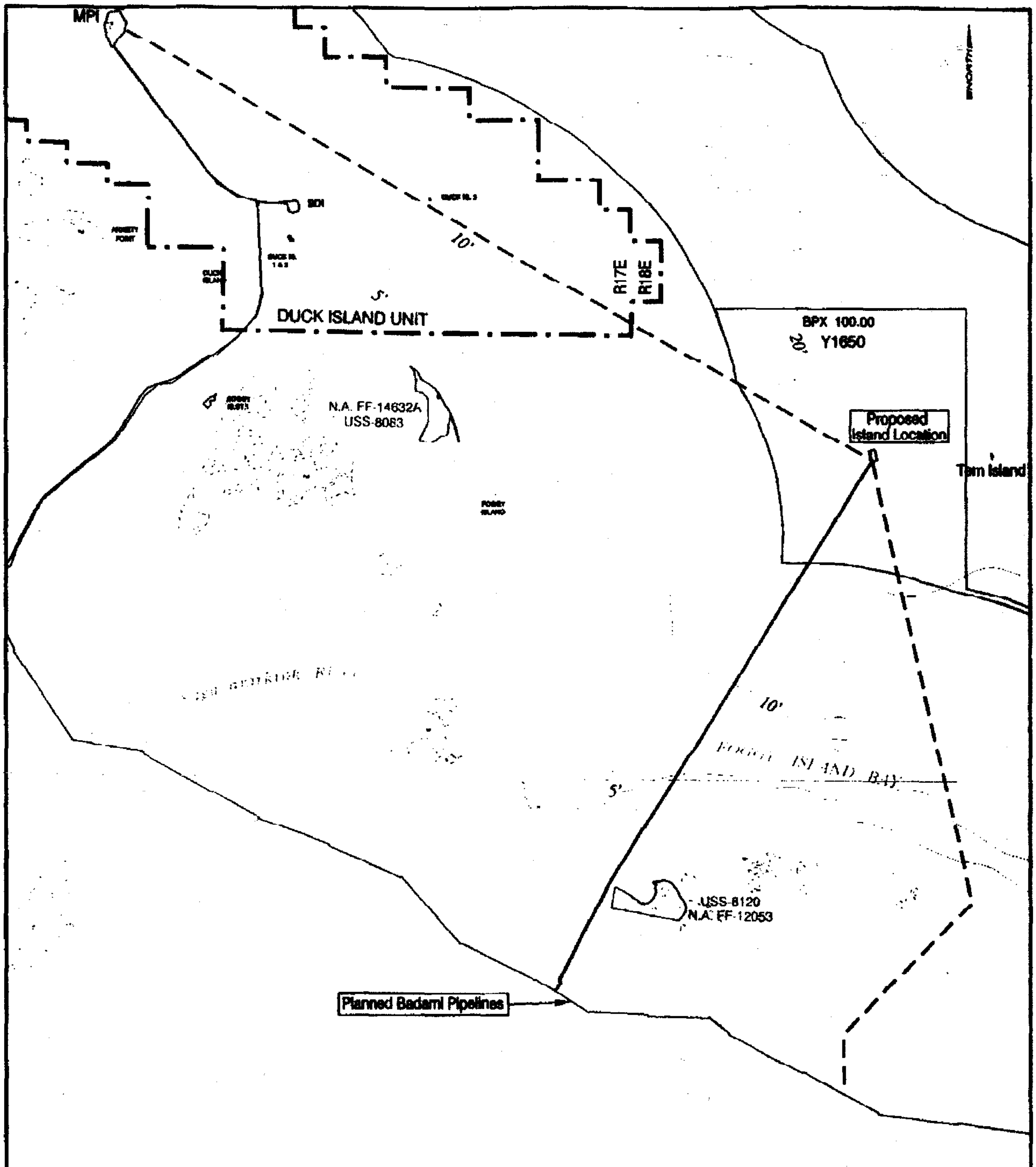


BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
WELL PAD ISLAND - NO PROCESSING
PLAN VIEW

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	2-5

lib198.dgn



Proposed Pipeline Route

Alternative Pipeline Routes

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT PIPELINE ROUTE OPTIONS

DATE:	SCALE:	FIGURE:
January 1998	1" = 1.75 Miles	2-6

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3. PROJECT DESCRIPTION

3.1 INTRODUCTION

This section provides a summary description of the proposed project. The Development and Production Plan and other permit applications provide additional detailed information.

The Liberty reservoir is located offshore in Foggy Island Bay, about 7.5 miles east of the Endicott Satellite Drilling Island (SDI), and about 5 miles north of the mouth of the Kadleroshilik River. This reservoir was discovered in the early 1980s by Shell Western E&P Inc., who drilled four wells in the area before abandoning the prospect in 1991.

In September 1996, BPXA acquired several leases on the OCS from U.S. Minerals Management Service Lease Sale 144. After the lease sale, BPXA initiated permitting for the Liberty #1 Exploration Well. The tophole location for the well was located on a gravel/ice structure on top of the abandoned Tern Island on Tract OCS-Y-1585 (Lease Sale 144), and the bottomhole location was on Tract OCS-Y-1650 (Lease Sale 144).

Drilling of the Liberty #1 Well began in February 1997, followed by testing in March 1997. The drilling operation was demobilized in April 1997. Conceptual and preliminary engineering activities have been ongoing throughout 1997, and BPXA currently intends to proceed with final engineering and permitting for project start-up in 1999.

Exhibit A and Figure 3-1 show the overall Liberty Development Project layout, and Figure 3-2 is an artist's illustration of the Liberty Island and pipeline system. The proposed project, including the island, facilities, associated infrastructure and improvements, and pipeline, has been formulated on the basis of alternatives analysis (see Section 2), preliminary engineering, environmental analysis, regulatory requirements, agency coordination, and local community liaison.

3.2 DEPLETION PLAN

Based on seismic data, well tests, and geologic interpretation, it is estimated that the reservoir contains about 120 million barrels of recoverable reserves. Included in the development plan is supplemental waterflood with gas re-injection to be initiated immediately. Natural gas and/or product will be exported as a separate product stream. At the proposed location, the entire field can be developed from one gravel island drilling site. Development drilling is planned for fall 2000, with first oil production expected in fourth quarter of 2000. Initial schedules call for drilling to continue until March 2002.

3.3 GRAVEL SOURCES

Approximately one million cubic yards of gravel will be required for island construction, for the pipeline landfall valve pad, and for the tie-in with the Badami pipeline. In addition, it is estimated that approximately 125,000 cubic yards of gravel would be required to construct an island from which to drill an emergency relief well, if one is ever required. Thus, a source of approximately 1,125,000 cubic yards of gravel is required to meet immediate and long term project needs.

The preferred source of gravel is a new mine site, developed specifically for this project, in the Kadleroshilik River flood plain. The mining and reclamation plan would be similar to that for other recent mine sites developed on the North Slope, including the East Badami Mine Site, the proposed Northstar mine site in the Kuparuk River, and the Kuparuk Dead Arm Mine Site. The general approach of these mining and reclamation plans is to minimize the effects of mining and to create conditions that improve fish habitat. The detailed Liberty Mining and Reclamation Plan is currently being developed in coordination with the state and federal agencies, and particularly with the Alaska Department of Fish and Game to ensure it meets that agency's criteria for mine site development.

An onshore gravel mine will be developed to meet project gravel requirements for construction of the island, select pipeline trench backfill material, the pipeline landfall pad, and the Badami pipeline tie-in pad. As a contingency, the mine site will also contain a reserve area with sufficient gravel resources for construction of a separate, smaller island for the drilling of an emergency relief well, if ever necessary.

A zone in the Kadleroshilik River floodplain has been identified as the general proposed location in which gravel mining will occur (Exhibit A). Within this zone, a preferred mine site (Exhibit A) has been defined. It lies approximately 1.4 miles south of Foggy Island Bay on a mostly unvegetated gravel island in the Kadleroshilik River floodplain. The ground surface elevation of this island is approximately seven to nine feet above MSL. The mine site is approximately 38 acres in size and the reserve area is approximately 7 acres, for a total mine site size of approximately 45 acres.

The gravel mining and rehabilitation plan was developed with the objective of minimizing environmental impacts through mitigation features incorporated into the project design. The mine site would be developed, gravel extracted, and site rehabilitation initiated within a single winter construction system.

Mining is scheduled to begin in January or February 2000. Unusable material will be stripped from the site and stockpiled in a designated reserve area. Gravel will be removed in two 20 foot lifts. After useable gravel has been removed from the mine, materials unsuitable for construction (e.g., materials stockpiled during mining and excess organic material or soil from the onshore pipeline trench excavation) will be placed in the mine excavation. These backfilled materials will be used to contour the side or bottom faces of the mine site to improve future habitat potential.

After mining is completed, the mine site will be connected to the active channel of the Kadleroshilik River. During spring breakup, the mine site will flood with fresh water. Subsequently, coastal storm surges flooding into the mine site are expected to create brackish water conditions.

Upon rehabilitation, the flooded mine site will provide several benefits. Deep water sources connected to streams and rivers are uncommon on the coastal plain. The excavation will create potential overwintering habitat for fish in an area where this type of habitat is limited. BPXA is also investigating the possibility of creating shallow water habitats in conjunction with the mine site rehabilitation. The pit also will provide a source of water for offshore ice road construction (if brackish water is present, the source cannot be used to construct onshore ice roads).

The preliminary mining and rehabilitation plan described above will be finalized based on results of winter 1998 geotechnical investigations. Final details of the mining and rehabilitation plan will be coordinated with the interested agencies.

3.4 PROJECT ACCESS

Liberty is an offshore development and will not have permanent access via a gravel causeway or other structure. Transportation to the island is essentially by three modes: helicopter, marine vessel, or ice road. Ice conditions limit barge traffic to three months per year (July, August, and September). Ice roads can be used from late December until May. The remaining four months (May, June, October, and November) will require the use of helicopters for access.

Ice roads will be required to support construction of both the island and the pipelines. For the construction phase of the project, two separate ice roads will be constructed: one for pipeline construction and one for island construction. Separate roads are required to avoid construction conflicts. Additional ice pads also will be constructed adjacent to the island and along the pipeline route to facilitate storage of equipment, materials and assembly/welding of pipe sections.

The process modules and permanent living quarters will be transported to the site by barge during the open water season after the island construction and slope protection have been completed. Drill rig mobilization will be by barge in the open water season between July and September 2000.

During drilling and production operations, supplies, particularly heavy bulk items, will be transported to the island during the ice road and/or open water windows.

Perishable items, including foodstuffs, will require transportation on a more frequent basis.

3.5 GRAVEL ISLAND

The Liberty gravel island will be designed according to similar criteria as BPXA's proposed Northstar gravel island. This design uses technology developed for offshore applications in the Alaskan Arctic during the past 15 years. The island design and construction techniques include logical extensions of earlier work successfully performed in the 1980s to support the Endicott development and the Northstar exploration island.

Conceptual drawings of the proposed island are shown on Figures 3-3, 3-4, and 3-5. The island work surface dimensions will be approximately 345 feet by 680 feet, requiring about 650,000 to 825,000 cubic yards of gravel. The dimensions of the island fill on the seafloor will be a maximum of 630 to 670 feet by 960 to 1000 feet. A maximum footprint area of 1000 feet by 1200 feet has been defined. The island will have a surface elevation of 12 to 15 feet MLLW, with a berm above that to limit wave splash effects.

The island will have side slopes of 3:1, with slope protection (Figures 3-6 to 3-9). The island slope protection is required to assure the integrity of the gravel island by protecting it from the erosive forces of waves, ice ride-up, and currents. In addition, by reducing the risk of erosion and associated introduction of sediment into the water column, slope protection offers a means to protect water quality.

The proposed Liberty slope protection design incorporates island side slopes and a bench protected with concrete mat slope armor, with a system of overlapping gravel-filled bags at the top of the bench. The entire slope protection system is underlain by highly permeable and durable filter fabric that will prevent leaching of sediment into the water column. The purpose of the bench and the gravel bags is to dissipate wave energy and limit ice ride-up potential. The position of the bags does not allow frequent exposure to damaging waves and ice, and loss of gravel bag fabric debris is expected to be negligible. The bag fabric will be polyester, which is heavier (sinks in seawater) and is about four times stronger than the polyethylene bags used in construction of islands used for exploratory drilling in the 1980s.

Maintenance procedures designed to prevent loss of bag material to the sea will be implemented. The bags will be inspected annually, before breakup. Any damaged bags will either be repaired, or removed and replaced.

Additional surface features on the island include:

- Helipad
- Sheetpile dock for island access during open water
- Water intake structure with protective sheet piles as required

3.6 FACILITIES

Based on current data, reservoir development will require 14 production wells, six water injection wells, two gas injection wells, and one waste injection well (two wells will be permitted, but the second well only would be drilled if a problem occurred with the first well). Manifold piping will route all produced fluids to the separation facilities. A manifold system will also route treated produced water and seawater to the water injection wells and excess gas to the gas injection wells. Lift gas will be piped to the low pressure production wells as required. A well test system will be installed to allow for the routine testing of production wells.

Produced fluids will be routed through three separation stages (intermediate, low pressure and gas boot) to remove gas and water from the crude oil stream. The crude oil stream transported through the Liberty Pipeline will meet the pipeline quality specification for TAPS. The approximate facility production capacities are:

- Crude Oil – 65 thousand barrels per day (MBPD)
- Total Gas – 150 million standard cubic feet per day (MMSCFD)
- Produced Water Treatment – 90 MBPD
- Seawater Treatment – 75 MBPD
- Total Water Injection Capacity – 140 MBPD

Gas removed from the crude oil stream will be dried and compressed to be used as fuel gas, lift gas for low pressure production wells, and for injection back into the producing formation for pressure maintenance. A portion of the processed gas also may be exported from the island as product. Produced water separated from the crude oil stream will be treated and injected into the producing formation for pressure maintenance and to aid in oil recovery. Seawater will be filtered and treated to remove oxygen, commingled with any produced water, and then injected into the producing formation for pressure maintenance. The seawater requirement will decrease as the produced water rate increases later in field life.

The surface facilities also will include all power generation and other utilities needed in support of the Liberty camp, processing facilities, and drilling.

In accordance with BPXA corporate policy, process design incorporated measures to reduce the emissions of "greenhouse gasses," notably carbon dioxide. These measures include the selection of efficient turbine drivers, minimizing flaring during operation upsets, waste heat recovery, seawater deaeration using vacuum stripping rather than fuel gas stripping, and fuel gas pretreatment to reduce carbon dioxide content.

3.7 DRILLING

Directional drilling will be used to reach targeted zones of the Liberty reservoir. The current plan calls for drilling 14 production wells, six water injection wells, two gas injection wells, and one waste injection well. Wells will be drilled on 9-foot centers. The island surface could accommodate future expansion of up to a total of 40 wells.

A drill rig will be mobilized to the island on a barge in between July and September 2000. Surface conductors and casing for all wells can be batch-drilled to minimize storage needs. The rig will be electrically powered, with associated reductions in air pollutants being emitted. Emergency power for normal operations will be provided by two 1500-kW diesel generators, which will be in full-time service during installation for construction power and will provide dedicated emergency backup for drilling. Instrumentation features will include:

- Local and remote monitoring of well, mud room, and safety data
- Standardized instrumentation for modules and equipment
- Unit shutdown and emergency shutdown system capability

Rig selection will be made at a later time, but will consider the following:

- Use of a self contained mobile rig
- Dual fuel capacity
- Capability to drill 9-foot centers

3.8 PIPELINE SYSTEM

3.8.1 Pipeline Route

The proposed project pipeline route is shown in Exhibit A and in Figure 3-1. The pipeline route is divided into two segments: offshore and onshore.

The offshore route segment is a nearly straight route from the Liberty Production Island to a landfall located about 6.1 miles to the south-southwest of the island. During preliminary engineering, the offshore route selection was based on preliminary bathymetric data, avoidance of strudel scour zones, avoidance of the Boulder Patch, and landfall siting criteria, including the need for a high bank and avoidance of archaeological and cultural sites and avoidance of salt marsh.

The overland route is approximately 1.5 miles long. It extends south to a tie-in with the proposed Badami sales oil pipeline approximately 1.5 miles west of the Kadleroshilik River. The overland route avoids major lakes and intersects the Badami pipeline at a new gravel pad.

3.8.2 Design

Design features for the sales oil pipeline include:

- design flowrate: 65,000 barrels per day
- maximum operating pressure: 1415 psig
- nominal diameter: 12 inches (12.75 inch outside diameter)
- wall thickness (offshore): 0.688 inch
- wall thickness (onshore): 0.281 inch
- pipeline material grade (offshore): API-5L X-52
- pipeline material grade (onshore): API-5L X-65

In addition, a 6-inch products pipeline will be constructed along the same route. This pipeline initially will transport fuel gas to the island. After local fuel gas is available, the products line can be used to export natural gas and products.

Design features for the products line include:

- maximum operating pressure: 3440 psig
- nominal diameter: 6 inches (6.625 outside diameter)
- wall thickness (offshore): 0.432 inch
- wall thickness (onshore): 0.375 inch
- pipeline material grade (offshore): API-5L X-52
- pipeline material grade (onshore): API-5L X-65

The onshore portion of the sales oil and the products pipelines will be elevated on standard VSMs, and will have polyurethane foam insulation. Expansion loops will be in an "L" loop configuration, spaced approximately 5,000 feet apart. The pipeline system will have a nominal minimum elevation of five feet above the tundra surface.

Automated pipeline isolation valves for the Sales Oil Pipeline and Products Pipeline will be located on the Liberty Production Island and at the Badami tie-in point. A manual isolation valve will be located at the landfall. New gravel pads will be constructed at the landfall and at the tie-ins. The landfall pad will be approximately 70 feet by 70 feet, requiring approximately 2,000 cubic yards of gravel; the tie-in pad will be approximately 150 feet by 150 feet, requiring approximately 7,200 yards of gravel. Gravel for both pads will be obtained from the proposed Liberty mine site. Provision for pigging both the oil and products lines will be provided. A fuel gas heater, power generation equipment, and pump may be required during the time the pipeline supplies fuel gas to the Liberty Island.

The offshore buried pipeline will approach the island in the trench. A vertical riser will be used to transition the pipeline from the buried offshore mode to the working surface of the Liberty Island (Figure 3-14). The pipeline and riser will be installed as the island is being constructed.

3.9 CONSTRUCTION PLAN

3.9.1 Gravel Island

Island construction will commence as soon as the ice road from the mine site to the island site has been completed. Gravel will be hauled from the Kadleroshilik River mine site over the ice road. The gravel haul will continue for about 45 days, and by mid-April, all gravel should be in place. Slope protection installation will follow, beginning before breakup and continuing until early July. The pile-driven sheetwall for the dock will be installed by the open water season. Precast foundations will be poured off-site and trucked to the island. Foundation installation will require approximately 30 days and will be complete by mid-August. Remaining island construction work will be completed prior to sealift arrival (mid-August). Materials will be transported to the island by ice road from Endicott or by barge.

3.9.2 Surface Facilities

The process facilities for Liberty will be constructed in modules to be assembled at the Port of Anchorage. Module fabrication will start in the spring of 1998 or 1999 and will be completed in the summer of 2000 in preparation of the sealift to the Liberty Island. The modules will be installed on the island in the early fall of 2000. During the fall of 2000, final tie-ins will be made between the process modules and production wells in preparation for first production in late 2000.

3.9.3 Pipeline

The pipeline system will be constructed during the winter within a proposed temporary construction right-of-way (250 feet wide onshore, 1,500 feet wide offshore). An ice road and/or thickened sea ice will be built within the construction right-of-way to support pipeline construction. An additional temporary site for welding of offshore pipeline strings will be required. This site will be located close to shore on grounded sea ice (generally less than 5.5 foot water depth), artificially thickened as required, on the east side of the pipeline right-of-way. Approximate dimensions of the make-up pad will be 5,000 feet long by 750 feet wide.

Onshore

The onshore sequence of activities includes VSM installation, placement of the pipelines on VSMs, and construction of the tie-in. Design and installation of the VSMs will be completed using standard North Slope procedures. The VSM piles will be set using a sand slurry.

Offshore

Offshore, the pipelines will be buried in a common trench. The proposed depth of cover over the 12-inch pipeline is seven feet (Figures 3-15 to 3-17). In addition, the pipeline will be buried from the shoreline to an inland point where the pipeline transitions from buried to elevated mode. The transition point will be located to provide protection from coastal erosion expected during the pipeline design life (currently estimated to be about 150 to 200 feet inland). The transition trench will be up to 200 feet long and as wide as 100 feet. Select backfill will be used, as necessary, to prevent thaw settlement. Backfill material will be obtained from the Liberty gravel mine site. The quantity and composition of select backfill will be determined in final design, but the maximum quantity expected to be required, based on trench geometry, is between 10,000 and 15,000 cubic yards. After laying the pipeline, the trench will be refilled, with organic layers from the top of the trench replaced on the surface. At the shore crossing, the backfill will be topped with a veneer of fine-grained soils and organics, and seeded as needed to promote revegetation. Coarser granular material from the gravel mine or the excavation will be used as needed to achieve erosion resistance similar to the adjacent, undisturbed material. This plan minimizes any increase in erosion due to construction through coastal bluffs and is intended to replicate the natural strength and character of the landform.

Offshore Trenching

The trench in which the offshore pipeline will be laid will be excavated through the sea ice in the winter. The execution sequence of the trenching and pipelaying operations is as follows:

- Thicken sea ice along route. This is required to support the excavation equipment. (Note: where bottomfast ice is present, thickening of the sea ice is not anticipated.)
- Cut a slot in the ice. The ice will be either cut into blocks using an ice trencher and removed by conventional excavation equipment or, where the ice is grounded, by using conventional excavation equipment. The blocks will be transported to a location away from the work site, as needed, to prevent excessive deflection of the ice in the work area.
- Excavate the trench using conventional excavation equipment. Excavated material will be backfilled over pipeline in the trench, or stockpiled in a designated area.

Hydraulic dredging is also being considered as a method for final pass excavation of the trench or as a contingency trench clean-out method in deep water in the winter season.

An option currently being considered is the use of spray ice construction techniques to ground the sea ice surrounding the trench. This would result in a solid ice wall on either side of the proposed trench along the entire pipeline route.

Offshore Pipeline Installation

Pipeline installation will follow immediately behind the trenching spread. The pipe joints will be welded into strings at the make-up site. Strings will be up to one mile in length.

Once trenching operations have begun, mobile equipment will tow a pipe string to the side of the trench. At the side of the trench, the Sales Oil and Product Pipelines pipe strings will be strapped together into a pipe bundle. Side booms will be used to control the vertical and horizontal position of the pipeline bundle down through the water column to the trench bottom. As an option, floats temporarily attached to the pipeline bundle may supplement the side booms supporting the bundle. The pipelines also may be laid in the trench without bundling them. Pipelaying will advance at the rate of trench excavation.

Subsequent pipe strings will be towed to the side of the slot and welded to the previous strings to form continuous pipelines (testing of the completed welds will be performed by using non-destructive techniques).

Offshore Trench Backfill

Generally, just-excavated trench spoils will be transported to be placed as backfill over recently-laid pipeline segments in a continuous process. An option is to store the spoil close to where it was excavated from the trench. After installation of the pipeline, the spoil will be then replaced in the trench. Initially, the spoils excavated from the trench will be temporarily stockpiled. The majority of spoils will be removed later from the stockpile and transported to be placed in the trench as backfill. Some select backfill may be required.

Excess Backfill Disposal

Certain circumstances, such as timing variations between the trenching and backfill operations, installation schedule delays, or unfavorable weather, may prevent the transportation of all the temporarily stored spoils back to the open trench section, resulting in sections of the trench not being fully backfilled. Worst case contingency planning thus is required for future backfilling of the trench.

Excess spoils generated during construction of the portion of the trench excavated through bottomfast sea ice may require disposal. In this area, it is possible that not all excavated material can be placed back into the trench. Additional excess spoil also may be generated along other segments of the pipeline due to several factors, including the possible use of select backfill. This excess material will be disposed of by distributing it on a storage location, where it will remain until breakup.

Two sites for spoil placement are being considered. The first storage site would be located on the west side of the pipeline right-of-way on ice outside the 5-foot isobath. Approximate maximum dimensions of the spoil placement site will be 5,000 feet by 2,000 feet. Depth of spoils placed on the site will normally range between approximately one and four feet.

Details regarding the 5,000 foot by 2,000 foot disposal site location will be developed based on results of winter 1998 Boulder Patch surveys, winter 1998 geotechnical studies (which will provide additional information on the expected quantity of excess spoils), and ongoing agency coordination and guidance. A major criterion that will be used in selecting the 5,000 by 2,000 foot site will be avoidance of impacts to any nearby Boulder Patch habitats, by not placing the disposal site directly over known Boulder Patch, using appropriate setbacks from known Boulder Patch, and consideration of normal oceanographic conditions. Other important criteria include maintaining a safe distance from active pipelaying operations, reasonable hauling distance, water depth greater than five feet, and other relevant factors.

The second storage site is a 200 foot wide section from the start of floating ice to within a point 2,000 feet south of Liberty island. Depth of spoils placed on the site will normally range between approximately one and four feet. This region is in the area of floating ice and water depths of 10 to 30 feet. It is an alternate storage and contingent disposal location for stockpiled excavated materials.

If hydraulic dredging were used as a contingency to create the required design trench configuration for pipe installation, the slurry (typically 60 percent seawater) will be placed on the surface of and freeze into the thickened sea ice on the construction right-of-way.

Hydrotesting

Hydrotesting of the pipelines will be completed by May 2000. Several options for test fluids are being considered, including glycol, a water/glycol mixture, or seawater. If any glycol is used, the test fluids would be recovered and returned to the vendor for future use, recycling, or approved disposal. If seawater is used, it will be discharged in accordance with the terms of a General NPDES permit.

3.10 POLLUTION PREVENTION AND SPILL RESPONSE

Liberty project planning includes pollution and spill prevention measures, as well as spill response preparedness. For the overall project to be authorized, it must meet the requirements of:

- 30 CFR Part 250.40 – MMS Pollution Prevention
- 30 CFR Part 250.42 – MMS Oil Spill Contingency Plan requirements
- 18 AAC 75 – State of Alaska Spill Prevention and Response regulations

MMS Pollution Prevention regulations require the lessee to take measures to "prevent unauthorized discharge of pollutants into offshore waters," and require the lessee to "not create conditions that will pose unreasonable risk to public health, life, property, aquatic life, wildlife, recreation, navigation, commercial fishing, or other uses of the ocean." These regulations also require that "all hydrocarbon-handling equipment for testing and production such as separators, tanks, and treaties will be designed, installed, and operated to prevent pollution: and that "maintenance or repairs which are necessary to prevent pollution of offshore waters … be undertaken immediately." These regulations also include requirements for secondary containment and control of surficial drainage.

The proposed project has incorporated design measures to assure that the potential for spills and leaks has been minimized to the extent practicable. These features include:

- Island grading plan – surface drainage controlled by generally flowing to sumps with oil/water separators to handle minor spills (Figure 3-18)
- Storage tanks and process facilities located in lined, bermed areas
- Pipeline leak detection system
- Pipeline valving plan
- Well control design

In addition to spill and leak prevention measures incorporated in design and operations planning, BPXA must develop an approved Oil Spill Contingency Plan (OSCP) addressing activities in federal waters, as well as an Oil Discharge Prevention and Contingency Plan (ODPCP) for activities in state waters and lands. These plans require identification of spill prevention measures, including use of Best Available Technology. The plans also require demonstration of the ability to identify, respond, and cleanup spills with the appropriate equipment in all conditions expected at the site, including open water conditions, broken ice conditions, and frozen conditions.

The spill plan for this project is being developed in coordination with a North Slope-wide effort. This planning effort involves all relevant local, state, and federal agencies, with the goal of developing a set of scenarios and associated responses to assure that North Slope operators can respond to spills. Liberty spill planning will consider this Slope-wide information, adjusting as necessary to reflect site specific conditions.

3.11 WASTE MANAGEMENT

The majority of wastes generated during project construction will consist of drill cuttings and spent muds. Some drilling waste also will be generated during operations from well workover rigs. Drilling fluids will be disposed of through on-site injection into a permitted disposal well, or will be transported off-site to permitted disposal wells. Cuttings will be disposed of on-site, or transported off-site for disposal. For on-site disposal, cuttings will be treated by a portable grinding unit and disposed of through injection into an on-site disposal well along with spent muds. Alternatively, cuttings will be transported off-site to the grinding facility and disposal well at Prudhoe Bay. Space for temporary storage of drilling wastes will be provided on the site, including storage for wastes from the first wells.

In addition to drilling wastes, domestic wastewater and solid waste will be generated during the project. Solid wastes, including scrap metal, will be hauled off-site for disposal at an approved facility.

An approved treatment unit will treat sanitary and domestic wastewater. Effluent from the unit will be chlorinated, and the treated effluent will either be discharged to sea or disposed of in an approved injection well. As a contingency, BPXA has applied for an NPDES permit authorizing marine discharge of sanitary and domestic wastewater. The permit application also will include discharges from a seawater treatment plant, desalination unit filter backwash, deck drainage, construction dewatering, and fire test water.

Wastes shipped off-site will be transported via winter ice roads or summer barges. Any wastes generated during spring and fall (when both ice road and barge travel are interrupted by breakup and freezeup), which must be transported off-site for disposal, will be stored on-site in appropriate containers until they can be transported to existing off-site facilities for disposal.

3.12 SUPPORT FACILITIES

3.12.1 Camp

The PLQ/Utility Module will provide life support for personnel on the island, including standby power generation, potable water, sewage treatment, living accommodations, medic room, and offices. The PLQ will be of modular construction, will have a minimum footprint on the island, and will be closely linked to the Utility Module. The wood frame three story structure will be sized for a combined operations and drilling crew of approximately 74 people. During the sealift and hook-up phase, up to 144 people could be housed in the PLQ on a temporary basis. The Utility Module will contain the following:

- Standby diesel generators with 2,800 barrel adjacent storage tank
- Switchgear and transformers
- Potable water system with 2,100 barrel adjacent storage tank
- Domestic wastewater treatment
- Incinerator and trash compactor
- Laboratory

3.12.2 Water Sources

Domestic potable water will be manufactured on-site from seawater. Water required for ice construction will be obtained from existing permitted sources (Exhibit A).

3.12.3 Power

Electric power will be generated on-site using one 22,000 hp gas fired turbine driven generator supplying approximately 25 megawatts of power. The turbine will burn fuel gas supplied from the Liberty reservoir. Fuel gas may also be supplied through the Products Pipeline during the drilling phase and during production shutdowns. Two back-up diesel fired generators will be capable of supplying 3,000 kilowatts during primary power outages and emergencies.

3.12.4 Communications

The communication system will include radio links, business computer network, production automation links, telephone system, local radio system and entertainment television satellite receivers. A high capacity redundant microwave system will bring in the telephone, computer network connections, and the route for pipeline controls. Production automation connections will be provided by light route (low capacity) microwave radios. The local radio will operate through a low power UHF repeater. The entertainment television will be provided by a satellite system with a fixed antenna.

3.12.5 Storage/Tanks

The island will have a permanent warehouse and workshop facility which will support normal operations and drilling activities. The building housing the warehouse and shop facilities will be a pre-engineered steel frame structure designed for maintenance, welding, storage, hazardous material handling, and safety briefings. A mezzanine level will be incorporated to meet space requirements and to keep the building footprint to a minimum.

Bulk storage tanks will be provided for produced water (3,000 barrels), slop oil (1,000 barrels), potable water (2,100 barrels), and diesel (2,800 barrels).

Provision will also be made for the storage of various chemicals to support production operations and life support facilities for up to four months, due to island access limitations.

3.13 OPERATIONS AND MAINTENANCE

The Liberty field will be a minimally staffed facility. Selection of facilities which are simple to operate was a key part of the conceptual design philosophy. Much of the operation will be automated, reducing the need for extensive personnel on-site during normal operations. At this point in the facilities design, it is estimated that up to 25 full-time personnel will be required to operate the field and pipeline.

A Health, Safety & Environmental (HSE) program will be implemented for this project and will include components such as safety briefings, identification and correction of potential hazards, environmental awareness, polar bear training, contingency plans for medical evacuations, first-aid training, and screening of workers for remote construction. All employees and contractors on the project will be required to attend regularly scheduled safety meetings. Any condition that could cause a hazard to the safety of the workers on the island or working on the pipeline will be reported to the responsible supervisor so that immediate action can be taken.

In addition, a program to address subsistence hunting and fishing activities, specific to an offshore location, will be implemented. The intent is to incorporate local knowledge in this program in an effort to reduce to a minimum operational impacts on these activities.

BPXA also will implement a program to ensure that construction, operation, and maintenance of project facilities are conducted in full compliance with relevant federal, state, and local regulations and permit conditions. Key objectives of this program will be to ensure personnel safety and island pipeline system integrity, prevention of spills or leaks, and establishing procedures for performance monitoring to ensure continued integrity and for response planning.

After island construction, an inspection and maintenance program will be implemented. The goals of this program will be to ensure that the structural integrity of the island is maintained. A program for inspection of slope protection for the island topsides and subsea surfaces will be implemented, initially on an annual basis. The subsea portion of the inspection and any required repairs will be carried out during the open water season. Topside repairs to slope protection, settlement or subsidence will be carried out on an as-required basis.

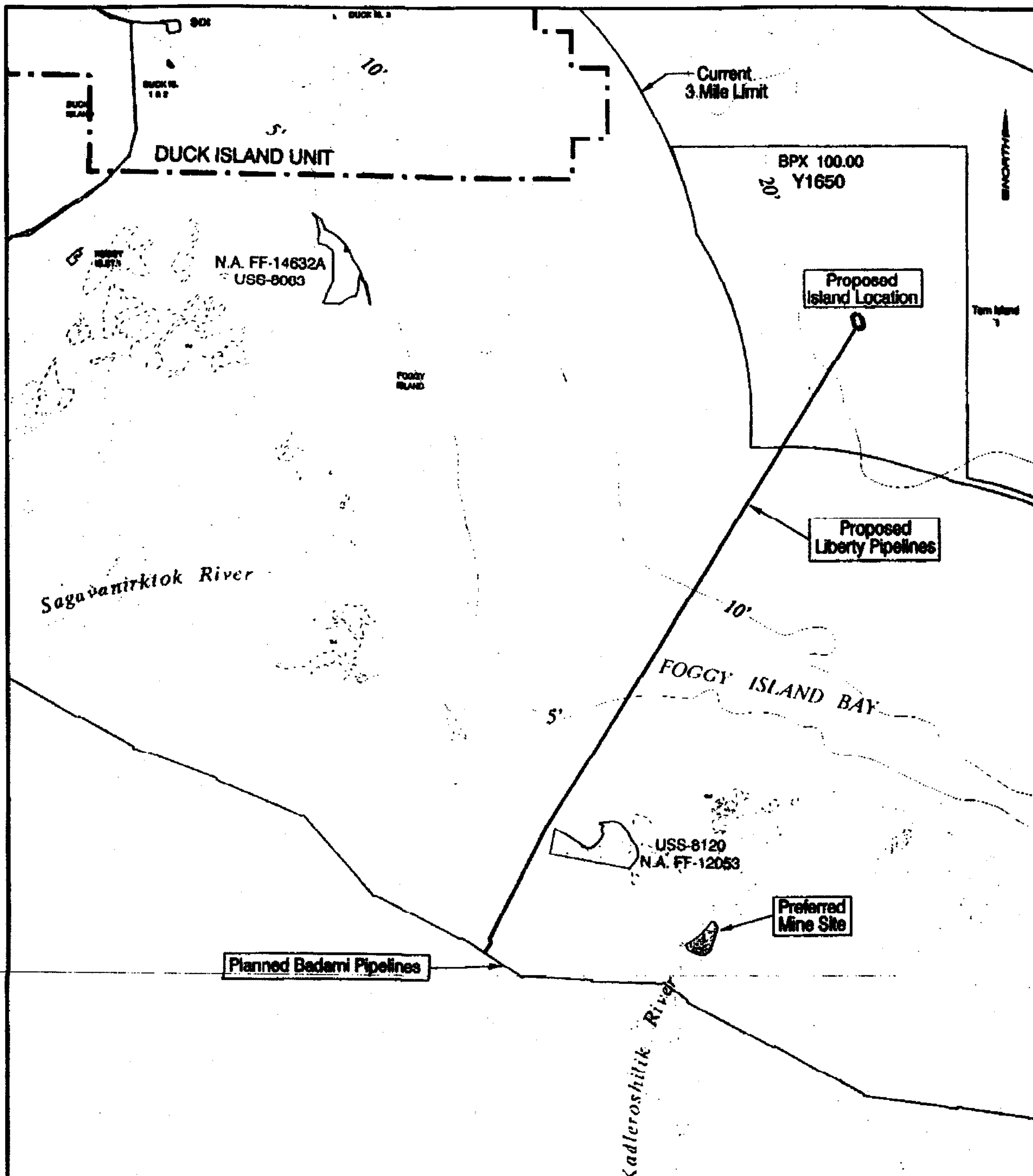
BPXA will conduct long-term monitoring and surveillance of the pipeline system. The purpose of this monitoring and surveillance program will be to assure design integrity and to detect any potential problems. The program will generally include visual inspections/aerial surveillance and pig inspections.

Visual inspections of the pipeline will be conducted by aerial surveillance on a weekly basis. The goal of these surveys will be to visually detect a pipeline leak, either by evidence of a sheen on the water surface or by staining of the tundra or snow. During the winter, standard aerial surveillance cannot detect a sheen under the ice. Therefore, survey crews will manually test for hydrocarbons under the ice during this period. Pipeline isolation valves will be inspected on a regular basis.

In addition to visual observations/inspections, BPXA will conduct a regular pipeline pig inspection program to assess continuing pipeline integrity. Three types of data collection pigs will be used:

- wall thickness measurement pigs
- 3D geometry pigs (axial, vertical, and lateral)
- mechanical damage pigs

The OSCP provides detailed information on the proposed pipeline surveillance and monitoring program.



Proposed Pipelines ————

BP EXPLORATION (ALASKA) INC.

PROPOSED LIBERTY DEVELOPMENT PROJECT

DATE:	SCALE:	FIGURE:
January 1998	1" = 1.5 Mile	3-1

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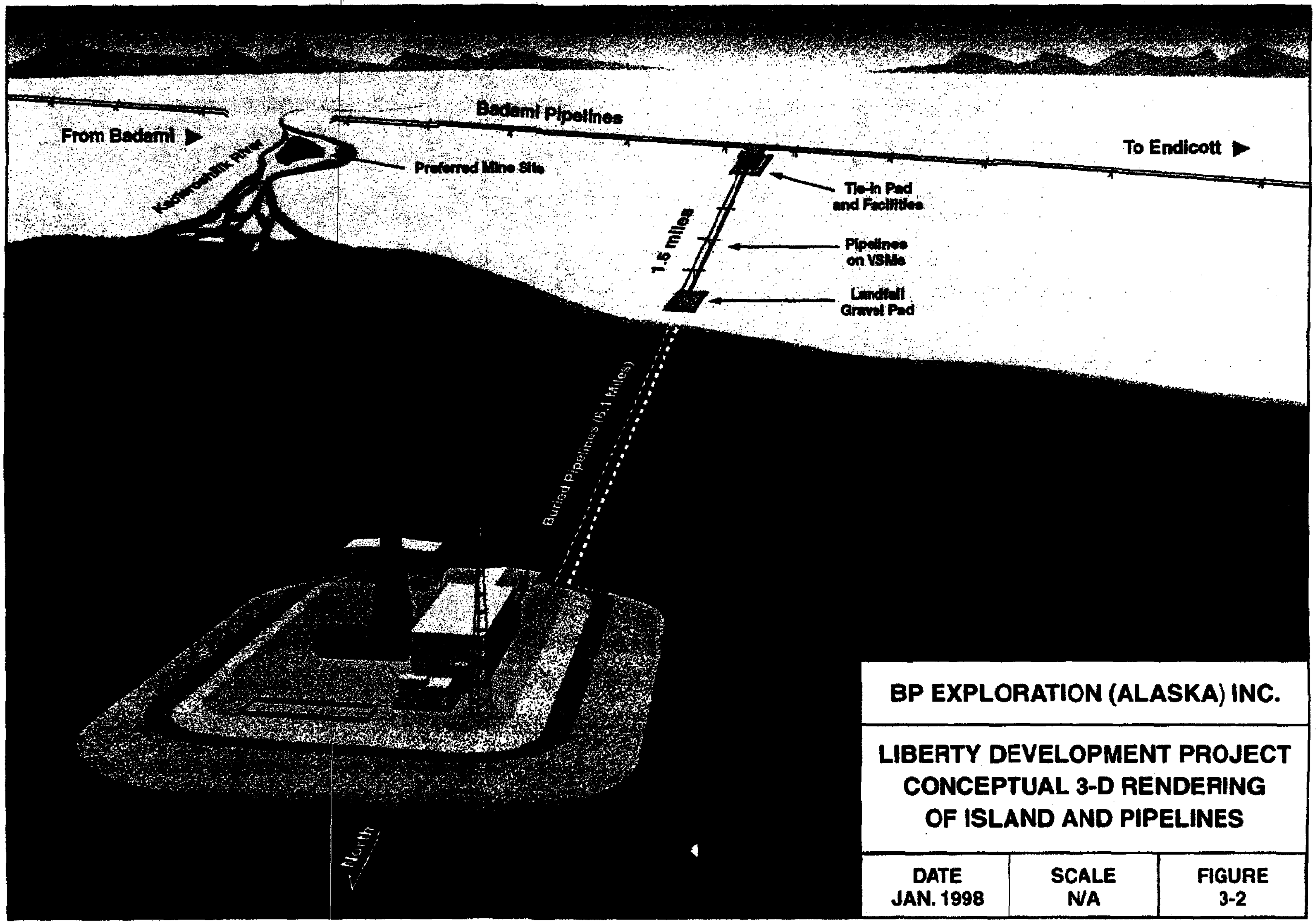
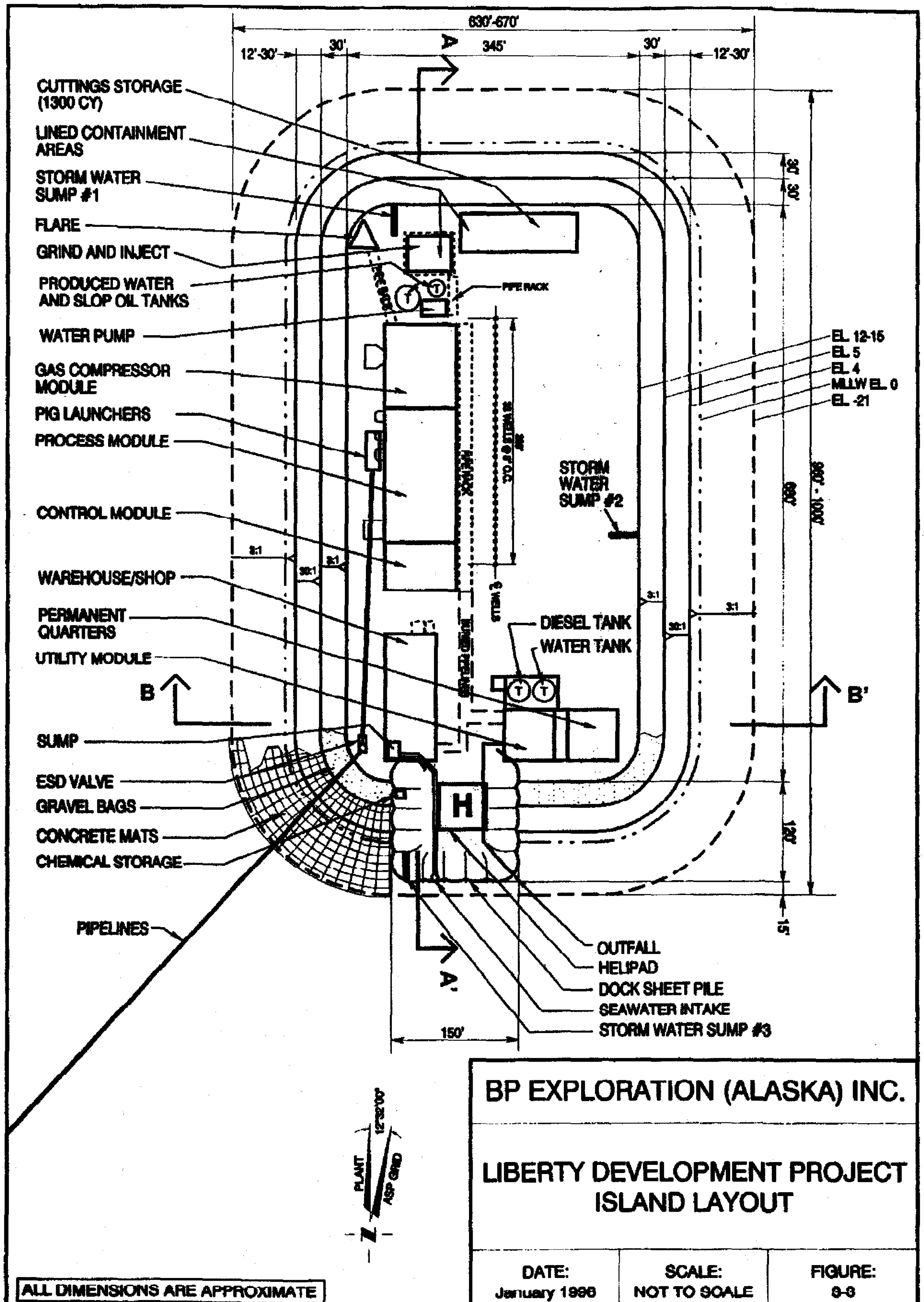


BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT CONCEPTUAL 3-D RENDERING OF ISLAND AND PIPELINES

DATE	SCALE	FIGURE
JAN. 1998	N/A	3-2

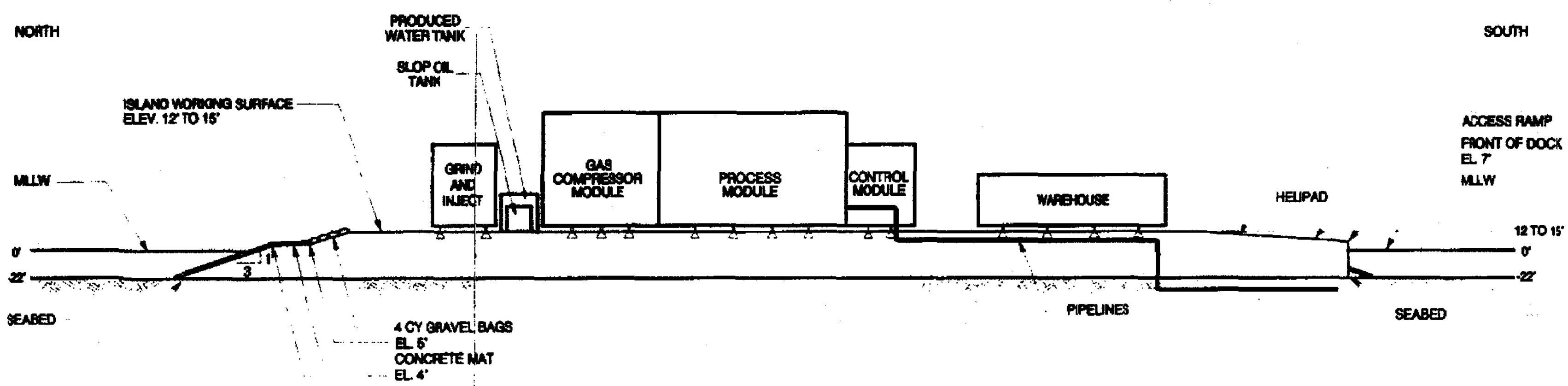


BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT ISLAND LAYOUT

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	8-8

lib198.dgn



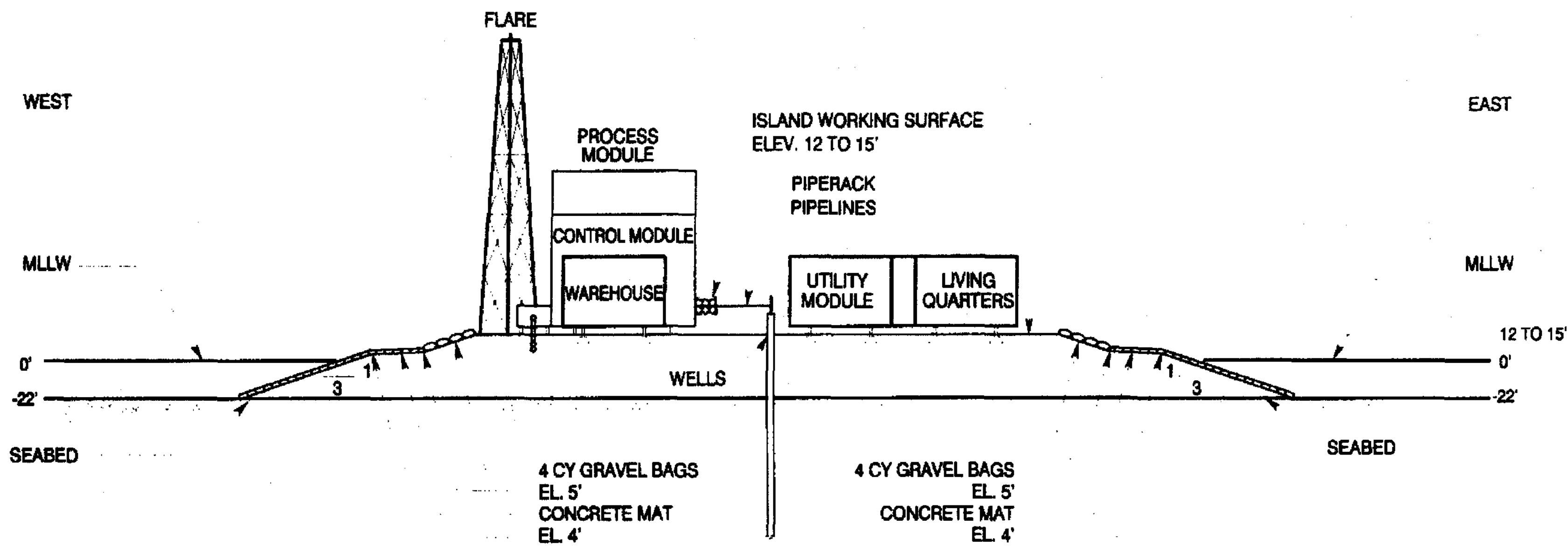
CROSS - SECTION A-A'

ALL DIMENSIONS ARE APPROXIMATE

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
ISLAND
CROSS SECTION

DATE:	SCALE:	FIGURE:
January 1998	N/A	3-4



CROSS - SECTION B-B'

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
ISLAND
CROSS SECTION

DATE:	SCALE:	FIGURE:
January 1998	N/A	3-5

ALL DIMENSIONS ARE APPROXIMATE

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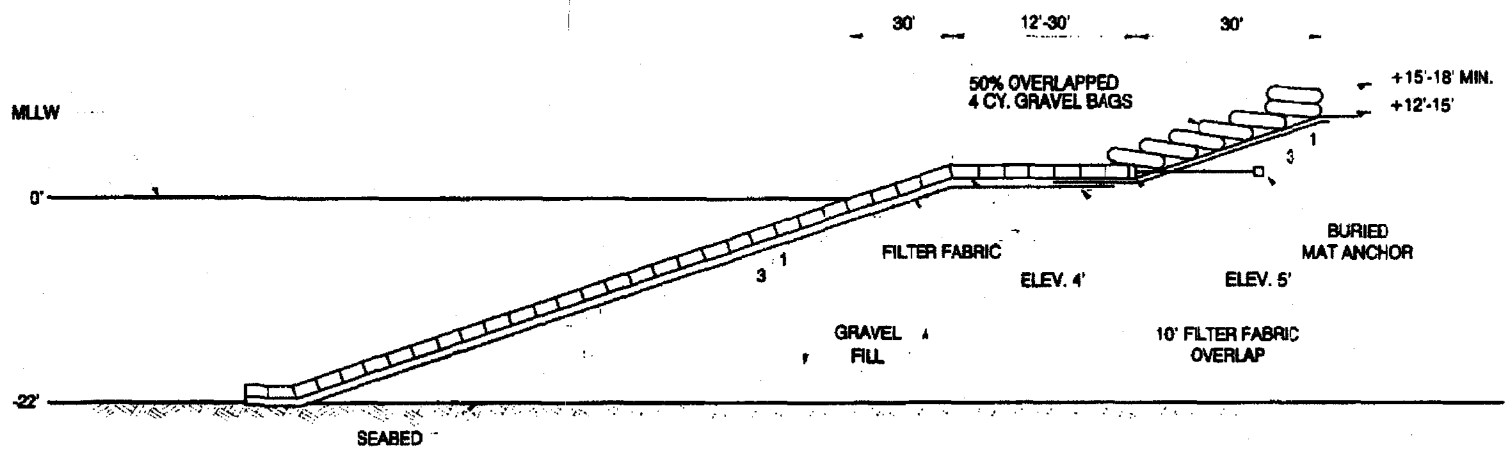


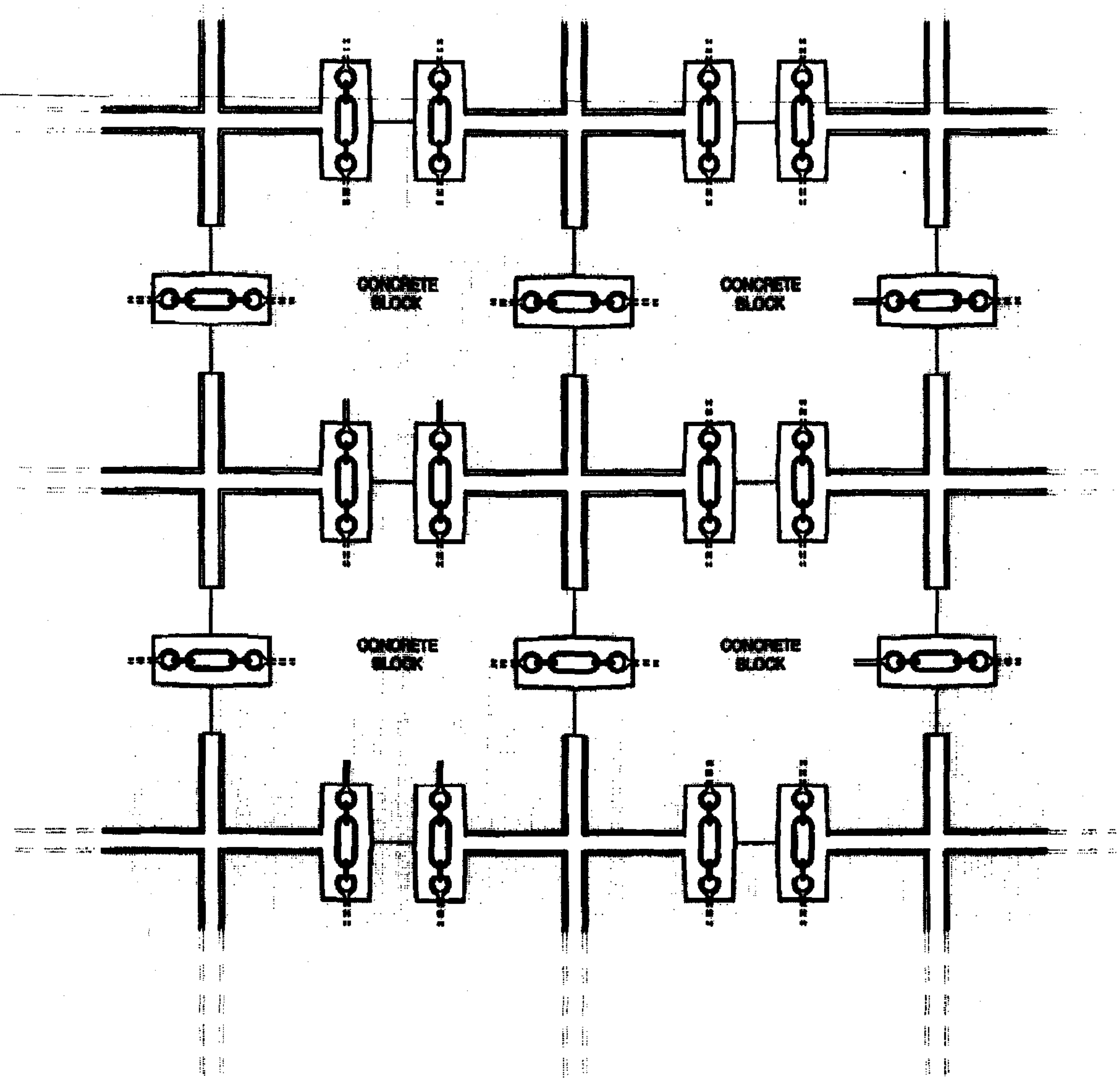
ALL DIMENSIONS ARE APPROXIMATE

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
ISLAND SLOPE PROTECTION
CROSS SECTION AND DETAIL

DATE:	SCALE:	FIGURE:
January 1998	N/A	3-6

fb108.dgn

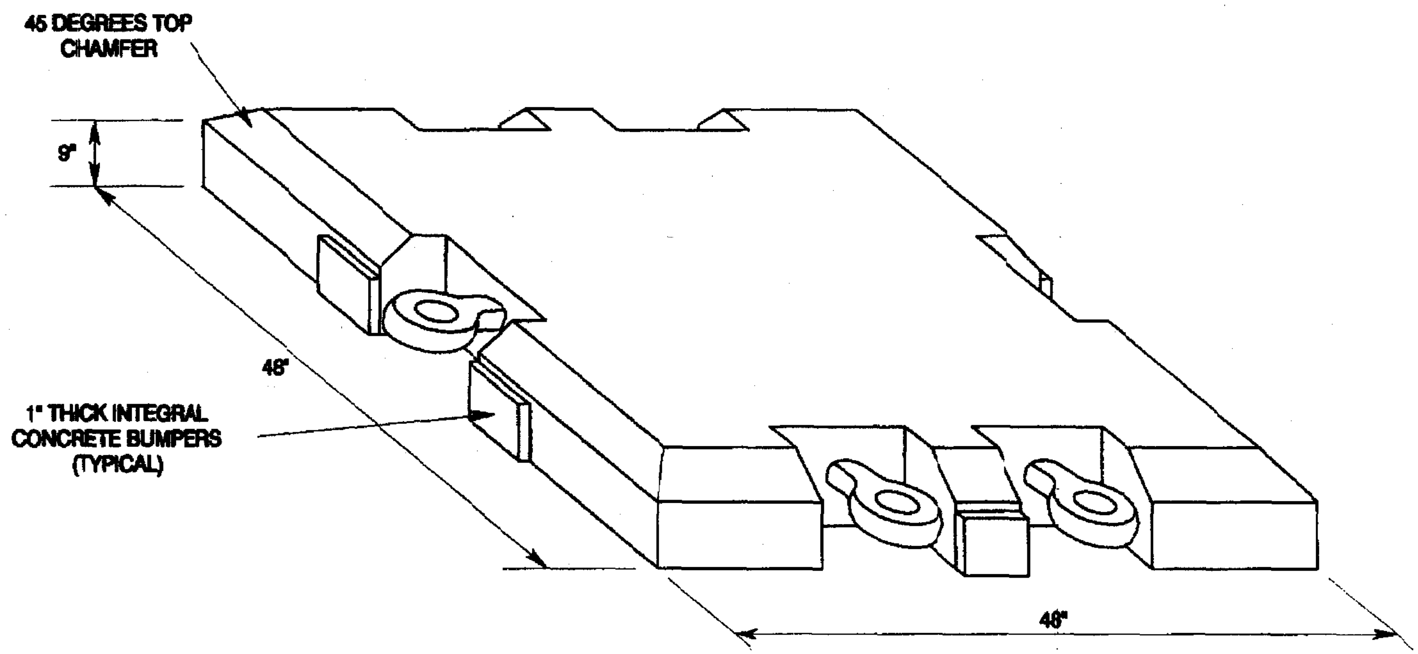


BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
ISLAND SLOPE PROTECTION
CONCRETE MAT
LAYOUT

DATE:	SCALE:	FIGURE:
January 1998	N/A	3-7

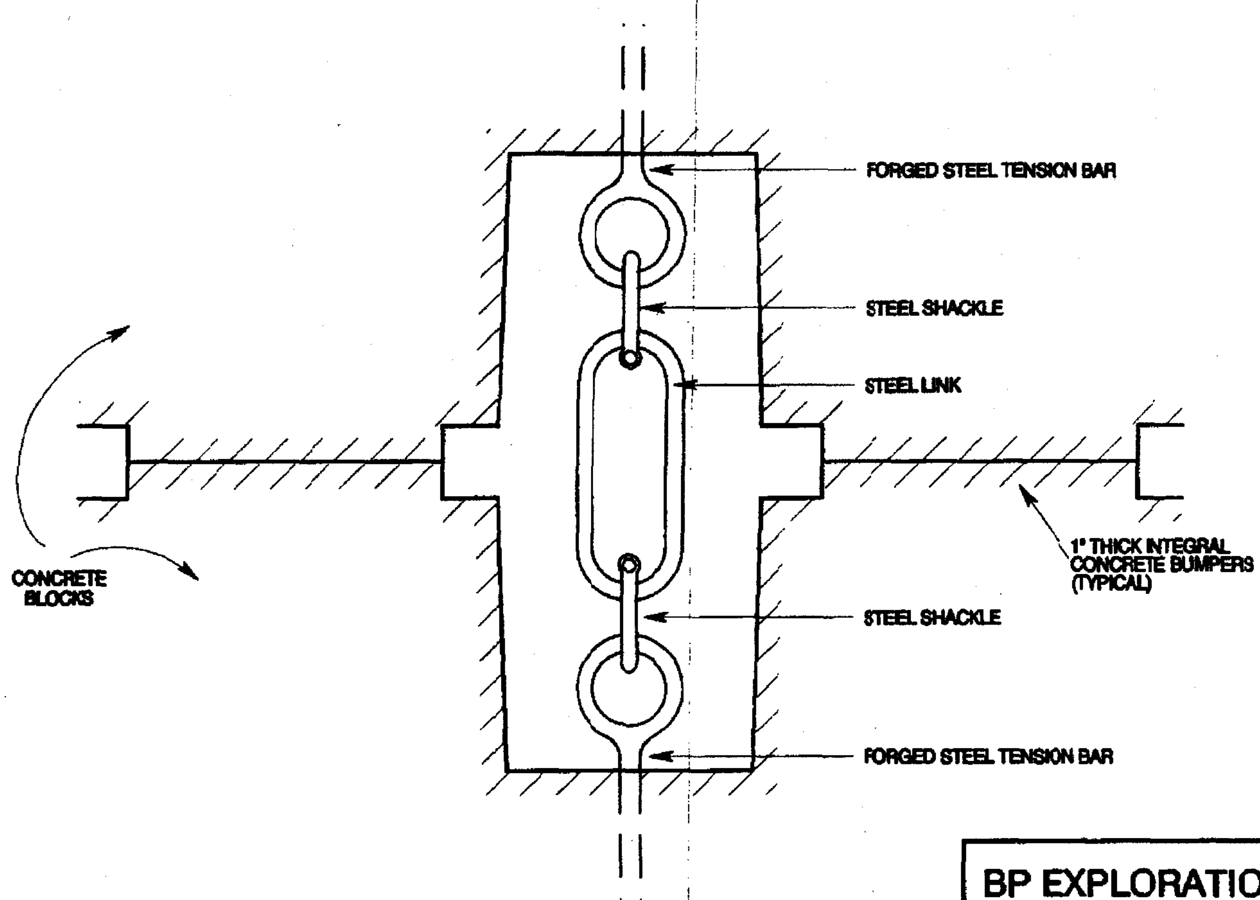
lib198.dgn



BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
ISLAND SLOPE PROTECTION
CONCRETE BLOCK

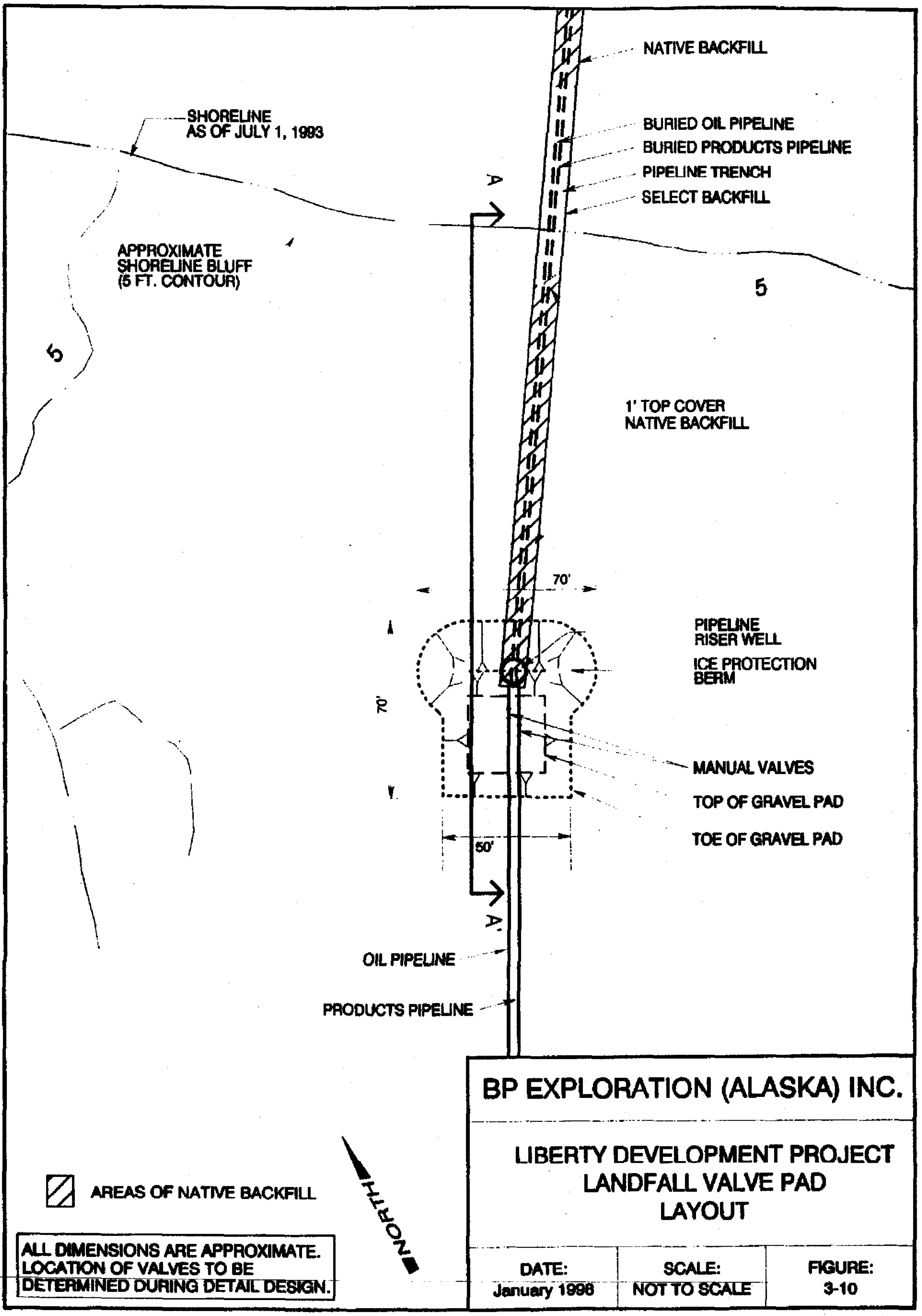
DATE:	SCALE:	FIGURE:
January 1998	N/A	3-8



BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
ISLAND SLOPE PROTECTION
CONCRETE MAT LINKAGE
DETAIL

DATE:	SCALE:	FIGURE:
January 1998	N/A	3-9

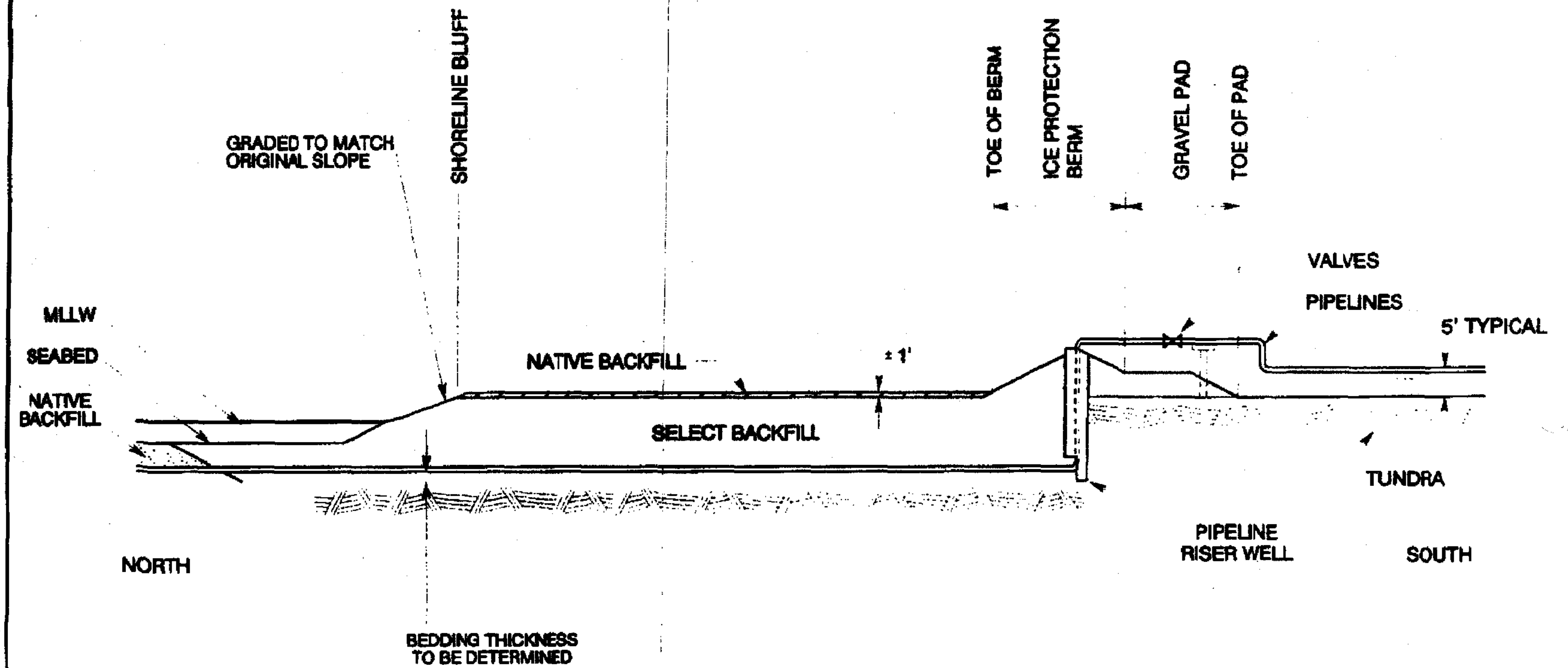


BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
LANDFALL VALVE PAD
LAYOUT

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	3-10

jan98, pads.dgn



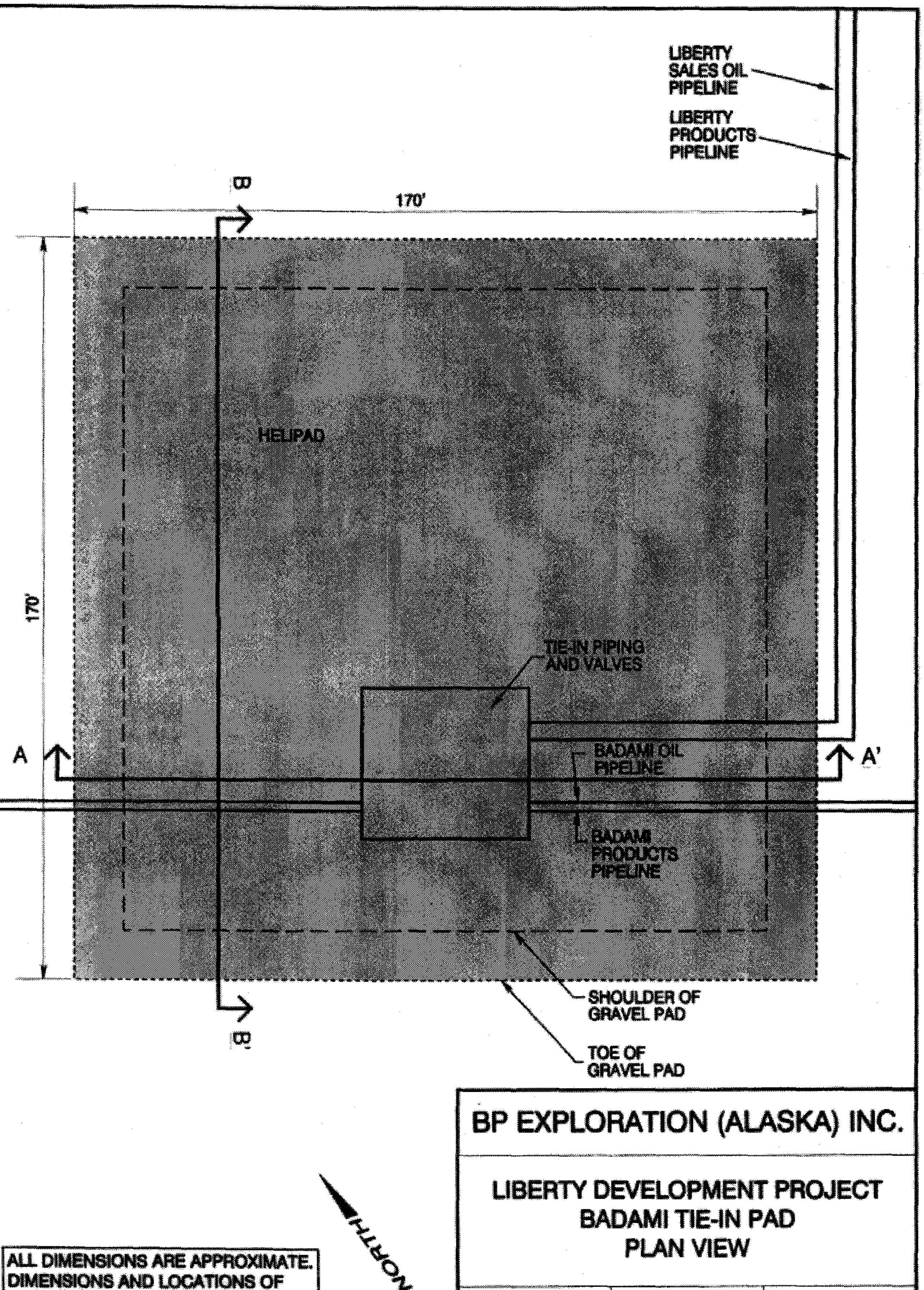
ALL DIMENSIONS ARE APPROXIMATE.
LOCATION OF VALVES TO BE DETERMINED DURING DETAIL DESIGN.

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
LANDFALL VALVE PAD
CROSS - SECTION
NORTH - SOUTH

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	3-11

lib198.dgn



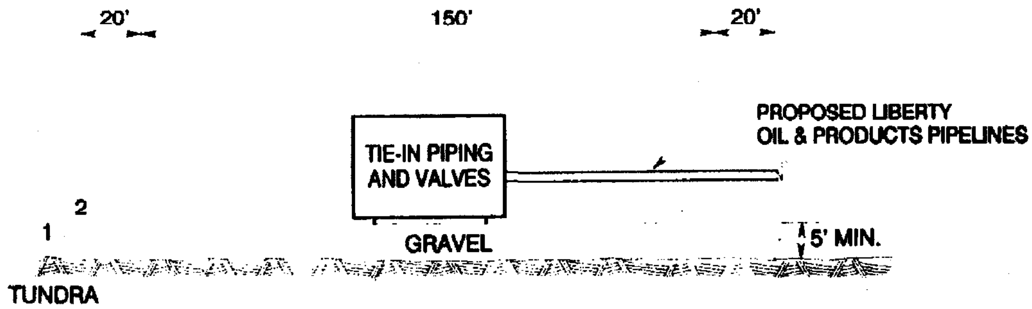
BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
BADAMI TIE-IN PAD
PLAN VIEW

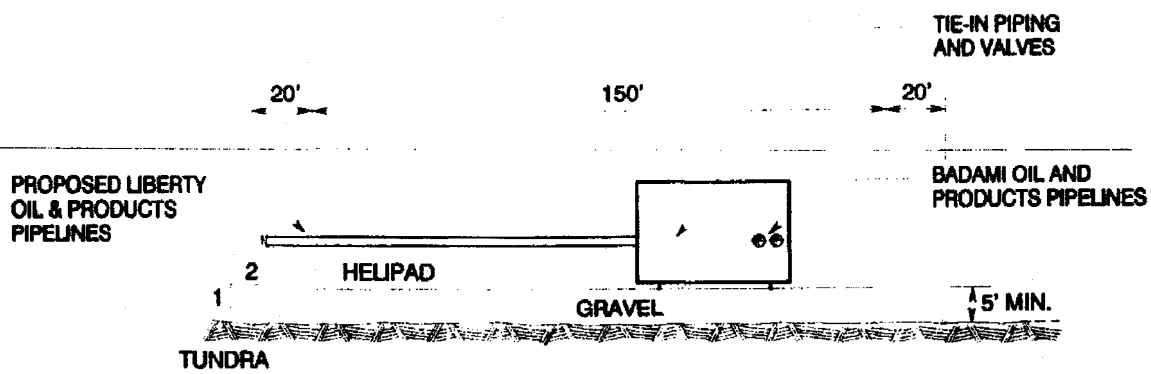
DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	3-12

ALL DIMENSIONS ARE APPROXIMATE. DIMENSIONS AND LOCATIONS OF FACILITIES TO BE DETERMINED DURING DETAIL DESIGN.

jan98,pads.dgn



SECTION A - A'



SECTION B - B'

ALL DIMENSIONS ARE APPROXIMATE

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
TIE-IN PAD
CROSS SECTIONS

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	3-13

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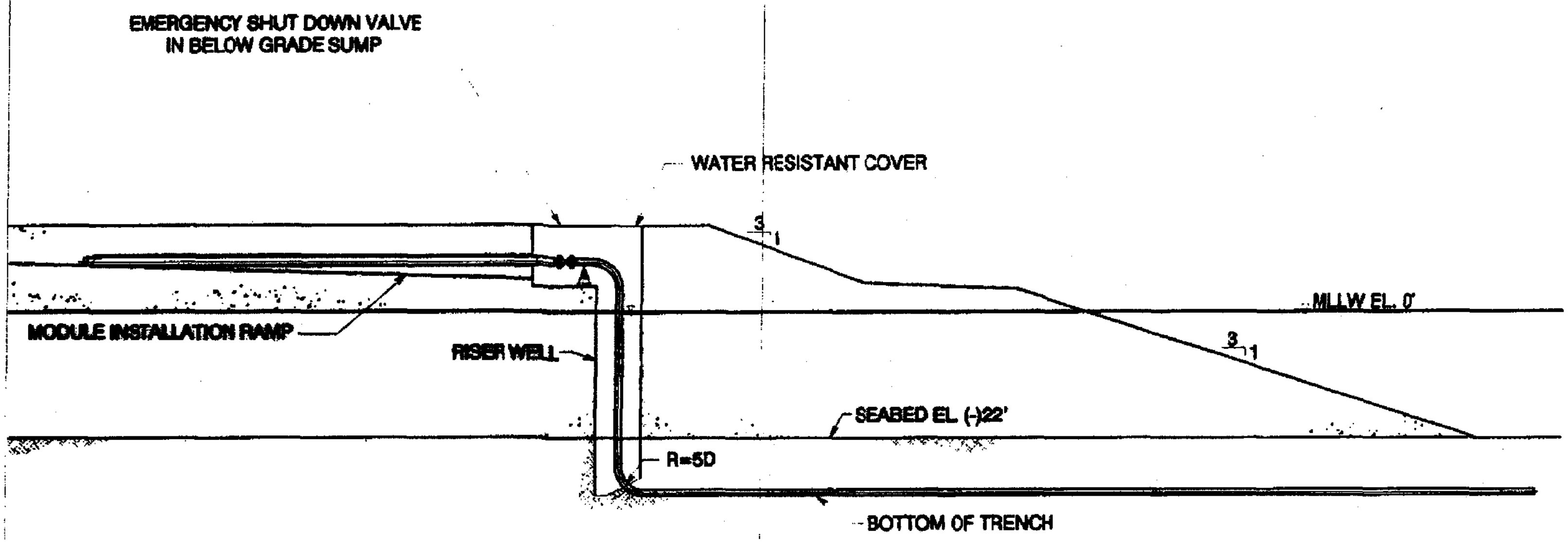

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
ISLAND APPROACH
CROSS - SECTION

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	3-14

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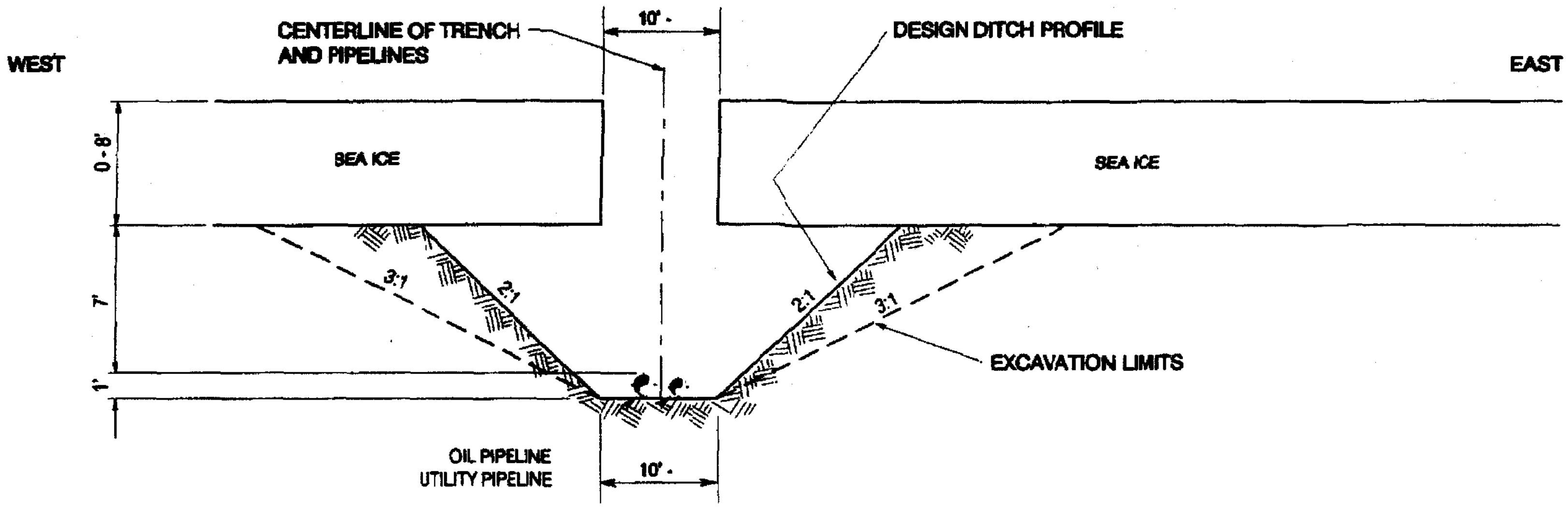


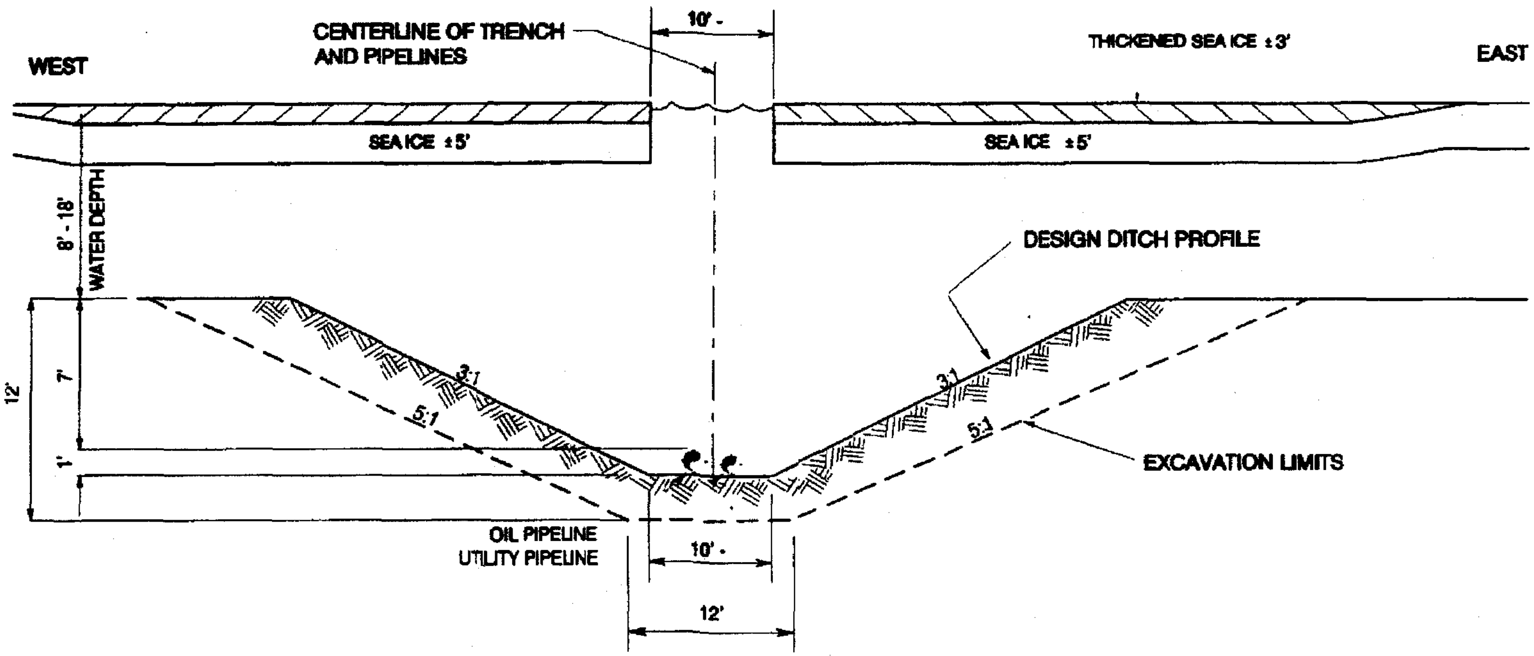
BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
TRENCH SECTION
SHALLOW AREA 0' - 8'

DATE:	SCALE:	FIGURE:
January 1998	N/A	3-15

NOTES:

1. PIPELINES DEPTH OF COVER IS 7 $\pm$ FEET.
2. TRENCH SIDE SLOPES ARE VARIABLE, DEPENDING ON SOIL CONDITIONS. SLOPES SHOWN ARE 1V : 2H.



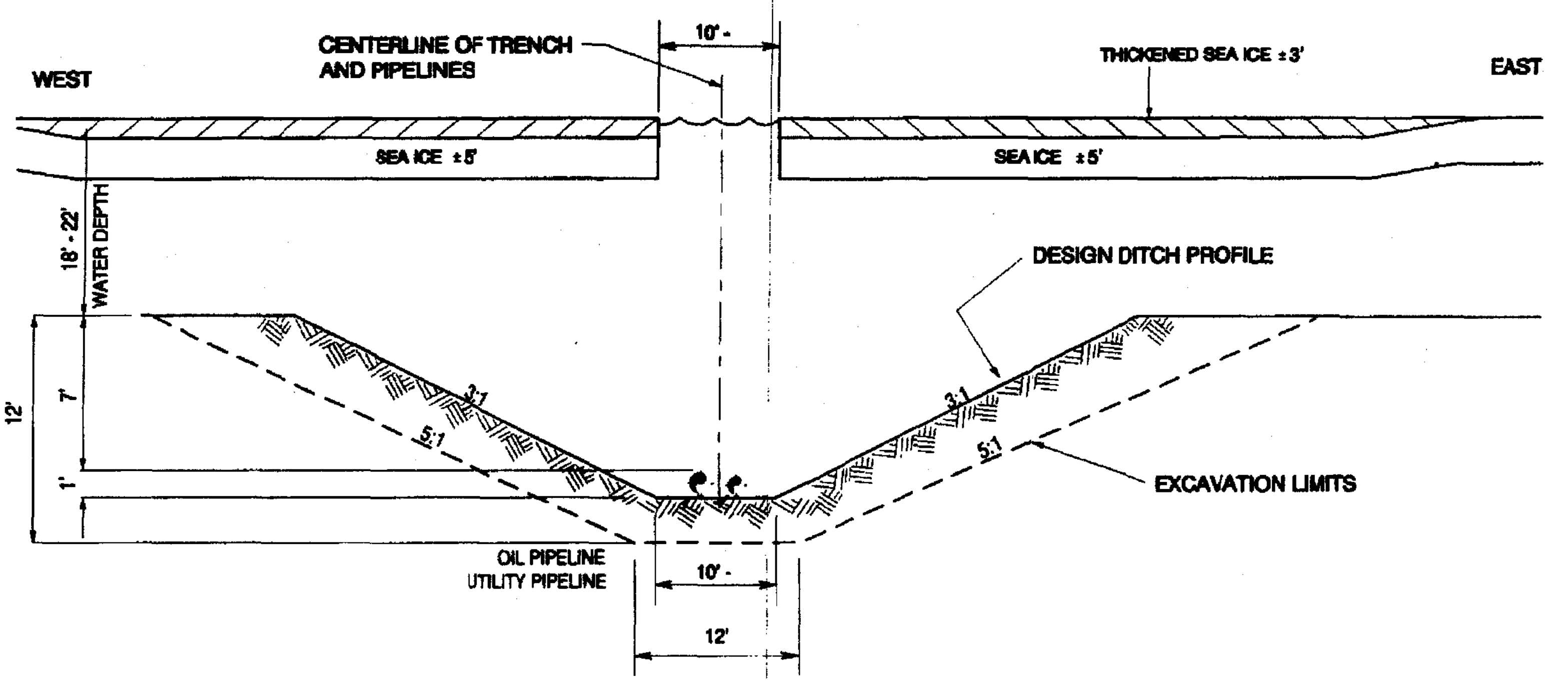
NOTES:

1. PIPELINES DEPTH OF COVER IS 7± FEET.
2. TRENCH SIDE SLOPES ARE VARIABLE, DEPENDING ON SOIL CONDITIONS. SLOPES SHOWN ARE 1V : 2H.

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
TRENCH SECTION
INTERMEDIATE AREA 8' - 18'

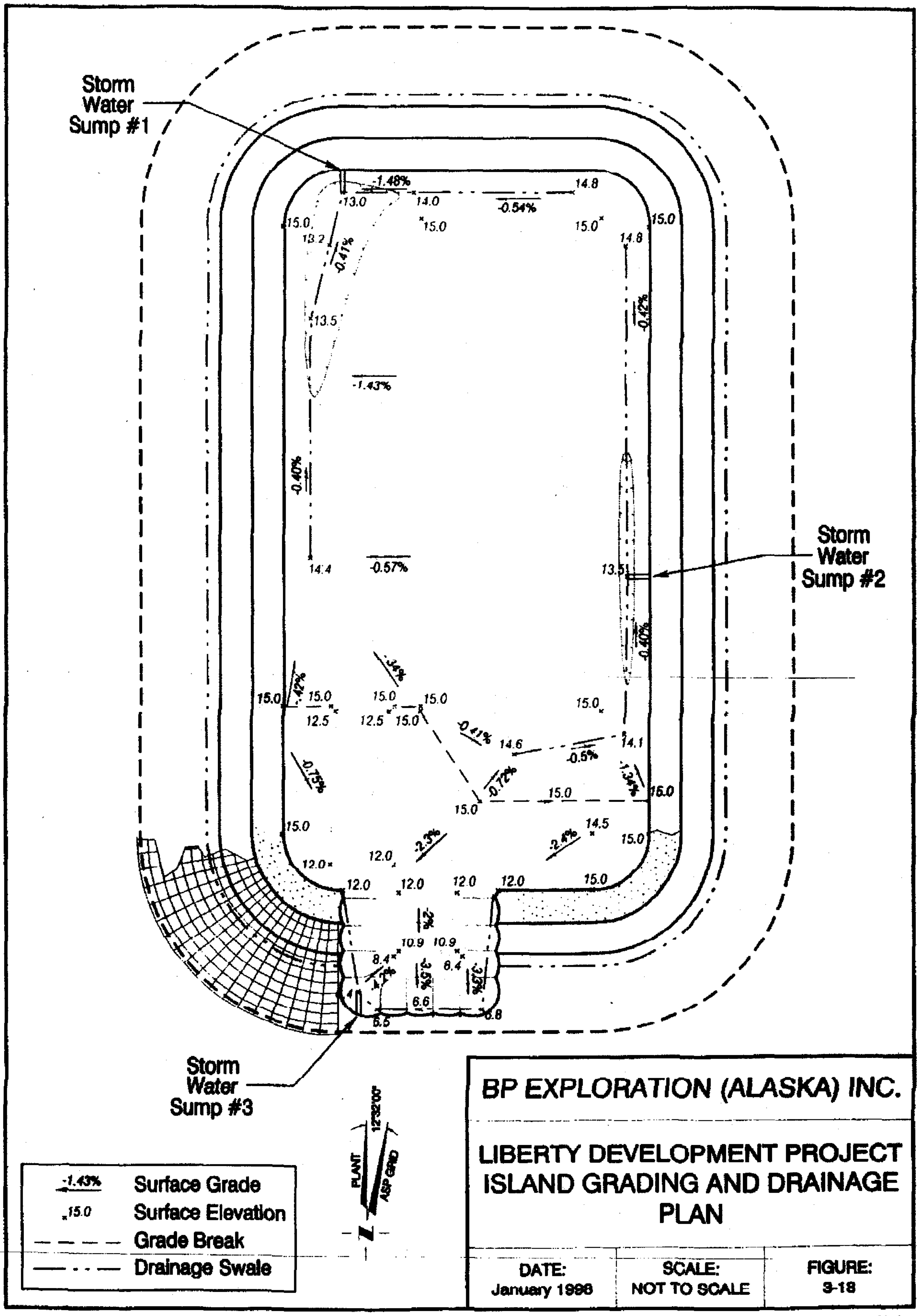
DATE:	SCALE:	FIGURE:
January 1998	N/A	3-16



NOTES:

1. PIPELINES DEPTH OF COVER IS 7 ± FEET.
2. TRENCH SIDE SLOPES ARE VARIABLE, DEPENDING ON SOIL CONDITIONS. SLOPES SHOWN ARE 1V : 2H.

BP EXPLORATION (ALASKA) INC.		
LIBERTY DEVELOPMENT PROJECT TRENCH SECTION DEEP AREA 18' - 22'		
DATE: January 1998	SCALE: N/A	FIGURE: 3-17



BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT ISLAND GRADING AND DRAINAGE PLAN

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	3-18

lib198.dgn

4. AFFECTED ENVIRONMENT

This section describes the physical, biological, and socioeconomic characteristics of the area that might be affected by the Liberty Development Project. Numerous earlier studies, including several Environmental Impact Statements (EIS) and Environmental Assessments (EA), have described and addressed potential developments in this area. These documents include:

- Tern Island Environmental Report (WCC 1981)
- Endicott EIS (USACE 1984)
- Lease Sale 97 (1988), 124 (1991), 144 (1996), and 170 (1996) EISs
- Badami EA and Project Description (BPXA 1995)
- EA for Incidental Harassment Authorization, BPXA 1996 Seismic Operations (NMFS 1996)
- Endicott NPDES Monitoring Reports
- Boulder Patch Environmental Reports since 1984 (see LGL and Dunton 1992).

In addition to these documents and reports, this Environmental Report includes information from a large number of other references to the physical and biological environment in this region, as cited throughout this and the following sections. The discussion in this section focuses on resources of concern for this specific project. More generalized information is available from the more comprehensive studies listed above, and the relevant background materials from these documents are included herein by reference.

4.1 METEOROLOGY

The Liberty Development Project is located in the Arctic climate zone, characterized by cold temperatures and low precipitation and nearly constant wind. Air temperatures can range from about 80° to -68°F. Mean temperatures are approximately 10°F. Freezing temperatures are normal on an average of 313 days per year. Fog occurs an average of 76 days annually at Barter Island, and in the form of ice fog at temperatures below -20.4°F (USACE 1984). The sun remains below the horizon in the study area from late November to mid-January.

The Arctic coast, especially during the winter, has a relatively dry climate. Annual precipitation ranges from 5 inches at Barrow to 7 inches at Barter Island and occurs mostly as summer rain. Winter snowfall is generally less than 30 inches at Barrow and 45 inches at Barter Island. Both Barrow and Barter Island receive most of the precipitation in August, averaging about 1 inch. April is the driest month, with an average precipitation of 0.11 inch at Barrow and 0.17 inch at Barter Island. Although rain accounts for most of the annual precipitation along the Beaufort Sea coast, snow begins falling in September and usually remains on the ground from October through June (BLM 1979). A 10.8-inch average annual snow depth recorded at Barter Island (USACE 1984) is representative of the study area.

Winds along the Beaufort Sea Arctic coast are constant in velocity (direction and speed) with wind occurring on greater than 95 percent of the days. Wind direction tends to be generally oriented with the coast: 70 percent easterly and 30 percent westerly. Winds consistently average 11.2 miles per hour (mph) at Barrow and 13.4 mph at Barter Island, with the prevailing distribution easterly (usually east-northeast to northeast). From January to April, the prevailing direction is northwesterly or westerly (WCC 1981). Part of this shift in winter is caused by air accumulating against the Brooks Range. Sea breezes occur during about 25 percent of the summer and extend to at least 12 miles offshore (MMS 1996a). Persistence of the wind from either direction varies from 1 to 14 days with typical events lasting 2 to 5 days (Colonell and Jones 1990). Winds exceeding 31 mph occur about 2 to 8 percent of the time.

Summer weather data were collected at a nearshore coastal site as part of the Endicott Monitoring Program from 1985 through 1990 (USACE 1987 to 1994). Data were collected at Resolution Island, which is located about 0.6 miles west of the Endicott Causeway and 8 miles west of the proposed Liberty Development Project site. Sampling generally included the period from June through September, although additional data were collected during October in some years. Weather conditions at Endicott are similar to those for Barter Island and other sites along the Beaufort Sea coast. Winds are generally from the east or northeast, but shifts to the west or northwest are common throughout the summer. Wind speed and direction at coastal sites are highly variable but are not significantly different from those at a more inland site (i.e., Deadhorse airport). Temperatures during summer also are highly variable and tend to be higher inland than at coastal locations.

Ice-free water conditions during summer months vary from year to year, thus providing variable fetch conditions for wave build-up. During late freezeup, the high storm winds of early winter blow over large areas of open water, creating sustained periods of large waves. At the Liberty offshore site, the significant typical wave height that can be expected to occur every year is 6.6 feet, while the 100-year value is 12.2 feet (BPXA 1997).

A combination of tides and wind-related phenomena causes the fluctuation of ocean water levels in the Alaskan Beaufort Sea. Wind strength and direction greatly influence sea level in this region (east winds deflect water offshore, while west winds deflect water onshore). The rise and fall in sea level (range) due to storms (storm surge) can be as much as 8 feet (4 foot rise to 4 foot fall) at the shore. Surveys of storm-driven debris onshore in this region as well as analysis of land relief near the Liberty Development indicate the 100-year storm surge could be +6.7 feet (BPXA 1997). That is, a storm surge could increase sea level and inundate the land up to about a 6.7 foot elevation.

4.2 RESERVOIR GEOLOGY

The Liberty #1 well confirmed the presence of hydrocarbons on Federal lease OCS-Y-1650. Three other wells exist in the area (Tern Island #1A, #2A, and #3), and provide additional data related to the discovery. A 3D seismic survey covers the accumulation and was used to map the top of the reservoir and define the prospect limits. The well and seismic data yield an oil reserve estimate of approximately 120 million barrels of recoverable oil. The accumulation is similar to the nearby Endicott Field, operated by BPXA. Experience with developing the Endicott Field allows BPXA to determine the most efficient method to maximize oil recovery in the Liberty Field.

In summer of 1997, BPXA conducted a shallow hazards survey of the proposed development area. This survey was designed to detect hazards, such as shallow gas, fault lines, slumps and slides, and other features affecting the safety of drilling and production operations. No shallow hazards were discovered as a result of this survey. Geophysical data and the interpretive results will be submitted to the MMS under separate cover in February 1998. Minor amounts of hydrogen sulfide were detected (less than 10 ppm) while testing the Liberty #1 well. BPXA will follow standard safety procedures typically used on the North Slope of Alaska for this level of hazard.

4.3 GEOMORPHOLOGY

4.3.1 Marine Geology

The Arctic Coastal Plain gently slopes northward from the foothills of the Brooks Range to the edge of the Beaufort Sea continental shelf. The average depth of the shelf is only 120 feet, and its width averages 44 miles (Sharma 1979). Continental shelf waters are ice-covered for about nine months of the year, with the open water season generally extending from mid-July until September. The nearshore zone lies between the mainland shoreline and the offshore barrier islands, and is typified by subtle seabed topography with gentle slopes. The wave cut shoreline indicates active erosion, a result of storm surges and thawing of exposed permafrost. The retreating shoreline consists of a series of bays, lagoons, deltaic mudflats, and narrow barrier islands. Based on air photo interpretation of four locations, thermal erosion is reported to average about 3 meters per year along this coast (Hopkins and Hartz 1978). At this rate, ancient coastlines would have long ago fallen into the sea and eroded by wave and ice processes (Duane Miller and Associates 1997). Undisturbed submerged sediments from intact coastal remnants are unlikely in Foggy Island Bay.

The major bathymetric features in the proposed development area are nearshore shoals (discussed in Section 4.4) and the McClure Islands, which are barrier islands northeast of Foggy Island Bay (Exhibit A). These islands, located approximately 4 miles to the north of the proposed Liberty Island site, consist of low-lying sand and gravel deposits. The seafloor in the vicinity of the proposed Liberty Development Project slopes gradually to the north. A site-specific survey, conducted by the USGS in this area in 1981, indicates a soft sea bottom devoid of relief. However, the low relief is not sufficient to cause unstable sediments (MMS 1981).

The surficial seafloor sediments of Foggy Island Bay consist of Holocene fine sands and soft silts and clay. This surface layer is generally about 6 to 8 feet thick. Coarser-grained sand and gravel coincide with the higher wave energy environments in the shallow nearshore areas close to the barrier islands and shoals. An area of mixed boulders and cobbles to the north and northwest of the proposed development site is known as the "Boulder Patch" (Exhibit A). This area provides a stable hard bottom substrate to support a complex kelp community. The Boulder Patch substrate is presumed to be deposited from the Flaxman Formation, a Pleistocene marine sandy mud containing boulders and cobbles (Dunton et al. 1982).

No near surface faults, slumps or unstable bottom sediments have been found at the site by BLM/NOAA OCSEAP surveys (USGS 1981). Based on a site-specific shallow hazards survey conducted around the island site during the summer of 1997, no adverse site conditions were found. A survey conducted prior to construction of Tern Island reflected a very flat, soft sea bottom devoid of even small scale vertical relief (Harding Lawson Associates 1981). Studies conducted in the project area by Coastal Frontiers Inc. and the Watson Company in summer of 1997 confirm this observation. The Watson Company did observe an apparent submerged distributary channel in the extreme northwest corner of the survey area. This feature is distant from any project construction site.

Beneath the 8- to 9-foot deep surface layer of Holocene silts and clays is a 55-foot thick Pleistocene marine deposit consisting of sandy mud and mixed alluvial sand and gravels. Soil borings collected in the vicinity of Tern Island in Foggy Island Bay indicate that ice-bonded permafrost occurs about 25 to 35 feet below the sea floor (WCC 1981).

Soil borings were completed at a site previously considered for Liberty Island and along the alternate pipeline corridors during March of 1997 (Duane Miller and Associates 1997). Offshore Holocene sediments generally consisted of lagoonal and deltaic deposits of silt and organic silt within which a few limited and thin layers (approximately 1 to 2 feet thick) of sandier beach and shoal deposits were encountered. The dominant silt layer reached to about 8 feet depth below which a zone of sand and gravely sand to about 30 feet was encountered. The nearshore borings encountered frozen materials throughout. Borings located further offshore and closer to the proposed island location had silt and sandy silt in the top 10 feet below the seafloor surface, with gravel sand and sandy gravel below 10 feet. No permafrost was encountered in these borings, some of which reached 50 feet below the seafloor surface. No undisturbed terrestrial sediments indicative of submerged land forms were found. One boring, near the proposed island location, reached to 105 feet below the seafloor surface. This boring showed silt to about 22 feet, and sand and gravely sand to 105 feet. Frozen soil was encountered at 44 feet, with little or no visible ice. A geotechnical program will be conducted in winter 1998 to further investigate soil conditions at the proposed island site and pipeline route.

4.3.2 Coastal Sediment Processes

Coastal erosion rates vary from year to year depending on the timing of sea ice breakup, variations in the size of the open water area, timing of the late summer and autumn storms, composition of the coastal bluffs, beach width, and morphology of the adjacent seafloor (MMS 1996a). Coastal erosion rates near Foggy Island Bay are estimated to range from about 1.2 to 3 meters per year (3.3 to 10 feet per year) (Grantz and Mullen 1992).

The principal sediment sources within Foggy Island Bay are rivers and shoreline erosion. Three streams provide fresh water and sediment input into Foggy Island Bay: the eastern distributary of the Sagavanirktok, the Kadleroshilik, and the western distributaries of the Shaviovik rivers (see Exhibit A). Deltas exist where these rivers enter the embayment, producing well developed delta complexes as a result of decreased river flow and deposition of river borne sediment load. Sediment input from shoreline erosion and riverine transport affect the nearshore bathymetry of Foggy Island Bay.

The arcuate shaped delta complex of the Shaviovik River extends to the 10-foot isobath located approximately 4 miles offshore and dominates the geomorphology of the eastern third of the embayment (see Exhibit A). Shallow waters and shoals are common throughout the delta complex. Tigvariak Island, located north of the Shaviovik River delta, defines the eastern extent of Foggy Island Bay and a 0.6-mile wide shallow channel separates the island from the mainland.

The Kadleroshilik River delta is located along the central portion of Foggy Island Bay (see Exhibit A). The pro-delta associated with this river is skewed to the west by the predominant easterly coastal currents of the central Beaufort Sea. The limited sediment load of the Kadleroshilik River has resulted in the formation of a small pro-delta which extends to the 6.5-foot isobath approximately one mile offshore.

The eastern distributary of the Sagavanirktok River defines the western extent of Foggy Island Bay. Approximately 3 percent of the river flow is discharged through this minor channel, and prevailing coastal currents transport the river sediment north towards Point Brower.

4.3.3 Arctic Coastal Plain Geology

The coastal area of the central Beaufort Sea, which includes Foggy Island Bay, is located in the Arctic Coastal Plain physiographic province (Wahrhaftig 1965). The Arctic Coastal Plain is typified by gentle topography, ice-bonded permafrost soils, wet tundra, and wind-oriented thaw lakes. The dominant feature of the onshore region is the perennially frozen ground known as permafrost. Permafrost extends from immediately below the ground surface to depths in excess of 2,000 feet.

Tundra soils are produced within an active thaw layer which may extend to depths of up to 2 feet by the end of the summer; these soils refreeze during winter. Tundra soils generally consist of a surficial layer of peat followed by layers of silt and organic rich silts which cover unconsolidated sands and gravels (Walker et al. 1980). The ice-rich silts, with varying amounts of organic material, are 1.5 to 2.5 meters thick (Walker et al. 1980). Permafrost in coastal areas contain relatively large volumes of ground ice, primarily within the upper 5 to 10 meters (Brown and Sellman 1973). Ground ice occurs as segregation ice and ice wedges (Walker et al. 1980).

The permafrost table underlying the Arctic Coastal Plain tundra acts as an impermeable surface resulting in poorly drained soils. Water accumulated in spring and summer from precipitation, annual snow melt, and melting of the active thaw layer is trapped above the permafrost table, resulting in the permafrost wetlands characteristic of the North Slope.

4.4 OCEANOGRAPHY OF FOGGY ISLAND BAY

4.4.1 Physical Oceanography

In shallow coastal sea areas such as Foggy Island Bay, the direction of the wind relative to the shoreline is more important than its speed. For example, Colonell and Niedoroda (1990) describe responses of nearshore Beaufort Sea waters in detail: easterly winds promote offshore transport of surface waters, which is only partially compensated by a shoreward transport of bottom water (upwelling), with the net result being a depression of sea level, which is also known as "negative" surge. Conversely, westerly winds promote an onshore transport of surface waters, which is only partially compensated by an offshore transport of bottom water (downwelling), with the net result being a rise in sea level ("positive" surge). These phenomena are the shallow-water manifestations of Ekman drift, which was first described by Ekman in 1905.

Easterly winds effectively force surface waters out to sea, resulting in a depressed sea level along the shoreline. To accommodate the offshore movement of surface waters, colder marine waters are drawn from the bottom and into the nearshore area. Upwelling is a wind-driven process, such that easterly winds tend to increase salinity in the nearshore areas. Conversely, west winds move surface waters toward the shoreline, resulting in an elevated sea level. Westerly winds often result in a reduction of nearshore salinity because surface waters are usually brackish. If an embayment is isolated from intermittent water sources, its hydrography will mimic regional conditions. However, if substantial fresh water enters the embayment, it can alter the salinity patterns that are imposed by regional upwelling/downwelling processes.

In winter, the Beaufort Sea nearshore currents are generally westerly and, under thick ice cover, tidal currents have been observed to maximum speeds of 10 to 15 centimeters per second (cm/s) along the 7-foot isobath. However, typical under-ice currents are much lower, usually below 5 cm/s (NORTEC 1981). Average velocities drop to 2 cm/s in deeper waters, although a tidal current on the order of 5 to 10 cm/s has been observed (MMS 1987a). Montgomery Watson (1997) found under-ice currents at the proposed Liberty Development Project pipeline routes to be less than the rated sensitivity of the current meters: 2 cm/s. In summer, currents are primarily wind driven and oriented parallel to the wind direction, with a velocity about 2 to 3 percent of the wind speed in magnitude (USACE 1982).

4.4.2 Bathymetry

The location of the proposed artificial island is north of the Kadleroshilik River delta and immediately seaward of the 20-foot isobath within Foggy Island Bay (Exhibit A). Foggy Island Bay is a shallow embayment, with shoals evident in nearshore areas. In the eastern half of the bay the sea floor is very shallow, such that the 10-foot isobath is about 2.5 miles from shore. Seaward of the 10-foot isobath, the sea floor exhibits a gradual uniform slope to the 20-foot isobath. The sea floor in the western half of the bay is similarly shallow. The steepest bottom slopes in Foggy Island Bay are located immediately off of the Kadleroshilik River delta, where the 5-foot isobath lies less than 1 mile offshore and the 10-foot isobath is about 1.5 miles offshore. At the far east end of the bay, a half-mile wide, but shallow 3 feet deep, channel separates Tigvariak Island from the mainland.

4.4.3 River Discharge

Three streams provide fresh water input into Foggy Island Bay:

- Western distributaries of the Shaviovik River

- Kadleroshilik River
- East Channel of the Sagavanirktok River

From its headwaters in Juniper Creek to the coast, the Shaviovik River is about 100 miles long with a drainage area of about 1,700 square miles. The discharge of the Shaviovik River is seasonal, annually averaging 800 cubic feet per second (cfs) with discharge ceasing in late fall as the river freezes (AEIDC 1974).

The Kadleroshilik River discharges directly into the middle of Foggy Island Bay. This river is 75 miles long, has a drainage area of about 650 square miles and an average annual flow of 325 cfs. The Sagavanirktok River has an annual average flow of 2,770 cfs (AEIDC 1974). Approximately 3 percent of the Sagavanirktok River flow, or 83 cfs, discharges through a minor east channel into Foggy Island Bay (USACE 1994). While the larger Sagavanirktok and Shaviovik rivers are prone to summer floods resulting from thunderstorms in the Brooks Range, the Kadleroshilik River is not prone to summer flooding since the watershed is smaller and is restricted to the Arctic Coastal Plain.

4.4.4 Sea Ice

The proposed island is located in water depths of 22 feet and is inside the barrier islands. This is within the land-fast ice zone that extends from the shore out to the zone of grounded ridges in 26 to 50 feet of water (Figure 4-1). In late winter, first-year sea ice in the Beaufort Sea is generally about 6.5 feet thick; from the shore to a depth of 6.5 feet, the ice is frozen to the bottom, forming the bottom-fast ice zone. The remaining ice in the land-fast ice zone is floating. Onshore movement of the floating ice is relatively common and generates pileups and rideups along the coast and on offshore structures and barrier islands.

Seaward of the land-fast ice zone, in 50 to 150 feet of water, is the stamukhi or shear zone. This region is characterized by dynamic interaction between the relatively stable ice of the land-fast zone and the mobile ice of the pack ice zone, resulting in the formation of ridges and leads. The pack ice zone, located in waters greater than 150 feet deep, includes first-year ice, multiyear deformed and undeformed ice, and ice islands. During winter, movement of the pack ice zone of the Beaufort Sea is generally small and tends to occur during events associated with strong winds lasting several days.

Sea ice forms within Foggy Island Bay in September or October, typically along shore where water is less saline. Initially, the water is covered with brash (floating slush) and pancake ice (small, thin patches) which gradually thicken into ice sheets. If storm surges occur during the early stages of freezeup, the smooth sheet of ice can be broken into blocks, forming a chaotic mass of ice. As the sea ice develops, the ice blocks freeze into an ice sheet which grows to a thickness of about 6.5 feet by April or May. Ice blocks within the sheet may extend to 13 feet below the surface.

In spring, melting of the sea ice begins at the surface. During the initial stages of melting, brine pockets isolated during freezeup form vertical channels draining through the sea ice. Meltwater that accumulates on top of the ice eventually drains through these brine channels further eroding the sea ice. River breakup brings freshwater to the coast which begins to overflow the nearshore sea ice. As the ice melts, freshwater eventually finds channels in the ice. Vortices form as the freshwater flows through the ice layer producing scour pits in the sea floor known as strudel scour. Earlier surveys in the Tern Island area yielded no indication of ice gouging or strudel scour (WCC 1981). Visual surveys were conducted in spring 1997. Strudel holes were prevalent at the mouths of the Sagavanirktok and Kadleroshilik rivers, with few holes found in the vicinity of the pipeline corridors.

During August 1997, BPXA conducted a sonar survey of the Liberty Project area to determine the nature and extent of ice gouges and strudel scours in the sea floor. The survey area encompassed the Liberty Island site, the proposed pipeline route, and the eastern alternative pipeline route. A series of north-south lines were also surveyed to expand the area of investigation. Preliminary results of this survey showed the occurrence of some ice gouging and strudel scour holes in the project area. None of these features, however, warranted relocation of the island location or pipeline route. Results of these studies will be published by summer 1998 and will be considered in final design.

Breakup of the sea ice usually occurs by June or July. As melting continues, most of the sea ice retreats from shore with the pack ice, but winds may bring ice floes near shore at any time during the open water season. By the middle of July, much of the land fast ice inside the 33-foot isobath has melted or moved offshore. The area of open water with few ice floes expands along the coast and away from the shore and the pack-ice zone migrates seaward. Winds from the east and northeast, which are common in the summer, tend to drive the ice offshore. Westerly winds move offshore ice into nearshore areas.

Traditional environmental knowledge (TEK) of general ice conditions, and especially their variability, is reasonably well documented (for example, most of Chapter 10 of Okakok 1981, interspersed throughout NSB 1980). The description of general project area ice conditions derived from "scientific" observations and data, summarized above, is consistent with TEK. Site-specific TEK for the project area may well exist, but would be difficult to locate. That is, such information may be contained within the large body of documented TEK which exists concerning ice conditions, but no reliable index or search mechanism is available. Geographical references are often general, vague, or labeled with names that have not been mapped. The North Slope Borough may also possess taped material pertaining to this topic that has not yet been processed and is thus not accessible.

4.5 MARINE WATER QUALITY

4.5.1 Salinity and Temperature

Marine waters are generally cold (30° to 37°F) and saline (27 to 32 parts per thousand (ppt) (Craig 1984; Colonell and Niedoroda 1990). Temperature and salinity within the central Beaufort Sea nearshore zone are strongly influenced by the prevailing summer wind velocity (direction and speed), the proximity of fresh water discharge by coastal river systems, and the presence of sea ice.

Data from the Endicott monitoring program show that, during open water conditions under east winds, flow in the bay is directed toward the northwest, generally aligned with the bathymetry (USACE 1987). The warm, low-salinity coastal water from Foggy Island Bay and river-plume water from the East Channel of the Sagavanirktok River are transported to the west during easterly winds. Input from the Shaviovik River (and to a lesser extent from the Kadleroshilik River), consisting of relatively warm, low salinity water, tends to remain close to shore within Foggy Island Bay. For example, at nearshore stations (inside of the 10-foot isobath), characteristic temperature and salinity values for four representative surveys ranged from 40° to 42°F and 18 to 19.5 ppt (USACE 1987). At the offshore stations located outside of the 10-foot isobath, characteristic salinity and temperature values for the same surveys ranged from 36.5° to 37.4°F and 20 to 21 ppt. The outer bay exhibits a uniform water mass with characteristics similar to the offshore Stefansson Sound water (USACE 1990).

Under west winds, water movement in the western portion of the bay is directed toward the southeast, and is generally aligned with the coastal bathymetry. Water levels generally rise, and fresher water from the Sagavanirktok River is pooled near shore (USACE 1993). The remainder of the bay tends to be homogeneous, with offshore water characteristics.

Thorsteinson et al. (1991) collected water temperature and salinity data in August 1990 along a north-oriented transect located offshore of the Kadleroshilik River. The distribution of temperatures indicated the lack of a strong thermal gradient, since temperatures varied by only 2°C (3.6°F) over the 12-km (7.5 mile) transect. Colder marine water was observed approximately 8 km (5 miles) from the coast, with transition waters (< 30 ppt with temperatures from 4° to 6°C [39° to 43°F]) found inshore of 8 km (5 miles). During collection of these data, mean daily winds were from the west at 4.4 meters per second (m/s) (9.6 mph).

In February 1997, Montgomery Watson (1997) determined salinity and temperature values under ice in the vicinity of the proposed pipeline routes for the Liberty Development Project. Under-ice water temperatures ranged from -2° to 0°C (28° to 32°F), with salinity ranging from 21 to 30 ppt. Ice thickness at the stations ranged from 3 to 5.1 feet, with total ice-free water depths of 0.3 to 16 feet.

4.5.2 Dissolved Oxygen

During the open water season, dissolved oxygen levels in the Beaufort Sea are usually high, about 8 milligrams per liter (mg/L), with values ranging from 7.88 to 11.76 mg/L (WCC 1981). During open water, the highest dissolved oxygen concentrations occur in the colder, more saline water located near the bottom of the water column. Under winter ice cover, respiration by planktonic and other organisms continues, but atmospheric exchange and photosynthetic production of oxygen cease. Throughout the ice-covered period, dissolved oxygen concentrations in areas with unrestricted circulation seldom drop below 6 mg/L. Under-ice dissolved oxygen concentrations in March 1997 along the proposed Liberty pipeline route ranged from 7.6 to 13.2 mg/L (Montgomery Watson 1997).

4.5.3 Turbidity and Suspended Sediment

Suspended sediment is introduced naturally to the marine environment through river runoff and coastal erosion (MMS 1996a) and is resuspended during summer by wind and wave action. North Slope rivers have been sampled by the U.S. Geological Survey (1981), and are characterized by low dissolved solids, with concentrations less than 120 mg/L. Water from the Sagavanirktok River was sampled during 1985 as part of the Endicott Monitoring Program (USACE 1987). Total suspended solids (TSS) ranged from 0.2 to 30.0 mg/L, and turbidity ranged from 0.4 to 24.0 NTU (nephelometric turbidity units) during summer months. Maximum values were associated with midseason peaks in discharge following large rainfall events, while low values corresponded to low flow periods later in the summer season.

Satellite imagery and suspended particulate matter data suggest that turbid waters are generally confined to depths less than 16 feet (5 meters) and are shoreward of the barrier islands. In mid-June through early July, the shallow nearshore waters generally carry more suspended material because runoff from the rivers (Sagavanirktok, Kadleroshilik and Shaviovik) produces very high turbidity adjacent to the river mouths. Storms, wind and wave action, and coastal erosion increase turbidity in shallow waters periodically during the open-water season. Chronic turbidity conditions are more prevalent in areas where silts and clays predominate as compared to areas having predominately sand bottom.

Extremely turbid conditions were observed throughout the Sound during late summer 1997 due to resuspension of bottom sediments from waves and swells. The ice pack was in excess of 100 miles offshore, resulting in an increased fetch and large swells inside Stefansson Sound. Remotely-operated vehicle (ROV) surveys in the Boulder Patch, at the Liberty Island site, and along the pipeline routes were rendered almost useless due to low visibility resulting from wave action resuspension sediments in all areas sampled.

Surface water grab samples were collected during late July as part of the 1986 Endicott Environmental Monitoring Program (USACE 1990). The values for TSS were generally low, but increased with increased wind and wave action. The highest TSS's (up to 3 mg/L) were recorded on the eastern side of the Endicott Causeway after a strong (21 to 24 mph) northeast wind event. The composition of the suspended material was predominantly medium to very fine silt.

Suspended sediment concentrations are governed primarily by wind-induced waves and fresh water input from the Sagavanirktok River and other major rivers (USACE 1987). Britch et al. (1983) found peak suspended sediment concentrations were associated with intervals of highest significant wave heights. The maximum value was 324 mg/L at a nearshore station where the average was 45 mg/L. The presence of ice cover limits wave action resulting in decreased turbidity (MMS 1996a). March 1997 under-ice TSS values along the proposed Liberty pipeline route ranged from 2.5 to 76.5 mg/L (Montgomery Watson 1997); field measured turbidity for March under-ice conditions ranged from 1 to 35.6 NTU, and laboratory measured turbidity ranged from 0.89 to 24 NTU (Montgomery Watson 1997).

4.5.4 Nutrients

Nitrogen and phosphorous are introduced to Foggy Island Bay by river runoff and coastal peat erosion. Levels decline in the summer, after breakup, and are considered limiting by the end of summer (BLM 1979). Schell (1982) found nutrient concentrations reached their annual maximum as offshore water replaced lagoon waters in Simpson Lagoon. He found mean nitrate concentrations of 6.4 g-atoms nitrogen (N) per liter and phosphate concentrations of 0.99 g-atoms phosphorous (P) per liter for a N:P ratio of 6.4:1. This indicates a severe nitrogen limitation relative to phosphorus once plant growth is established. Schell (1982) concluded the N:P ratios in the inorganic nutrient pools in late winter in Simpson Lagoon were very low relative to the generally accepted values of 15:1 or 16:1, leading to the conclusion that nitrogen availability limits most marine plant growth during most of the arctic summer season. The dominant kelp found in Stefansson Sound (*Laminaria solidungula*) is one of the few marine plants that has developed a life history strategy to contend with nutrient limitation in summer and light limitation in winter (e.g., Dunton 1990).

4.5.5 Trace Metals

Trace metals are introduced naturally to the central Beaufort Sea through river runoff (relatively unpolluted by humans), coastal erosion, atmospheric deposition, and natural seeps. Since there is little industrial discharge activity in this region, most contaminants occur at low levels in the Beaufort Sea (MMS 1996a). Trace-metal concentrations in Beaufort Sea sediments, suspended sediments, and water are shown on Table 4-1. Mercury values above the USEPA chronic criterion have been reported in water samples, but were probably due to sample contamination (MMS 1996a).

In addition to the data in Table 4-1, 16 seafloor sediment samples were collected throughout the Northstar Unit (WCC 1996). Although these samples were taken 31 miles west of Foggy Island Bay, the sediment chemistry values are indicative of concentrations expected throughout the Beaufort Sea. This study found a strong correlation between the concentrations of chromium, lead, and zinc, and a notable relationship between trace metal concentrations and sediment grain size. Elevated trace metal concentrations were associated with finer sediments. No site-specific groupings or clustering indicative of industrial contamination were found, and it was concluded that samples reflected natural background metal concentrations (WCC 1996).

Sediment samples were obtained for sediment chemistry background data along the Liberty pipeline route during late winter 1997. The mean sediment concentration of arsenic was 5.5mg/Kg, total barium was 67.5 mg/Kg, barium sulfate was 27.5 mg/Kg, chromium was 18.5 mg/Kg, mercury was 0.24 mg/Kg, and lead was 10.1 mg/Kg. No diesel range organics were detected. Acetone ranged from 12-88 mg/Kg, and no other volatile or semi-volatile organic compounds were detected (Montgomery Watson 1997).

4.5.6 Hydrocarbons

Background water hydrocarbon concentrations in the Beaufort Sea tend to be low, generally less than one part per billion (ppb), and appear to be biogenic. No evidence of hydrocarbon concentrations derived from oil industry activities has been found in Beaufort Sea sediments (MMS 1996a). The sediment sample program conducted for the Northstar Unit (see Section 4.5.5), detected no diesel range organics (DRO). Detection of trace amounts of specific volatile organic carbons (VOCs) and semivolatile organic carbons (SVOCs) were determined to be artifacts of laboratory sampling or sampling procedures. No DROs, VOCs (with the exception of acetone), or SVOCs were detected in sediment samples collected during winter 1997 along the proposed Liberty pipeline routes (Montgomery Watson 1997).

4.6 BENTHIC AND BOULDER PATCH COMMUNITIES

Most of the nearshore seabed of the Alaskan Beaufort Sea consists of a soft-bottom featureless plain comprised of mud or sand. The benthic communities associated with soft-bottom benthic habitat include microalgae and bacteria, and invertebrates. Benthic microalgal assemblages, consisting primarily of diatoms, have been studied in

TABLE 4-1

TRACE-METAL CONCENTRATIONS IN BEAUFORT SEA SUSPENDED SEDIMENTS

Source: Minerals Management Service 1996a

	TRACE METALS (SYMBOLS DEFINED BELOW)									
	As	Cr	Hg	Pb	Zn	Cd	Ba	Cu	Ni	V
Sediments (ppm)										
Nearshore, Lagoons, and Bays[1]	---[2]	17-19	0.02-0.09[3]	3.9-20	19-116	0.04-0.31	185-745	4.9-37	33[4]	33-153
Shelf[5]	16-23[6]	85[4]	0.03-0.16[7]	3[8]	98	0.2[7]	---	57	47	140[4]
Slope and Abyssal[9]	55[6] 2[9]	99[9]	0.07-0.17[7]	---	82	---	---	59	56	19
Average World Coastal Ocean[8]	---	10-100	0.01-0.07[10]	2-20	5-200	0.2-3.0	60-1,500[11]	5-40	16-47[11]	130[9]
Average Liberty Pipeline Routes[12]	5.5	18.5	0.24	10.1	---	---	67.5	---	---	---
Suspended Sediments (ppm of dry weight)[13]	---	21-140	---	---	8-232	---	---	5-83	10-100	2-307
Water (ppb)										
Total[13]	---	0.1-2.1	0.005-0.57[7]	---	0.4-3.7[14]	---	---	0.4-2.1	---	---
Dissolved[8]	---	0.02-0.3	0.008-0.032[15]	0.02-1.7	0.2-3.4	0.02-0.11	---	0.3-1.8	---	---
Typical Worldwide Marine Total[16]	1.35-2.5[17]	0.3	0.001[18]	0.01	1	0.04	---	0.3	0.3	---

Symbol Definitions: As = Arsenic; Cr = Chromium; Hg = Mercury; Pb = Lead; Zn = Zinc; Cd = Cadmium; Ba = Barium; Co = Copper; Ni = Nickel; V = Vanadium.

[1] Boehm et al. 1987.
[2] No data.
[3] Northern Technical Services 1981b, Weiss et al. 1974.
[4] Naidu 1982 (cited in MMS 1996a).
[5] Naidu 1974.
[6] Robertson and Abel 1979.
[7] Weiss et al. 1974.
[8] Thomas 1988.
[9] Naidu et al. 1975, for central Bering Shelf and Chukchi Sea.
[10] Nelson et al. 1975 (for central Bering Shelf and Chukchi Sea)
[11] Chester 1965.
[12] Montgomery Watson 1997.
[13] OCSEAP data, NODC/NOAA data bank.
[14] Burrell et al. 1970.
[15] Guttman, Weiss, and Burrell 1978 (for Chukchi and Beaufort Seas).
[16] Berhard and Andreae 1984.
[17] Burton and Statham (1982) in Langston (1990).
[18] Gill and Fitzgerald 1985.

Stefansson Sound and were found to not contribute significantly to primary production (Horner and Schrader 1982; Dunton 1984). Benthic invertebrates typically are classified as either epifauna (on or near surface of the substrate) or infauna (within the substrate). The organisms comprising these groups, as well as the general patterns of their distribution and abundance, have been described in the FEISs for Sales 97, 109, 124, and 144 (MMS 1987a, 1987b, 1990b and 1996a, respectively) and Thorsteinson (1983).

Nearshore benthic communities are subjected to a wide array of natural events, including storm waves during the open-water season, ice gouging and scour during breakup and freezeup, large-volume inflow of fresh water during breakup and occasionally during the summer, and deposition of sediment and organic material following high river discharges. These processes affect the distribution and relative abundance of benthic species along the Beaufort Sea coast. One of the largest annual fluctuations in the benthic community is associated with shallow nearshore waters. During winter, the nearshore zone is covered by bottomfast ice out to a depth of 2 meters (~6 feet). When this ice cover dissipates in summer, the shallows are re-invaded by a host of marine invertebrates including mysids, amphipods, copepods, isopods, and polychaetes (Griffiths and Dillinger 1981; Moulton et al. 1986; Knutzen et al. 1990; Knutzen and Jewett 1991; WCC 1996). Beyond the 2-meter isobath most nearshore, shallow-water areas of the Beaufort Sea (i.e., areas with water depths of 1.8 to 6 meters [~6 to 20 feet]) contain relatively diverse, predictable benthic communities dominated by polychaetes, molluscs and crustaceans (Feder et al. 1976; Girder et al. 1977, 1978; Robilliard et al. 1978, 1988; Busdosh and Robilliard 1979, 1982; WCC 1979, 1983, 1996; Feder and Jewett 1982; Robilliard and Busdosh 1983; Robilliard and Colonell 1983; Busdosh 1984; Carey 1991). Ice gouging may periodically disturb this offshore community out to a depth of about 40 meters. The intensity of these perturbations decreases with depth. Large bivalves such as *Astarte*, *Axinopsida*, *Macoma*, *Portlandia* and *Boreacola* were associated with collections at deepwater stations (26 to 45 feet) during the August 1995 Northstar sampling, and may be a good indicator of the degree of physical disturbance (WCC 1996). The bivalve *Astarte* was collected from the Sound during the summer 1997 ROV sampling program, and bivalve shells were observed in ROV video tapes. The diversity and biomass of infauna increase with distance offshore (Carey 1978), at least as far as the edge of the continental shelf (200 meters).

4.6.1 Endicott/Foggy Island Bay Communities

Studies of marine benthos were conducted in the vicinity of the Endicott Causeway as part of the Endicott National Pollutant Discharge Elimination System (NPDES) monitoring program from 1986 through 1990 (ENSR 1991). These studies identified 99 taxa of marine macrobenthos within the sampling area seaward of the 2-meter isobath. Faunal composition changed annually and in conjunction with water depth and bottom sediment composition. Faunal diversity was low during the 5-year study, which is typical for shallow, ice-stressed benthic systems in the Arctic. The marine benthic community in the Endicott study area was dynamic and subject to disturbances due to storm activity, ice gouging, and outflow from the Sagavanirktok River. Benthic species abundance and diversity measurements conducted as part of the environmental program for the Northstar Unit were higher than those previously reported (WCC 1996). A total of 21 stations were sampled, ranging from 7 to 45 feet deep and located from Endicott westward to the Kuparuk River. The dominant species included polychaetes (82 taxa), molluscs (42 taxa), and crustaceans (40 taxa), which were the same taxonomic groups dominant in previous studies (WCC 1996).

Epibenthic invertebrates were sampled in Foggy Island Bay in 1985 and 1986 as part of the Endicott Monitoring Program (Cannon et al. 1987; Knutzen et al. 1990). Average biomass in Foggy Island Bay (range 0.4 to 0.8 grams per square meter, g/m^2) was comparable to areas to the west such as the Sagavanirktok Delta (0.1 to 1.2 g/m^2) and Gwydyr Bay (0.5 to 0.7 g/m^2). Invertebrate abundance was generally correlated with water temperature and salinity, with higher abundance in areas subject to mixing of fresh and marine waters.

4.6.2 Trophic Functions

The coastal lagoons of the Beaufort Sea (e.g., Simpson Lagoon, Stefansson Sound, and those lagoons landward of Stockton and Maquire islands) support a nearshore benthic environment that is used as a summer feeding ground by many vertebrate consumers (Thorsteinson 1983). Benthic invertebrates, predominantly amphipods, mysids, copepods, and other motile crustaceans, are fed upon widely by some marine mammals (walruses, bearded seals and ringed seals; see Frost and Lowry 1983). Shallow-water (less than two meters) benthic communities also serve as the primary summer food source for ducks, some species of marine fishes, and the anadromous fish populations of the Alaskan North Slope (Craig and Haldorson 1981; Griffiths and Dillinger 1981; Craig et al. 1984). The collective trophic pressure exerted on these benthic communities is offset by the continual onshore transport and migration of marine invertebrates from deeper offshore waters (Griffiths and Dillinger 1981). In general, the food habits of marine invertebrates themselves vary depending on habitat, and season; but they typically rely on marine plankton, other invertebrates, detritus, or carrion.

4.6.3 Boulder Patch

In the early 1970s, researchers from the U.S. Geological Survey discovered sites in the Stefansson Sound area of the Beaufort Sea, Alaska, that were characterized by patches of scattered rocks on the bottom, ranging in size from pebbles to boulders

(Reimnitz and Toimil 1976). Areas with dense rock cover (more than 25 percent rock cover) contained a rich epilithic flora and fauna, including extensive kelp beds. Isolated patches of marine life occurred in areas where the rocks were more widely scattered (10 to 25 percent rock cover). This area of Stefansson Sound containing rocky substrate was charted (Exhibit A; Reimnitz and Ross 1979) and was designated as the "Boulder Patch" by the U.S. Board of Geographic Names. Although boulders up to two meters across and one meter high are sometimes encountered, most of the rock cover occurs in the pebble to cobble size range. The Boulder Patch is thought to be composed of rocks of Flaxman formation origin that were incorporated as lag deposits into the Gubik formation (Dunton et al. 1982).

Isolated patches of marine life were discovered in areas where rock substrate covered as much as 10 to 25 percent of the bottom. With the exception of rocks recently upturned by ice, nearly all exposed surfaces of the rocks in these areas were found to be covered by algae and epilithic invertebrates. Dunton and Schonberg (1981) concluded that biological richness could be inferred by the regularity of such cover: any rock cover greater than 10 percent was considered to be biologically rich, with richness increasing with rock cover density. An extensive epilithic flora and fauna was present in areas of dense (25 percent) rock cover, including extensive beds of the kelp *Laminaria solidungula*. While kelp communities are common in Arctic waters outside of Alaska, the Boulder Patch community is hundreds of kilometers disjunct from the primary range of Canadian Arctic communities. With few spatially-limited exceptions, Stefansson Sound is unique along the Alaskan Beaufort Sea in that it provides the necessary combination of rocky substrate, depth sufficient to allow a 12- to 14-foot thick layer of free water under the ice during winter, and protection from extensive gouging and reworking of the bottom by ice by the offshore shoals and barrier islands.

The Boulder Patch was intensively studied during the late 1970s and early 1980s as part of the National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program (NOAA/OCSEAP). In addition, a refined delineation of the distribution for a portion of the Boulder Patch resulted from offshore oil and gas exploration in Stefansson Sound (e.g., Toimil and England 1980; Miller and England 1982; Lee and Toimil 1985; Exhibit A). The summer 1997 program of side-scan sonar surveys, complimented with ROV and diver observations, provided data further refining the known distribution of this community in Stefansson Sound.

The NOAA/OCSEAP studies documented the uniqueness of this community, particularly the growth of the dominant kelp, *Laminaria solidungula*. Dunton et al. (1982) described the overall community structure and composition of the Boulder Patch biological community (Table 4-2) and the growth characteristics of *L. solidungula*. Growth of *L. solidungula* was found to be both energy- and nitrogen-limited because the two resources are not available in sufficient quantities simultaneously. However, this kelp has developed a life history strategy that enables it to successfully deal with these

TABLE 4-2

DENSITY (N/m^2), BIOMASS (g/m^2) AND FREQUENCY OF OCCURRENCE (F) OF THE PREDOMINANT BENTHIC BIOTA ON ROCK SUBSTRATA OF THE BOULDER PATCH

Source: Table from Dunton et al. (1982)

Species	N/m^2	g/m^2	F
PORIFERA			
Choanites lutkenii		3.6	4
Halichondria panicea		3.0	32
Haliclona rufescens		2.5	44
Leucandra sp.		0.2	26
Phakettia cribrosa		11.8	34
CNIDARIA			
HYDROZOA			
Abietinaria sp.		<0.1	2
Calicella syringa		0.1	30
Corymorpha sp.		<0.1	2
Eudendrium sp.		<0.1	8
Lafoeina maxima		0.3	28
Obelia sp.		<0.1	12
Rathkea sp.		<0.1	2
Sertularia cupressoides		8.5	86
Sertularia sp. cf. *albimaris*		0.4	6
ANTHOZOA			
Gersemia rubiformis		3.0	14
MOLLUSCA			
GASTROPODA			
Amauropsis purpurea	0.4	<0.1	2
Lacuna sp.	0.4	<0.1	2
Margarites sp.	2.4	<0.1	10
Margarites costalis	1.6	<0.1	2
Oenopota sp.	1.6	<0.1	6
Plicifusus sp.	1.2	<0.1	2
Polinices sp.	0.8	<0.1	2
Retusa obtusa	1.2	<0.1	2
Solariella sp.	2.0	<0.1	6
Solariella varicosa	0.8	0.1	4
POLYPLACOPHORA			
Amicula vestita	16.0	11.0	38
Ischnochiton albus	1.2	<0.1	2
BIVALVIA			
Astarte sp.	1.6	<0.1	6
Boreacola vadosa	0.8	<0.1	4
Musculus sp.	239.6	0.1	82
Musculus discors	69.2	2.1	8
Macoma calcarea	0.4	<0.1	2
Portlandia arctica	0.4	<0.1	2
BRYOZOA			
Alcyonidium sp.		1.0	44
Callopora lineata		2.6	90
Carbasea carbasea		<0.1	2
Crisia sp.		0.1	10
Cyclostomata		0.2	20
Dendrobeania sp.		<0.1	2
Eucratea loricata		3.8	66
Flustra sp.		0.1	2
Flustrella sp.		<0.1	2
Hippothoa hyalina		5.1	90
CHORDATA			
ASCIDEACEA			
Chelyosoma macleayanum	2.0	<0.1	8
Molgula sp. cf. *siphonalis*	0.4	0.4	2
Molgula griffithsii	1.2	0.3	8
Styela rustica	0.4	<0.1	2
OSTEICTHYES			
Liparis herschelinus	0.4	0.1	2
Myoxocephalus quadricornis	0.4	2.9	2
PHAEOPHYTA			
Laminariales (10%-25% rock cover)[1]		66.7	20
Laminariales (10%-25% rock cover)[1]		262.1	54
RHODOPHYTA			
Crustose corallines		0.5	20
Neodilsea integra		30.9	26
Odonthalia dentata		4.2	40
Phycodrys rubens		45.3	88
Phyllophora truncata		33.4	80
Rhodomela confervoides		5.3	58

[1] Includes *Laminaria solidungula*, *L. saccharina* and *Alaria esculenta*.

restraints. During the summer open-water period when light is available, the plants must fix all the carbon necessary for their annual growth, reproduction and metabolism. However, little linear growth occurs during this period due to insufficient concentrations of inorganic nitrogen needed for synthesis of new tissue. The products of photosynthesis, carbohydrates in the form of laminarin or manitol, are stored and used during the winter when inorganic nitrogen concentrations have increased to levels enabling growth of a new blade (Dunton and Schell 1986). Because of this pattern, *L. solidungula* completes nearly 90 percent of its annual linear growth in darkness under a turbid ice cover that completely excludes light from the bottom from late October to late June (Dunton et al. 1982). In some years, when the ice canopy is clear, light reaches the plants during spring, and annual growth increases significantly (Dunton 1984). Kelp production provides 50 to 56 percent of the carbon available to Boulder Patch consumers and releases approximately 60 percent of the particulate organic matter found in the kelp-bed environment (Dunton 1984).

Laminaria solidungula is exceptionally well adapted for low-light conditions characteristic of the arctic (Dunton and Jodwalis 1988). Its light compensation level is on the order of 2.1 $E/m^2/s$, its saturation level is 38 $E/m^2/s$, and its photoinhibition level is 123 $E/m^2/s$. Annual growth and carbon content of *Laminaria solidungula* is significantly correlated with the number of hours that the plant receives saturation levels of light during summer (Dunton 1990). Productivity improves with light levels from the compensation level to the saturation level, after which no further gain is realized by additional light levels (Dunton 1990). In fact, productivity of the plant is photoinhibited when light exceeds the 123 $E/m^2/s$. These light threshold values are generally the lowest levels known for any member of the genus *Laminaria*. One consequence of this low-light adaptation is that summers characterized by unusually clear waters and high levels of light at the bottom may not necessarily result in increased productivity because the plants have such a low level of photoinhibition.

Data from the Endicott Monitoring Program show that light received at the bottom is lower at sites with fine sediments (silt-clay) than at sites with sandy sediments at the same depths and levels of rock cover (LGL Ecological Research Associates [LGL] and Dunton 1992). This is likely due to more frequent episodes of sediment resuspension and increased turbidity in areas having fine-grained sediments as compared to areas having sandy sediments.

Water depths also play a role in the success of Stefansson Sound Boulder Patch communities. The habitat is not found at depths less than 6 to 6.5 feet due to the seasonal presence of ground-fast ice as described previously. Further, Niedoroda and Colonell (1991) have suggested that the entire upper shoreface (water depths of approximately 6 to 12 feet) of Stefansson Sound is generally depositional in nature and, thereby, unsuitable for kelp community development. Benthic-dwelling kelp do not thrive in depositional environments. The distribution of kelp bed communities in Stefansson Sound is thus generally restricted to depths greater than 10 to 12 feet (Exhibit A).

The Boulder Patch community, although dominated by *L. solidungula*, also contains red algae and benthic invertebrates. Approximately 98 percent of the carbon produced annually in the Boulder Patch is derived from kelp and phytoplankton. *Laminaria* is estimated to contribute 50 to 56 percent of the annual production (134 grams of carbon per square meter per year [g $C/m^2/yr$] to 211 g $C/m^2/yr$), depending on whether the plants are beneath clear or turbid ice (Dunton 1984). The only herbivore that consumes kelp in the Boulder Patch is the chiton, *Amicula vestita*. Dunton (1984) estimated the annual ingestion of kelp by *A. vestita* is approximately 0.8 g C/m^2. Sponges and cnidarians, including the soft coral *Gersemia rubiformis*, are the most conspicuous invertebrates (Dunton et al. 1982).

The USEPA has established drill mud disposal criteria relative to the Boulder Patch in Arctic NPDES Permit No. AKG284200. No disposal is allowed within 1,000 meters of the Boulder Patch or between individual units of the Boulder Patch, where the separation between units is greater than 2,000 meters but less than 5,000 meters. The Boulder Patch is defined in the General Permit as an area which has more than 10 percent of a 100-square meter area covered by boulders to which kelp is attached.

In the summer of 1984, BPXA independently initiated a pre-construction study to evaluate the effects of the Endicott Development on the Boulder Patch (Dunton et al. 1985). This study was followed by a six-year monitoring program (1986-1991) yielding five years of synoptic light and kelp growth data and six years of invertebrate community diversity data (Gallaway and Martin 1987; Gallaway et al. 1988; LGL Ecological Research Associates, Inc. [LGL] and Dunton 1989, 1990, 1991 and 1992). A synthesis of the seven-year study determined the effects of the Endicott Development on Boulder Patch community kelp health, kelp growth, and taxa diversity (Martin and Gallaway 1994).

In terms of the relative abundance of the dominant species, the faunal community structure was found to be relatively stable over the course of the seven study years. The most frequently occurring taxa were three algae, *Phycodrys rubens, Coccotylus truncata,* and *Leptophytum* spp.; the sponge *Halichondria panicea*; and the hydroid *Sertularia cupressoides* (Martin and Gallaway 1994). Five rare species from 1984 decreased in abundance areawide, but this was attributed to a proliferation of *Phycodrys rubens* in 1991 and this leafy algae may have hidden the rare species from view.

Increased mean difference in linear kelp growth between the control and impact sites, before and after construction based on three years of pre-construction data, suggested a decrease in linear growth following construction. However, overlap of the 95 percent confidence intervals for the means indicated differences were within natural variations in kelp growth (Martin and Gallaway 1994). Longer term pre-construction data available for site DS-11 indicated there was little difference between pre- and post-construction kelp growth. Mean annual pre-construction growth was 28.3 centimeters (cm, range 20.0 to 44.2 cm) compared to post-construction mean growth of 28.0 cm (range 19.2 to 49.6 cm) (Martin and Gallaway 1994). Sediment and benthic macroinvertebrate monitoring studies similarly documented that adverse effects were few and were restricted to areas within 500 meters of the source (ENSR 1991 *in* Martin and Gallaway 1994).

A study initiated in August 1984 determined the rates and diversity of faunal and floral recolonization (Martin and Gallaway 1994). Two bare Flaxman boulders were deployed at each of three locations (DS-11, E-1, W-1), where rock cover was > 25, < 15, and < 20 percent, respectively. Recolonization boulders were positioned away from neighboring boulders to reduce rapid recolonization by vegetative growth from bordering communities. Overall, recolonization of bare boulders occurred slowly (Table 4-3). Colonization in 1986 and 1987 was considered negligible, although there was early episodic colonization dominated by the polychaete *Spirorbis* sp. and the algae *Phycodrys rubens* (Martin et al. 1988). By 1988, *Phycodrys rubens, Spirorbis* sp., some encrusting Bryozoans, and hydroids were evident at all sites. By 1989, the DS-11 site was inhabited by six species of epilithic organisms; and in 1990, six years after deployment, this same DS-11 boulder had five colonizing species, including a new arrival, the soft coral *Gersemia rubiformis* (Table 4-3). These taxa persisted through the last year of the study. Colonization of boulder W-1-1 at site W-1 showed an increase from three species in summer 1989 to six species in 1991. An additional three species (total of nine) were found when this boulder was examined in the laboratory (Table 4-3). Similarly, photographs of boulders E-1-1 and E-1-2 at site E-1 showed increases from three and four species in summer 1988 to seven and nine species in 1991, respectively. Examination in the laboratory revealed two additional species on each boulder (Table 4-3).

The slow appearance of colonizing organisms, and the presence of uncommon species, suggests that Boulder Patch species disperse as relatively long-lived larvae; the larvae grow very slowly; and/or the larvae may have a non-motile dispersal stage or be otherwise limited in terms of dispersal capabilities. Within seven years, many of the eplilithic organisms characteristic of the Boulder Patch were represented on the recolonization boulders. Placement of bare rock in areas otherwise suitable for Boulder Patch communities was concluded to represent a viable mitigation option (Martin and Gallaway 1994).

Remote sensing and limited video photographic ground-truth data collection during the 1997 Boulder Patch sampling program, in conjunction with historical observations and existing data, led to the conclusion that biologically rich Boulder Patch habitat (^{h} 10 percent rock cover) is not represented at the island site or along the proposed Liberty Development pipeline corridor. The shoreward half of this route occurs at depths too shallow (0 to 12 feet) for community development due to seasonal presence of ground-fast ice and sediment deposition characteristics. In deeper areas, side-scan

TABLE 4-3

SUMMARY OF SPECIES OBSERVED IN PHOTOGRAPHS OF COLONIZATION BOULDERS AT SITES E-1, W-1, AND DS-11 IN YEARS 1986 THROUGH 1991. TWO COLONIZATION BOULDERS WERE PLACED AT EACH SITE IN 1984. ONLY BOULDERS WHICH WERE FOUND IN A PARTICULAR YEAR ARE INCLUDED.

Source: Table from Martin and Gallaway 1994

	1986			1987			1988				1989		1990	1991			
SITE:	**W-1-1**	**W-1-2**	**DS-11**	**E-1-2**	**W-1-2**	**DS-11**	**E-1-1**	**E-1-2**	**W-1-1**	**DS-11**	**W-1-1**	**DS-11**[1]	**DS-11**	**E-1-1**	**E-1-2**	**W-1-1**	**DS-11**
TAXA																	
Algae																	
Laminaria solidungula															X		
Leptophytum spp.								X				X			X		X
Odonthalia dentata															X		
Phycodrys rubens			X[1]	X		X	X	X	X[1]	X	X	X	X	X	X	X	X
Coccotylus truncata		X															
Sponges																	
Halichondria panicea			X			X				X		X	X	X[2]		X[2]	X
Phakettia cribrosa														X[2]	X[2]	X[2]	
Hydroid																	
Obelia sp.														X			
Sertularia cupressoides											X	X	X		X	X	X
Tubularia sp.							X[1]	X									
Unidentified hydroid							X		X	X[1]							
Coral																	
Gersemia rubiformis													X			X[2]	
Polychaete																	
Spirorbis sp.	X	X		X	X		X	X	X	X	X	X	X	X		X	X
Crustacean																	
Unidentified barnacle														X	X		
Bryozoans																	
Alcyonidium gelatinosum														X	X	X	
Eucratea loricata														X	X	X	
Flustra sp.															X[2]		
Unidentified encrusting							X[1]	X[1]	X[1]	X[1]		X		X	X	X	X

1 Identified *in situ*.

2 Identified in the laboratory after collection.

sonar and other remote sensing data showed the bottom also to be devoid of highly reflective targets (potential rock cover), except for a 4,700-foot long section. Reflective targets can be boulders or cobbles, gravel, consolidated clay areas, mollusc shell fragments, or other features. Within these more reflective areas, the coverage of the bottom by potential rock cover was estimated to be less than 10 percent, usually closer to 1 to 5 percent. Rich biological communities would therefore be absent. Due to weather and turbidity conditions, these remote sensing observations could not be definitively ground-truthed with video photography. Following a presentation on 10 November 1997 by investigators and representatives of BP Exploration (Alaska) Inc., the Arctic Biological Task Force agreed, in principle, that the proposed pipeline route is acceptable (no Boulder Patch habitat), pending the acquisition of additional ground-truth data supporting the interpretation of the remote sensing data and pending full public review of the proposed project. An ROV survey will be conducted in winter 1998 to provide the requisite ground-truth data.

4.7 FISH

4.7.1 Fish Use of Freshwater Habitats

Table 4-4 lists freshwater and marine fish species occurring in the Liberty Development Project area. The Alaska Department of Fish and Game *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fish* identifies the following streams in the study area as containing anadromous fish (ADF&G 1992):

- Sagavanirktok River 330-00-10360 (Dolly Varden, broad whitefish, pink salmon, and chum salmon)
- Unnamed Drainage 330-00-10330 T10N, R17E, Sect. 15 (Dolly Varden)
- Kadleroshilik River 330-00-10320 (Dolly Varden)

In the summer of 1994, ADF&G personnel surveyed the river and stream crossings along the proposed Badami pipeline route (Hemming 1994; Hemming and Ott 1994). In their report, they indicated that fish presence is highly likely in two beaded tundra streams (tributary to the Sagavanirktok) that the Badami pipeline route crosses. Also, there is one small unnamed stream crossed by the proposed eastern Liberty pipeline alternative. It is a small beaded, intermittent tributary potentially draining to the Kadleroshilik River east of the Kadleroshilik in T10N, R18E, Sec 33 and 28 (see Exhibit A). This stream probably contains ninespine stickleback.

The Dolly Varden char is the most abundant and widely distributed of the five anadromous fishes (Dolly Varden, broad whitefish, Arctic cisco, and occasionally pink salmon and chum salmon) inhabiting freshwater systems within the study area. The

TABLE 4-4

SPECIES TAKEN IN NEARSHORE AND OFFSHORE WATERS OF THE WESTERN AND CENTRAL BEAUFORT SEA

Sources: Frost and Lowry, 1983; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993, 1994a,b; Reub 1991

Clupeidae
- Pacific herring *(Clupea pallasi)*

Salmonidae
- Arctic cisco *(Coregonus autumnalis)*
- Bering cisco *(Coregonus laurettae)*
- Broad whitefish *(Coregonus nasus)*
- Humpback whitefish *(Coregonus pidschian)*
- Least cisco *(Coregonus sardinella)*
- Chum salmon *(Oncorhynchus keta)*
- Pink salmon *(Oncorhynchus gorbuscha)*
- Round whitefish *(Prosopium cylindraceum)*
- Dolly Varden *(Salvelinus malma)*
- Arctic grayling *(Thymallus arcticus)*

Osmeridae
- Capeline *(Mallotus villosus)*
- Rainbow smelt *(Osmerus mordax)*

Gadidae
- Polar cod *(Arctogadus glacialis)*
- Arctic cod *(Boreogadus saida)*
- Saffron cod *(Eleginus navaga)*
- Burbot *(Lota lota)*

Zoarcidae
- Fish doctor *(Gymnelis viridis)*
- Saddled eelpout *(Lycodes mucosus)*
- Canadian eelpout *(Lycodes polaris)*
- Marbled eelpout *(Lycodes raridens)*
- Threespot eelpout *(Lycodes rossi)*

Cottidae
- Hamecon *(Artediellus scaber)*
- Slimy sculpin *(Cottus cognatus)*
- Arctic staghorn sculpin *(Gymnocanthus tricuspis)*
- Twohorn sculpin *(Icelus bicornis)*
- Spatulate sculpin *(Icelus spatula)*
- Great sculpin *(Myoxocephalus polycanthocephalus)*
- Fourhorn sculpin *(Myoxocephalus quadricornis)*
- Ribbed sculpin *(Triglops pingeli)*

Liparidae
- Leatherfin lumpsucker *(Eumicrotremus derjugini)*
- Snailfish (*Liparis* sp.)

Agonidae
- Arctic alligatorfish *(Aspidophoroides olriki)*

Stichaeidae
- Slender eelblenny *(Lumpenus fabricii)*
- Stout eelblenny *(Lumpenus medius)*
- Fourline snakeblenny *(Eumesogrammus praecisus)*

Pholidae
- Rock gunnel *(Pholis gunnellus)*

Anarhichadidae
- Wolf-eel *(Anarrhichtys ocellatus)*

Ammodytidae
- Pacific sandlance *(Ammodytes hexapterus)*

Gasterosteidae
- Threespine stickelback *(Gasterosteus aculeatus)*
- Ninespine stickleback *(Pungitius pungitius)*

Pleuronectidae
- Arctic flounder *(Liopsetta glacialis)*
- Starry flounder *(Platichthys stellatus)*
- Alaska plaice *(Pleuronectes quadrituberculatus)*

Hexagrammidae
- Kelp greenling *(Hexagrammos decagrammus)*

Sagavanirktok River supports a population of broad whitefish and occasional pink and chum salmon, but the Dolly Varden is the principal anadromous species that occurs in streams between the Sagavanirktok and Canning rivers (Craig 1984). The Arctic grayling is the most common resident species in fish-bearing streams within the Liberty Development Project area and is considered an important sport species in Alaska.

A common feature of rivers in the study area that originate in the Brooks Range is the presence of perennial springs, which are used by Dolly Varden for spawning and overwintering and by Arctic grayling for overwintering (Craig and McCart 1974). The scarcity of overwintering habitat in North Slope rivers has been proposed as limiting populations of both Dolly Varden and Arctic grayling (Craig 1989a, 1989b). During 1993 field studies, no springs were apparent adjacent to the rivers within the study area (Hemming 1994; Hemming and Ott 1994).

4.7.2 Fish Use of Nearshore and Marine Habitats

Two general types of fish habitat have been identified in the Beaufort Sea: warm nearshore brackish waters and colder offshore marine waters (Craig 1984). The nearshore zone serves as a movement corridor for fishes that are intolerant of more marine conditions and as feeding habitat for both amphidromous and marine fishes. Temperatures and salinities in this nearshore zone are highly variable, both over short time periods (i.e., hours) and over the summer open-water period, and exert a significant influence on the direction and extent of fish movements. In addition to Dolly Varden (age 5 and older), anadromous fishes in the nearshore zone include Arctic cisco (all ages), and adult and subadult least cisco and broad whitefish. Adult Arctic cisco and Dolly Varden range across most of the Beaufort Sea coast; least cisco and broad whitefish, because they do not disperse far from their rivers of origin, are rarely found in nearshore waters of eastern Alaska (Craig 1984). However, large numbers of adult least cisco were captured in Mikkelsen Bay in 1995, 140 km from their natal Colville River (Fechhelm et al. 1996). Marine species may be found in and adjacent to nearshore waters, including primarily Arctic cod, saffron cod, fourhorn sculpin, Arctic flounder, and rainbow smelt.

Arctic cod are the most dominant species in the Arctic Ocean (Walters 1955; Morrow 1980; Thorsteinson et al. 1991) and are the most abundant fish collected in the Prudhoe Bay region. Snailfish, another widely distributed taxon in the Beaufort and Chukchi seas, are also taken in moderate numbers in the Prudhoe Bay area and, therefore, also will likely be found in the Liberty Development Project area (Table 4-5).

4.7.3 Plankton

Information on lower-trophic-level communities has been summarized in the FEIS for Lease Sale 144 and is incorporated here by reference (MMS 1996a). Specific

TABLE 4-5

SPECIES COMPOSITION OF FISHES COLLECTED AS PART OF THE 1985-1994 FISH MONITORING STUDIES

Sources: Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993, 1994a,b; Reub 1991

Common Name	Scientific Name	Total Catch	Percent
Anadromous/Amphidromous			
Arctic cisco	*Coregonus autumnalis*	805,241	11.8
Least cisco	*Coregonus sardinella*	277,699	4.1
Dolly Varden	*Salvelinus malma*	149,811	2.2
Broad whitefish	*Coregonus nasus*	141,297	2.1
Rainbow smelt	*Osmerus mordax*	105,569	1.5
Humpback whitefish	*Coregonus pidschian*	7,040	0.1
Hybrid cisco	*Coregonus* sp.	437	<0.1
Pink salmon	*Onchorhynchus gorbuscha*	244	<0.1
Chum salmon	*Onchorhynchus keta*	29	<0.1
Bering cisco	*Coregonus laurettae*	2	<0.1
Freshwater			
Ninespine stickleback	*Pungitius pungitius*	22,086	0.3
Round whitefish	*Prosopium cylindraceum*	17,380	0.3
Arctic grayling	*Thymallus arcticus*	6,478	0.1
Burbot	*Lota lota*	97	<0.1
Threespine stickleback	*Gasterosteus aculaetus*	89	<0.1
Slimy sculpin	*Cottus cognatus*	50	<0.1
Marine			
Arctic cod	*Boreogadus saida*	4,410,172	64.4
Fourhorn sculpin	*Myoxocephalus quadricornis*	658,804	9.6
Arctic flounder	*Liopsetta glacialis*	204,048	3.0
Saffron cod	*Eleginus navaga*	26,415	0.4
Capelin	*Mallotus villosus*	8,267	0.1
Snailfish	*Liparis* sp.	5,197	0.1
Pacific herring	*Clupea pallasi*	233	<0.1
Great sculpin	*Myoxocephalus polyacanthocephalus*	42	<0.1
Pacific sandlance	*Ammodytes hexapterus*	26	<0.1
Wolf-eel	*Anarrhichthys ocellatus*	14	<0.1
Starry flounder	*Platichthys stellatus*	6	<0.1
Prickleback	Stichaeidae	5	<0.1
Rock gunnel	*Pholis gunnellus*	3	<0.1
Kelp greenling	*Hexagrammos decagrammus*	3	<0.1
Eelpout	Zoarcidae	2	<0.1
Alaska plaice	*Pleuronectes quadrituberculatus*	1	<0.1
Lumpsucker	Cyclopteridae	1	<0.1

community sampling within the lease area was conducted in 1978 to 1980 by Horner and Schrader (1984). Plankton communities in the Alaskan Beaufort Sea were found to be composed of assemblages both within the water column and on the underside of sea ice. Annual primary production can be as high as 30 g C/m^2/yr in shelf and coastal environments, although annual primary production in the Alaska Beaufort Sea is low compared to other oceans. Sources of primary production include ice algal communities, phytoplankton, benthic microalgae, benthic macroalgae, and peat entering the system from terrestrial areas. Ice turbidity and spring breakup patterns influence the timing and degree of primary productivity.

Planktonic species within the Alaskan Beaufort Sea are widespread and often circumpolar in distribution (Horner 1969, 1979; Horner et al. 1974). In studies at Prudhoe Bay (Horner et al. 1974), three distinct phytoplankton communities were identified: pennate diatoms predominated just after breakup, centric diatoms dominated in deeper more saline waters, and flagellates dominated brackish surface waters. Within Foggy Island Bay, phytoplankton levels were low from November through March with flagellates predominating. By May, diatoms dominated by *Nitzschia frigida* were more numerous and flagellates were abundant. Productivity was low within the water column, but was higher for neritic forms (Horner and Schrader 1984). The ice algal community off Narwhal Island was dominated by pennate diatoms, especially *Nitzschia cylindrus*, while *Amphor ocellata*, *Cylindrotheca closterium* and *Navicula directa* also were common. Most of the cells within the water column appeared to have originated from the ice communities, and again pennate diatoms dominated (Horner and Schrader 1984).

Zooplankton communities in Prudhoe Bay were primarily dominated by copepods: within the bay, *Arcartia clausi* was abundant; in brackish waters, *Calanus glacialis* and *Pseudocalanus minutus* dominated; and outside the barrier islands, meroplankton dominated (Horner et al. 1974). Within Foggy Island Bay, *P. elongatus* was dominant, with *P. major* and *Derjugiania tolli* abundant (Horner and Schrader 1984). *P. elangatus* also dominated off Narwhal Island, while *Arcartia longiremis*, *P. major* and *Eurytemora hermani* were common. The amphipods *Onisimus litoralis* and *Helirages mixtus* were also present (Horner and Schrader 1984).

4.8 MARINE MAMMALS

Eight species of marine mammals, including two baleen whales (bowhead and gray whales), one toothed whale (beluga whale), four pinnipeds (ringed seal, bearded seal, spotted seal, and walrus) and the polar bear, inhabit or visit the Alaskan Beaufort Sea regularly. Descriptions of non-endangered marine mammals in the Beaufort Sea have been presented in FEISs for Lease Sales 97, 109, 124, 144, and 170 (MMS 1987a, 1987b, 1990a, 1996a, 1997a, respectively) and are incorporated by reference.

Bowhead and beluga whales migrate through the Alaskan Beaufort Sea. Gray whales, which sometimes summer in Alaskan Beaufort Sea water near Point Barrow, are unlikely to be present in the area of concern. The Liberty Development Project, located in Stefansson Sound, is inside the barrier islands and south of the usual migration corridor used by bowhead and beluga whales. The bowhead whale is currently listed as an endangered species. The Beaufort Sea stock of beluga whales is not classified as a strategic stock (Small and DeMaster 1995). That is, this beluga stock is not in decline or otherwise threatened by present levels of human activities. A strategic stock under the Marine Mammal Protection Act is one for which the level of direct human-caused mortality exceeds the potential biological removal, which is declining and likely to be listed as threatened within the foreseeable future, or which is listed as a threatened or endangered species or is designated as depleted. In 1994, the gray whale was removed from the List of Endangered and Threatened Wildlife (Small and DeMaster 1995).

The "ice seals" (ringed, bearded, and spotted seals) are usually observed in open water areas during summer and early autumn, although spotted seals also haul out on beaches and offshore islands and bars, and can be found in bays, lagoons, and estuaries. Ringed seals are found in areas of landfast ice during winter, while bearded seals occupy the active ice zone during winter and spring. Because of low whale and seal densities south of the barrier islands, autumn marine mammal survey transects generally sampled only the northern side of the lagoon. A few ringed and bearded seals were seen near the project area during the MMS aerial surveys. Spotted seals were not identified during aerial surveys. Systematic agency-sponsored surveys for ringed seals were conducted within the project area in spring during 1985, 1986 and 1987, and have recently resumed (K. Frost, ADF&G, pers. comm.; Frost et al. 1997). Boat-based marine mammal monitoring for an Ocean Bottom Cable 3-D seismic survey from July 25 to September 18, 1996, in an area near and to the west of the proposed Liberty Development Project, documented the presence of all three seals, with 92 percent ringed seals, 7 percent bearded seals, and 1 percent spotted seals (Harris et al. 1997). Site-specific BPXA-sponsored aerial surveys for ringed seals were initiated around Liberty in May/June 1997. These surveys, over landfast ice, found ringed seals widely distributed throughout the Liberty area, but no other seal species were encountered.

The Alaskan Beaufort Sea is outside of the principal range of the walrus, which normally extends east as far as Point Barrow. Occasionally, individuals will move as far east as the Liberty Development Project. A single juvenile walrus was sighted during the 1996 boat-based monitoring for seismic work within Stefansson Sound near the Liberty Development Project area (Richardson [ed.] 1997, p. A-2).

Polar bears are normally associated with the pack ice, well offshore of the development area. Denning females, females with cubs, and subadult males may occasionally come ashore; and females with young cubs hunt in fast-ice areas. Most female polar bears den on pack ice, but five den sites on land have been identified within the development area (Figure 4-2). Polar bears may also den on barrier islands near the development area. Polar bears may be near the Liberty Development Project at any time, although they are most likely to occur near the coast in the fall. Polar bears also may be attracted to the development area by whale carcasses disposed of on Cross Island by Native subsistence hunters. In November 1996, at least 28 polar bears were attracted to the island by a whale carcass.

4.8.1 Pinnipeds

4.8.1.1 Bearded Seal

The stock of bearded seals (*Erignathus barbatus*) in the Alaskan Bering, Chukchi and Beaufort seas, has been estimated at 300,000 (MMS 1996b). However, Small and DeMaster (1995) concluded that current estimates are unreliable without additional surveys. The Alaska stock of bearded seals is not classified as a strategic stock by NMFS, which is consistent with the recommendations of the Alaska Scientific Review Group (Small and DeMaster 1995).

The bearded seal is the largest of the northern phocids. Primarily bottom feeders, feeding on benthic organisms such as crabs, shrimp, and clams, they prefer habitats with water depths less than 200 meters (660 feet). Bearded seals may also feed on ice-associated organisms and have been found associated with ice in water depths much greater than 200 meters.

Seasonal movements are related to both the advance and retreat of sea ice and to water depth. Some bearded seals in Alaskan waters winter in the Bering Sea. As the ice recedes in spring, these seals migrate through the Bering Strait during mid-April to June, and summer either along the margin of the multiyear ice in the Chukchi Sea, or in nearshore areas of the central and western Beaufort Sea. That some portion of the Alaskan Beaufort Sea bearded seal population migrates to the Bering Sea during the winter months is consistent with the observed seasonal decline in sightings during late summer and autumn aerial surveys (LGL and Greeneridge 1996).

Suitable bearded seal habitat may be limited in the Beaufort Sea, where the continental shelf is comparatively narrow and the pack-ice edge frequently occurs seaward of the shelf, over water too deep for feeding (Nelson et al. n.d.). The preferred habitat in the western and central Beaufort Sea during the open water period is the nearshore area seaward of the scour zone. However, bearded seals are widely distributed over the shelf from nearshore waters out at least as far as the shelf-break. A few bearded seals have been observed in the project area (Figure 4-2).

Bearded seals breed in the spring, when their distinctive underwater calls dominate the natural underwater ambient noise (Richardson et al. 1995a). Pupping occurs on top of the ice from late March through May, primarily in the Bering and Chukchi seas, although some pupping occurs on moving pack ice in the Beaufort Sea. Pups are weaned at the end of a 12-18 day nursing period. These seals do not form herds, although loose aggregations of animals may occur.

The number of bearded seals within the Liberty Development Project area during the open water period is low. Only a few bearded seals were seen during boat-based marine mammal monitoring near the project in late July through early August 1996 (Harris et al. 1997 and unpubl. data). Studies indicate that pups and other young seals up to three years of age comprise 40 to 45 percent of the population (Nelson et al. n.d.), and that younger animals may be found closer to shore. Although all age and sex classes may occur within the development area during the open water season, many may be young, non-reproductive animals.

Bearded seals are not expected to occur at all in the development area during late autumn, winter and early spring months when the development area will be covered by fast ice. Intensive aerial surveys in the Liberty project area during May–June 1997 detected no bearded seals in the area (G.W. Miller, LGL Ltd. unpubl. data).

There are no data on hearing abilities of bearded seals, but they are likely to be generally comparable to those of other phocinid seals (Richardson et al. 1995a: 211 ff).

Bearded seals emit distinctive descending trills, generally starting near 2.5-3 kHz and descending to below 1 kHz (Ray et al. 1969). Source levels are much higher than for ringed seals. These calls are believed to be involved in breeding (Ray et al. 1969; Stirling et al. 1983). Calls are much less common in late summer/early autumn than during the spring mating season.

4.8.1.2 Ringed Seal

Ringed seals (*Phoca hispida*) are year round residents in the Beaufort Sea and the development area. This species is the most common seal in the Liberty Development Project area. The worldwide population of ringed seals is estimated at 6 to 7 million (Stirling and Calvert 1979), while the Alaska stock in the Bering-Chukchi-Beaufort area is 1 to 1.5 million (Kelly 1988; Small and DeMaster 1995). An estimated 80,000 seals are found in the Beaufort Sea during the summer, and 40,000 in the winter (Frost and Lowry 1981).

During winter and spring, the ringed seal occurs in land-fast ice and offshore pack ice of the Bering, Chukchi and Beaufort seas, with the highest densities usually found on stable shore ice. In areas with limited fast ice but wide expanses of pack ice, such as the Beaufort Sea, Chukchi Sea and Baffin Bay, the number of ringed seals on pack ice may exceed those on shore-fast ice (Burns 1970; Stirling et al. 1982; Finley et al. 1983). Ringed seals maintain breathing holes in the ice and birth lairs in accumulated snow by using their claws (Smith and Stirling 1975). Mating occurs in late April and May, primarily in areas of land-fast ice. Pups are born in birth lairs starting in late March;

adults nurse their pups for 4-6 weeks. Quantitative surveys of ringed seals are usually conducted during late winter and spring. Frost and Lowry (1988) found ringed seal densities on the shore-fast ice between Oliktok Point and Flaxman Island ranging from 0.97 seals/km^2 to 1.69 seals/km^2 during the 1985-1987 period. Their surveys were mainly over land-fast ice seaward of the barrier islands, extending about as far south into the lagoons as the planned Liberty Island site. Site-specific BPXA-sponsored aerial surveys for ringed seals were initiated around Liberty as well as in fast-ice areas north of the barrier islands in May–June 1997. Four surveys, each consisting of 13-14 north-south transects and taking 2-4 days to complete, were flown on 8 days during the May 26–June 4 period. Densities of ringed seals hauled out on the ice between the coastline and the barrier islands ranged from 0.43 seals/km^2 (maximum survey density) to 0.48 seals/km^2 (maximum daily density). North of the barrier islands, ringed seal densities were slightly higher, ranging from 0.51 (maximum survey density) to 0.58 (maximum daily density) seals/ km^2 (G.W. Miller, LGL Ltd. unpubl. data) (Figure 4-3).

During summer, ringed seals are found dispersed throughout open water areas, although in some regions they move into coastal areas. In the eastern Beaufort Sea and Amundsen Gulf, ringed seals concentrate in predictable offshore areas, often in large groups (Harwood and Stirling 1992), which may be associated with food concentrations related to oceanographic features. These seals feed on fish and benthic invertebrates such as crabs and shrimp. Similar summer concentrations of ringed seals have not been reported in the central or western Beaufort Sea. Ringed seals in the development area are likely to be dispersed individuals or small groups.

Only a small proportion of the ringed seals present in open water have been sighted during high-altitude late summer aerial surveys designed to search for whales (Figure 4-2). Abundance of this species in the project area during late summer and autumn is much higher than Figure 4-2 would indicate. Ringed seals were often seen during boat-based marine mammal monitoring in the lagoon near the project area in late July through early August 1996 (Harris et al. 1997 and unpubl. data). The spring seal surveys conducted in 1997 indicated that ringed seals are common in this area (Figure 4-3).

Underwater audiograms have been obtained using behavioral methods for three species of phocinid seals, including the ringed seal (reviewed in Richardson et al. 1995a). Below 30-50 kHz, the hearing threshold is essentially flat down to at least 1 kHz, and ranges between 60 and 85 dB re 1 μPa. There are few published data below 1 kHz, but a harbor seal's threshold deteriorated gradually to 97 dB re 1 μPa at 100 Hz (Kastak and Schusterman 1995). If this also applies to ringed seals, they have considerably better hearing sensitivity at low frequencies than do small odontocetes such as belugas (for which the threshold at 100 Hz is about 125 dB).

Ringed seals produce clicks with fundamental frequency 4 kHz and varying harmonics up to 16 kHz (Schevill et al. 1963). Stirling (1973) described barks, high pitched yelps, and low and high pitched growls. Most calls have most energy below 5 kHz (Stirling 1973; Cummings et al. 1984). Source levels range from 95 to 130 dB re 1 μPa-m/Hz (peak source spectrum levels). These levels are low when compared to many other marine mammals, and imply that detection ranges of those sounds are only about 1 km (Cummings et al. 1984). Ringed seals seem much less vocal in summer than during the breeding season in spring (Stirling et al. 1983).

4.8.1.3 Spotted Seal

An early estimate of the size of the world population of spotted seals (*Phoca largha*) was 335,000 to 450,000, and the size of the Bering Sea population, including animals in Russian waters, was estimated to be 200,000 to 250,000 animals (Bigg 1981). A reliable estimate of the size of the entire Alaska stock of spotted seals is currently not available because of incomplete sampling (Small and DeMaster 1995).

During spring, when pupping, breeding, and molting occur, spotted seals are found along the southern edge of the sea ice in the Okhotsk and Bering seas. In late April and early May, adult spotted seals are often seen on the ice in female-pup or male-female pairs. Subadults may be seen in larger groups of up to two hundred animals.

During summer, spotted seals are found primarily in the Bering and Chukchi seas, but some range into the Beaufort and perhaps into the East Siberian seas (Lowry n.d.). At this time of year, an unknown proportion haul out on mainland beaches and offshore islands and bars (Frost et al. 1993). Summer tagging studies at Kasegaluk Lagoon in the Chukchi Sea indicate that spotted seals may travel long distances offshore to feed, and that a very small proportion (< 10 percent) may be hauled out at any one time (Frost et al. 1993). In summer, they are rarely seen on the pack ice, except when the ice is very near to shore. Spotted seals are commonly seen in bays, lagoons and estuaries. As ice cover thickens in autumn, spotted seals leave the northern portions of their range and move west and south into the Bering Sea.

A few spotted seal haul outs have been documented in the central Beaufort Sea, primarily in the deltas of the Colville and (at least formerly) Sagavanirktok rivers. Historically, these sites supported as many as 400 to 600 seals; but, since the 1980s, fewer than 10 seals have been seen at any one site (J.W. Helmericks, Golden Plover Air, pers. comm.; S.R. Johnson, LGL Ltd., unpubl. data). One spotted seal was identified in Stefansson Sound during boat-based marine mammal monitoring near the Liberty Development Project area in late July through early August 1996 (Harris et al. 1997 and unpubl. data). There are probably only a few spotted seals along.the coast of the central Beaufort Sea during summer and early fall; but, as noted by Frost et al. (1993), only a small proportion may be hauled out at any one time. They may be feeding either offshore or in the lower reaches of the rivers or the river deltas.

Spotted seals migrate out of the Beaufort Sea in the fall (September to mid-October) as the shorefast ice re-forms and pack ice advances southward. They spend the winter and spring along the ice front throughout the Bering Sea where pupping, breeding and molting occur. Spotted seals feed on invertebrates, such as shrimp and cephalopods; they also feed on pelagic and demersal fish, such as herring, capelin, sand lance, Arctic cod, saffron cod and sculpins.

There are no data on hearing capabilities of spotted seals, but they are likely to be comparable to those of ringed and harbor seals, as summarized above under "Ringed Seals."

Calls of captive spotted seals (Beier and Wartzok 1979) are similar to those of their close and better-studied relative, the harbor seal. Both species emit faint clicks near 12 kHz (Schevill et al. 1963; Cummings and Fish 1971). Captive spotted seals were relatively silent during most of the year, but calls became more common during the mating period (Beier and Wartzok 1979). Frequencies were 500-3500 Hz.

4.8.1.4 Walruses

Although the Alaskan Beaufort Sea is outside the principal range of the walrus (*Odobenus rosmarus*), small numbers of walruses do occur in the Beaufort Sea in some years. The extent of these summer incursions probably varies with annual changes in ice conditions, and possibly with changes in the size of the population. Walruses feed on benthic organisms, primarily bivalves, and typically are found in waters < 100 meters deep.

There have been at least seven sightings of walruses between 146° and 150°W in the Prudhoe Bay region during MMS and LGL surveys conducted during the period from 1979 to 1996. All sightings were in waters < 40 meters deep. Walrus sightings are unusual in the area, which is well to the east of their main summer range. Five sightings were north of the barrier islands, but two were within Stefansson Sound near the proposed Liberty Island site: one sighting in the lagoons during MMS aerial surveys (Figure 4-2), and another sighting of a single juvenile walrus during the 1996 boat-based marine mammal monitoring (Richardson [ed.] 1997).

4.8.2 Cetaceans

4.8.2.1 Bowhead Whale

The Western Arctic (Bering-Chukchi-Beaufort) stock of bowhead whales (*Balaena mysticetus*) is currently estimated to consist of about 8,000 animals (with 95 percent confidence limits of 6,900 to 9,200 animals) (Small and DeMaster 1995; Zeh et al. 1995). The most recent bowhead census was completed in 1993. The current population is believed to be increasing at a rate of 2.3 percent per year (with 95 percent confidence limits of 0.9 to 3.4 percent) (Zeh et al. 1995), despite subsistence harvests of 14 to 74 bowheads per year from 1973 to 1993 (Suydam et al. 1995). The Western Arctic stock of bowhead whales is currently listed as endangered under the Endangered Species Act, and thus is classified as a strategic stock by the National Marine Fisheries Service (NMFS) (Small and DeMaster 1995).

Western Arctic bowheads winter in the central and western Bering Sea, summer in the Canadian Beaufort Sea, and migrate around Alaska in spring and autumn (Moore and Reeves 1993). Spring migration through the western Beaufort Sea occurs through offshore ice leads, generally from mid-April to mid-June (Braham et al. 1984; Moore and Reeves 1993; Richardson et al. 1995b). The route follows a corridor centered at 71°30'N latitude, and broadly occurring between latitudes 71°20'N and 71°45'N. Calving occurs primarily during spring migration (Nerini et al. 1984; Koski et al. 1993). This migration corridor is very far offshore of the Liberty Development area. Bowheads first arrive in coastal areas of the Canadian Beaufort and Amundsen Gulf in late May and June.

The Bureau of Land Management and MMS have funded or conducted fall aerial surveys for bowhead whales in the Alaskan Beaufort Sea since 1979 (e.g., Ljungblad 1981; Ljungblad et al. 1982, 1983; Treacy 1988-1997). In some years, these surveys involved some summer survey coverage. Bowhead sightings during MMS and BPXA/LGL aerial surveys near the Liberty Development Project are shown in Figures 4-4 and 4-5. A few bowheads have been observed in lagoon entrances and shoreward of the barrier islands during MMS and LGL surveys. Figure 4-5 shows these locations in the Liberty area from surveys conducted in 1997. Survey coverage in nearshore areas was more intensive than for offshore areas, although transects generally did not extend south of the middle of Stefansson Sound. Because of the uneven survey coverage, maps and tabulations of raw sightings overestimate the importance of nearshore areas relative to offshore areas. Nonetheless, these data provide extensive and long-term information on the use of waters near the development area by bowhead whales during autumn migrations.

Autumn migration of bowheads into Alaskan waters is primarily during September and October. A few bowheads occur offshore of the development area in late August during some years (e.g., LGL and Greeneridge 1996; Greene et al. 1997, p. 3-56), but the main migration period begins in early to mid-September, with the migration ending by late October.

Sea ice conditions can vary dramatically during the fall migration, from open water to over 90 percent ice coverage. Bowhead whale distribution during fall migration seems to be strongly influenced by ice. In heavy ice years, bowheads tend to migrate in deep water (> 195 feet), while in light ice years, a larger proportion of the bowheads sighted are found in shallow water (< 130 feet). During fall migration, most of the bowheads sighted migrate in water ranging from 65 to 165 feet deep (Ljungblad et al.

1984). These migration corridors are all outside of the development area. When passing the development area, most bowheads are in depths > 65 feet, but a few occur closer to shore in some years (Figure 4-4). Even in 1997, an autumn with unusually large numbers of bowhead sightings close to shore, the bowhead sightings were predominantly north of the barrier islands (S. Treacy and D. Hansen, MMS unpubl. data; LGL/BPXA unpubl. data), although some were observed in lagoon entrances and shoreward of the barrier islands (Figure 4-5). LGL observed a few bowheads in entrances or within lagoons during the 1997 ocean bottom cable seismic observer program (LGL and Greeneridge 1997). The majority of the Western Arctic stock apparently migrates west within about 60 miles of the Liberty Development Project, but only a very small proportion, if any, of these travel close enough to shore to come within 6 miles of the Liberty Development Project (Figures 4-4 and 4-5). Whaling captains from Nuiqsut indicate that historically an occasional whale will move through the area inside the Midway Islands barrier island group. Thomas Napageak, whaling captain from Nuiqsut, reported that whales normally are seen and harvested near Cross Island (MMS 1997b). The few data on age and sex composition of bowheads migrating through the area in autumn (Koski and Johnson 1987; Richardson [ed.] 1987) suggest that all ages and sexes of bowheads could be encountered offshore of the project area during the autumn migration, including mothers with young-of-the-year calves.

Bowhead whales feed mainly in the eastern Beaufort Sea in summer and perhaps in the Chukchi Sea in autumn (Würsig et al. 1984, 1989; Schell and Saupe 1993). However, during fall migration through the Alaskan Beaufort Sea, some bowheads have been observed feeding or have been harvested with food in their stomachs. Bowheads feed throughout the water column, depending on the depths of prey concentrations (Würsig et al. 1984, 1989; Bradstreet et al. 1987; Richardson [ed.] 1987). Food items most commonly found in the stomachs of harvested bowhead whales include copepods, euphausiids, mysids, and amphipods (Lowry and Frost 1984; Lowry 1993). Copepods and euphausiids have been the most common organisms at locations in the Beaufort Sea where feeding bowheads were observed (Griffiths and Buchanan 1982; Bradstreet et al. 1987; Richardson [ed.] 1987; Wartzok et al. 1990). Areas to the east of Barter Island often are used for feeding as bowhead whales begin to migrate slowly westward across the Beaufort Sea (Ljungblad et al. 1986; Thomson and Richardson 1987). In some years, sizable groups of bowhead whales also have been seen feeding just east of Point Barrow or elsewhere in the Alaskan Beaufort Sea (Braham et al. 1984; Ljungblad et al. 1985; Landino et al. 1994; D. Hansen, MMS, pers. comm.).

The auditory sensitivity of bowhead whales has not been measured, but they appear to be specialized for low-frequency hearing, with some directional hearing capability (Richardson and Malme 1993). Their frequency ranges of optimum hearing are believed to overlap broadly with the low-frequency range of many industrial sounds.

Most bowhead calls are tonal, frequency-modulated sounds at frequencies of 50 to 400 Hz, with a few containing energy up to 1200 Hz (Clark and Johnson 1984; Würsig and Clark 1993). Bowhead "songs" occur in spring, but have not been reported in late summer or autumn. Functions of bowhead calls are not positively known, but are believed to include maintenance of contact among widely-separated individuals, mother-calf interactions, and various other social functions. Calls may be especially important during spring migration through areas of extensive ice, but may be less important during autumn migration which usually is not restricted by ice. Source levels are quite variable, with the stronger calls having source levels up to about 180 dB re 1 μPa-m; some bowhead calls are measurable at least 20 km away.

4.8.2.2 Gray Whale

Most summering gray whales (*Eschrichtius robustus*) congregate in the northern Bering Sea, particularly off St. Lawrence Island and in the Chirikov Basin, and in the Chukchi Sea. Few gray whales occur east of 155°W in the Beaufort Sea (Clarke et al. 1989). A single dead gray whale was sighted by MMS on September 3, 1988 in Mikkelsen Bay near Tigvariak Island (Treacy 1989). No gray whales have been sighted by MMS or LGL in the development area during the 18 years from 1979 to 1996 (LGL and Greeneridge 1996; Miller et al. 1997; Richardson (ed.) 1997).

Very few gray whales have been seen in the far eastern Canadian portions of the Beaufort Sea (Rugh and Fraker 1981; W.J. Richardson, LGL Ltd., unpubl. data). Gray whale summer feeding areas are in the Bering and Chukchi seas, and gray whales generally avoid areas with significant ice. This indicates that individuals do not commonly travel through the Alaskan Beaufort Sea during summer. Very few, if any, gray whales are expected to occur in the Liberty Development Project area.

4.8.2.3 Beluga Whale

The beluga whale (*Delphinapterus leucas*) is an Arctic and subarctic species consisting of several subpopulations or stocks. The most recent uncorrected aerial survey estimate of the size of the Beaufort Sea stock was 19,629 individuals (95 percent confidence interval of 15,134 to 24,125) (Harwood et al. 1996). The Beaufort Sea stock has recently been estimated at 41,610 individuals (Small and DeMaster 1995), based on the application of a sightability correction factor of 2x. The Beaufort Sea stock of beluga whales is not classified as a strategic stock (Small and DeMaster 1995).

The majority of whales in this stock migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March or as late as July. The spring migration occurs through ice leads in offshore areas similar to those used by bowhead whales (Frost et al. 1988; Moore et al. 1993; Richardson et al. 1995b).

Calving probably occurs in June to August. A portion of the Beaufort Sea stock concentrates in the Mackenzie River estuary during July and August, but most of the population remains in offshore waters of the Beaufort Sea and Amundsen Gulf (Davis and Evans 1982; Harwood et al. 1996), or ranges into the Arctic Archipelago (A.R. Martin, Sea Mammal Research Unit, Cambridge, U.K., pers. comm.). Belugas are rarely seen near Liberty during the summer.

During autumn migration, small numbers of belugas are sometimes seen near the coast, east or west of the Liberty Development Project area (Johnson 1979, Figure 4-2), but the great majority of the belugas migrate well offshore (Frost et al. 1988; Clarke et al. 1993; Miller et al. 1997). Migration extends from August to October, with most movement in September (Moore et al. 1993; Clarke et al. 1993). Small numbers of beluga whales (none to a few hundred) could occur near the project area in autumn.

Beluga whales feed on a variety of fish, shrimp, squid and octopus (Burns and Seaman 1985). The Arctic cod is an important food for belugas in many parts of the Arctic.

The hearing thresholds of belugas at low frequencies are high. Published studies of captive animals show thresholds of 125 dB re 1 μPa or above at ≤ 100 Hz and about 100 dB at 1,000 Hz (Awbrey et al. 1988; Johnson et al. 1989). Recent data indicate that low-frequency hearing of belugas in the open sea may be slightly more sensitive than reported for captive animals, but even so, the low-frequency thresholds are high (S.H. Ridgway, NRaD, pers. comm.). Beluga hearing thresholds improve greatly with increasing frequency. Their hearing is most sensitive above 20 kHz, consistent with their use of ultrasonic echolocation calls.

The beluga's extensive vocal repertoire includes trills, whistles, clicks, bangs, chirps and other sounds (Schevill and Lawrence 1949; Sjare and Smith 1986a; Ouellet 1979). Beluga whistles have dominant frequencies at 2-6 kHz, and other call types include sounds at mean frequencies ranging upward from 1.0 kHz (Sjare and Smith 1986a, 1986b). These sounds are above the frequency range produced by most oil production developments.

Beluga echolocation signals have most of their energy at frequencies of 40-120 kHz and broadband source levels up to 219 dB re 1 μPa-m (zero-peak) (Au 1993). These ultrasonic echolocation calls are far above the frequency range of drilling and production noises, but are within the frequency range of some sonar and navigation transponder signals.

4.8.3 Polar Bears

Polar bears (*Ursus maritimus*) have a circumpolar distribution throughout most ice-covered seas of the Northern Hemisphere, and occur at low densities throughout these areas (Amstrup et al. 1986). Within this range, polar bears are divided into five geographically isolated populations. The Beaufort Sea population extends from the northwest Chukchi Sea to Cape Bathurst, Canada (Lentfer 1974; Amstrup et al. 1986). Mean estimates for the Beaufort Sea population during 1972 through 1983 ranged from 1,300 to 2,500, yielding densities of one bear per 53 to 93 square statute miles (Amstrup et al. 1986). The current population estimate is 1,800 bears (IUCN Specialist Group 1993).

In the Liberty Development Project area, polar bears are present in coastal regions during the ice-covered period and infrequently during the summer. Polar bears generally prefer areas of heavy offshore pack ice (Stirling 1988), and adult males typically remain on the pack ice, rarely coming ashore (Amstrup and DeMaster 1988). However, denning females, females with cubs, and subadult males occasionally come ashore; and females with young cubs hunt in fast-ice areas. The majority of female polar bears (75 percent) den on the pack ice, but the rest den at terrestrial den sites. Most terrestrial dens are located within 5 to 6 miles of the coast. Four historical den sites have been identified within the general vicinity of Foggy Island Bay and the Sagavanirktok Delta; none of these has been used more than once, and one den dates back to 1912 (Figure 4-2). No searches for polar bear dens within the study area have been conducted since 1993-94 (G. Durner, USGS/BRD, pers. comm.).

During winter and spring, polar bears tend to concentrate in three types of ice: shore-fast ice with deep drifted snow along pressure ridges, the floe edge, and areas of drifting ice with 7/8 or more ice cover (Stirling et al. 1975, 1981). Highest densities are recorded in the latter two categories, presumably because these habitats offer bears greater access to seals. In spring and early summer, polar bears move north with the ice as it recedes from coastal areas. They remain on the drifting pack ice during the summer months. Little has been published about their offshore distribution during this season.

In autumn when new ice begins to form, polar bears that summered on pack ice well north of the Alaskan coast begin moving south. Some pregnant females go onshore in November and early December to establish maternity dens in deep snow drifts. However, in the Alaskan Beaufort Sea region, most females den on multiyear pack ice (Amstrup 1986). Cubs (one or two) are born in late December and early January and remain in the maternity den with the mother until late March or early April. Upon emerging from terrestrial dens, the mother and cubs move out onto the pack ice. Cubs usually stay with their mothers until they are 1½ to 2½ years old, although some may remain with the female into their third or fourth year (Stirling et al. 1975). The breeding season is from April through June when both males and females are active on the sea ice, and gestation lasts about eight months.

Polar bear sightings during autumn MMS (1979-1996) and BPXA/LGL (1991) surveys and den locations (1910-1993) are shown in Figure 4-2. Seals are the primary prey of polar bears throughout their range. In the Alaskan Arctic, polar bears prey primarily on ringed seals and to a lesser extent on bearded seals. Polar bears opportunistically feed on whale carcasses, and on November 6, 1996, 28 polar bears, primarily subadults and a few adult females with dependent cubs, were observed at a carcass on Cross Island (G. Durner, USGS/BRD, pers. comm.). Cross Island is used by Nuiqsut whale hunters, and carcasses disposed of there can, at least temporarily, increase polar bear densities near the development area.

4.9 BIRDS

An estimated 10 million individual birds representing over 120 species use the Beaufort Sea area from Point Barrow, Alaska to Victoria Island, NWT, Canada (Johnson and Herter 1989). Descriptions of marine and coastal birds in the Alaskan Beaufort Sea area have been presented in FEISs for Lease Sales 97, 109, 124 and 144 (MMS 1987a, 1987b, 1990b, 1996a, respectively). Nearly all species are migratory, occurring in the Arctic from May through September. The most abundant marine and coastal birds in the Foggy Island Bay and the Liberty Development Project areas include Oldsquaw, Glaucous Gull, Common Eider, Snow Goose, Red Phalaropes, and Red-necked Phalaropes, Semipalmated Sandpiper, Dunlin, and Stilt Sandpiper. Table 4-6 lists species likely to occur in the study area.

Species that may overwinter in the onshore portion of the development area during mild winters include the Gyrfalcon, Rock and Willow ptarmigan, Snowy Owl, and Common Raven. Black Guillemots and occasionally Snowy Owls overwinter offshore in lead systems. Of these, the Common Raven is the most conspicuous winter North Slope inhabitant.

Bird usage of the proposed Kadleroshilik River gravel mine site is partially dependent upon the vegetation types present. The area is not likely influenced by storm surges. The gravel bar is covered with low shrubs and tundra vegetation typical of gravel river bars on the Coastal Plain. Birds likely present include waterfowl (ducks, loons, Tundra Swan, White-fronted Geese, Snow Geese, Canada Geese, and Black Brant), shorebirds (Lesser Golden Plover, Semipalmated Sandpiper, Pectoral Sandpiper, Dunlin, and Red Phalarope), and songbirds (Lapland Longspur and Snow Bunting) (BPXA 1995).

4.9.1 Chronology of Events in Foggy Island Bay

Spring migration of waterfowl (primarily Black Brant, Oldsquaw, Common Eider and King Eider) is primarily eastward along a broad band inland, along the coast, and offshore along lead systems, during the first two weeks of June (Johnson and Richardson 1981; Richardson and Johnson 1981). Loons, Common Eiders, and King Eiders congregate in early spring runoff water in the coastal river deltas (Bergman et al. 1977), diving and feeding where the river flows through and under the sea ice. After arriving on the Arctic Coastal Plain, most shorebirds and waterfowl disperse to nesting grounds on

TABLE 4-6

SELECTED BIRD SPECIES LIKELY TO OCCUR IN THE LIBERTY DEVELOPMENT PROJECT AREA

Pacific Loon (*Gavia pacifica*)	Hudsonian Godwit (*Limosa haemastica*)
Red-throated Loon (*Gavia stellata*)	Bar-tailed Godwit (*Limosa lapponica*)
Yellow-billed Loon (*Gavia adamsii*)	Ruddy Turnstone (*Arenaria interpres*)
Tundra Swan (Cygnus columbianus)	Semipalmated Sandpiper (Calidris pusilla)
White-fronted Goose (Anser albifrons)	Western Sandpiper (Calidris mauri)
Snow Goose (Chen caerulescens)	White-rumped Sandpiper (Calidris fuscicollis) *
Ross's Goose (Chen rossii)	Baird's Sandpiper (Calidris bairdii)
Brant (Branta bernicla)	Pectoral Sandpiper (Calidris melanotos)
Canada Goose (Branta canadensis)	Dunlin (Calidris alpina)
Mallard (*Anas platyrhynchos*)	Stilt Sandpiper (*Calidris himantopus*)
Northern Pintail (*Anas acuta*)	Buff-breasted Sandpiper (*Tryngites subruficollis*)
Northern Shoveler (*Anas clypeata*)	Long-billed Dowitcher (*Limnodromus scolopaceus*)
Gadwall (*Anas strepera*) *	Common Snipe (*Gallinago gallinago*)
American Wigeon (*Anas americana*)	Red-necked Phalarope (*Phalaropus lobatus*)
Greater Scaup (*Aythya marila*)	Red Phalarope (*Phalaropus fulicaria*)
Common Eider (*Somateria mollissima*)	Pomarine Jaeger (*Stercorarius pomarinus*)
King Eider (*Somateria spectabilis*)	Parasitic Jaeger (*Stercorarius parasiticus*)
Spectacled Eider (*Somateria fischeri*)	Long-tailed Jaeger (*Stercorarius longicaudus*)
Steller's Eider (*Polysticta stelleri*)	Glaucous Gull (*Larus hyperboreus*)
Oldsquaw (*Clangula hyemalis*)	Ross's Gull (*Rhodostethia rosea*)
Red-breasted Merganser (*Mergus serrator*)	Sabine's Gull (*Xema sabini*)
Northern Harrier (*Circus cyaneus*)	Arctic Tern (*Sterna paradisaea*)
Rough-legged Hawk (*Buteo lagopus*)	Snowy Owl (*Nyctea scandiaca*)
Golden Eagle (*Aquila chrysaetos*)	Short-eared Owl (*Asio flammeus*)
Merlin (*Falco columbarius*) *	Horned Lark (*Eremophila alpestris*)
Peregrine Falcon (*Falco peregrinus*)	Common Raven (*Corvus corax*)
Gyrfalcon (*Falco rusticolus*)	Northern Wheatear (*Oenanthe oenanthe*)
Willow Ptarmigan (*Lagopus lagopus*)	Northern Shrike (*Lanius excubitor*)
Rock Ptarmigan (*Lagopus mutus*)	Yellow Wagtail (*Motacilla flava*)
Sandhill Crane (*Grus canadensis*) *	Savannah Sparrow (*Passerculus sandwichensis*)
Black-bellied Plover (*Pluvialis squatarola*)	Lapland Longspur (*Calcarius lapponicus*)
Lesser Golden-Plover (*Pluvialis dominica*)	Snow Bunting (*Plectrophenax nivalis*)
Semipalmated Plover (*Charadrius semipalmatus*)	Common Redpoll (*Carduelis flammea*)
Whimbrel (*Numenius phaeopus*)	

* Uncommon in project area.

moist tundra and marshlands, although they may congregate on snow-free and ice-free areas such as river deltas or the foothills until snow melts from nesting areas.

Common Eider, Arctic Tern, Glaucous Gull, and Black Guillemot nest on barrier islands (Johnson and Herter 1989). Snow Geese and Black Brant nest on Howe Island and Duck Island in the Sagavanirktok Delta (Johnson 1994a, 1994b). Glaucous Gulls and Common Eiders nest on Duck Island and on abandoned exploratory islands in the Sagavanirktok Delta. Successful nesting on barrier and river delta islands is largely influenced by the absence of Arctic foxes (Johnson and Richardson 1981; Johnson et al. 1987).

From mid-July to early September, seaducks, primarily Oldsquaw and eiders, congregate in coastal waters inside the barrier islands to feed and molt prior to their fall westward migration (Johnson and Richardson 1981, 1982; Johnson 1985). Molting (2,400 birds) and post-molting (1,200 birds) concentrations of Oldsquaws have been recorded along the south shores of the McClure Islands (Johnson and Richardson 1981), northeast of the Liberty Development Project.

Waterfowl, especially Snow Geese and Black Brant (Johnson 1994a, 1994b), move into deltas and coastal saltmarshes for brood-rearing and molting during early to mid-July (Figure 4-6). The distribution of Snow Goose brood-rearing flocks has been monitored continuously since 1980; important brood-rearing areas, based on repeated aerial survey observations and banding locations, are shown on Figure 4-6.

Tundra Swans, loons, White-fronted Geese and Canada Geese nest throughout the area crossed by the proposed elevated pipelines which will connect the Liberty Development Project to the Badami Sales Oil Pipeline. Wetlands in the pipeline corridor provide nesting, feeding and brood-rearing habitat for waterfowl. Dabbling ducks, especially Northern Pintail, molt in areas of dense cover, such as aquatic tundra in drained lake basins. Geese congregate on the Arctic Coastal Plain to feed prior to fall migration. Most waterfowl leave the coastal plain by mid- to late August. Loons and Tundra Swans may remain until waterbodies are nearly frozen, usually in late September.

During mid-June to late July, adult Red Phalaropes and Red-necked Phalaropes leave tundra breeding areas. In mid- to late August, juvenile Red Phalaropes and Red-necked Phalaropes form large flocks on coastal and barrier island beaches where they feed on copepods, small amphipods and small mysids (Johnson and Richardson 1981). Feeding flocks of phalaropes tend to concentrate on seaward sides of barrier islands and leave the Coastal Plain by early to mid-September (Johnson and Richardson 1981). August concentrations of shorebirds along the mud and silt shorelines of the Sagavanirktok Delta were predominantly Semipalmated Sandpiper, Dunlin and Stilt Sandpipers (Troy 1982). Other species included American Golden Plover, Ruddy Turnstone, phalaropes, Long-billed Dowitcher, Baird's Sandpiper, Pectoral Sandpiper and Buff-breasted Sandpiper. Density of shorebirds in the Sagavanirktok Delta peaked in early August 1981 at 62 birds/km of shoreline (Troy 1982).

In late August to mid-September, both immature Arctic Peregrine Falcons and adult and immature Gyrfalcons, principally from the Colville River drainage, concentrate in coastal areas to feed on shorebirds and waterfowl. While these species have not been reported in the Liberty Development Project area, they may utilize the coastal areas of Foggy Island Bay in some years.

4.9.2 Tundra Breeding Bird Densities

The corridor surrounding the Liberty pipeline and its tie-in to the Badami Sales Oil Pipeline (Figure 1-1) crosses thaw-lake and tundra zone. The results of 1994 investigations along the Badami Pipeline route indicate that bird use across the pipeline corridor is heterogeneous (TERA 1994b). Two areas received detailed study: the vicinity of the Badami production site (Badami study area) and the thaw lake plain between the Kadleroshilik and Shaviovik rivers (Kadleroshilik study area).

Tundra breeding birds disperse throughout the snow-free tundra in late May or early June to begin nesting. Both vegetation and land surface forms as defined by Everett et al. (1981) have been found to be important determinants of bird use (Troy 1991; TERA 1993a). Generally, heterogeneous terrain types with mixtures of dry and wet microsites in close proximity, such as polygonal ground, support the highest densities of birds (especially nesting birds) early in the summer. As the summer progresses, many birds move into wetter areas for brood-rearing and foraging, and microrelief may become less important.

4.9.3 Threatened and Endangered Species

There are two threatened or endangered species which may occur near the Liberty Development Project area. The Spectacled Eider (*Somateria fischeri*) is the only endangered or threatened species likely to occur regularly in the study area. The Alaska-breeding population of the Steller's Eider (*Polysticta stelleri*) was listed as threatened on 11 July 1997 by the U.S. Fish and Wildlife Service (62 *Federal Register* 31748). This species may occur in very low numbers in the Prudhoe Bay area and may occur occasionally in the study area. The Arctic Peregrine Falcon (*Falco peregrinus tundrius*) had been listed as threatened, but the U.S. Fish and Wildlife Service removed it from the list on 5 October 1994 (59 *Federal Register* 50796).

4.9.3.1 Spectacled Eider

The Spectacled Eider was listed as threatened under the Endangered Species Act effective 9 June 1993 (58 *Federal Register* 27474). The status, distribution, and population trends of this species in the Prudhoe Bay area are summarized in Warnock and

Troy (1992), TERA (1993b), and TERA (1995). In northern Alaska, Spectacled Eiders nest on the Arctic Coastal Plain at least as far east as the Okpilak River delta (Garner and Reynolds 1987). During the breeding season they favor wet coastal tundra—in particular, areas of shallow water with emergent vegetation such as occurs in drained lake basins. Within the study area, Spectacled Eiders are known to breed in the Sagavanirktok River delta (TERA 1995) and between the Kadleroshilik and Shaviovik rivers (Nickles et al. 1987; Field et al. 1988; TERA 1994). Suitable habitat for this species appears to become progressively more restricted from west to east through the study area. Surveys conducted in NPRA have found Spectacled Eiders more than 50 miles inland (Larned and Balogh 1994). In the Prudhoe Bay area (Warnock and Troy 1992; TERA 1993b, 1994, 1995), Spectacled Eiders occur within at least 12 miles of the coast (the width of the survey area). Between the Sagavanirktok and the Shaviovik rivers, the range narrows rapidly, with Spectacled Eiders restricted to within 8 miles of the coast (Figure 4-7). Farther to the east, the coastal fringe occupied by Spectacled Eiders may continue to narrow. Spectacled Eider distribution roughly follows the Arctic Coastal Plain physiographic province boundary, with the White Hills and Franklin Bluffs portions removed (Walker and Acevedo 1987). However, the southern boundary for Spectacled Eider surveys (USFWS 1996) follows a similar path and narrows toward the coast in the east.

During surveys for Spectacled Eiders in 1994 (TERA 1994), many sightings of this species were made on the coastal plain south of Foggy Island Bay; however, Spectacled Eiders were scarce east of the Shaviovik River. Ground surveys confirm these findings. Spectacled Eiders were not recorded on study plots in the Badami Development area but were present in the Kadleroshilik study area, where three nests were located. Aerial surveys undertaken in 1993 as part of other investigations also indicate relatively high use of the Foggy Island Bay coastal plain, but markedly less use of areas east of the Shaviovik River (Figure 4-6, Larned and Balogh 1994; Byrne et al. 1994).

4.9.3.2 Steller's Eider

The Alaska breeding Steller's Eider (*Polysticta stelleri*) recently was listed as threatened under the Endangered Species Act (62 *Federal Register* 31748). This species may occur in low numbers in the Prudhoe Bay area, but is not likely to be found in the Liberty Development Project area (Myres 1958; Gavin 1970, 1972 in Johnson and Herter 1989; Watson and Divoky 1974a, 1974b in Johnson and Herter 1989). The normal distribution of Steller's Eiders only marginally extends eastward of Prudhoe Bay. In fact, there is no confirmed nesting record of Steller's Eiders east of Prudhoe Bay (Johnson and Herter 1989). Studies in the Arctic National Wildlife Refuge (Spindler 1978, 1979; Martin 1980; Garner and Reynolds 1985; BPXA 1993b) indicate that Steller's Eiders do not nest in the refuge. Thus, this species is unlikely to be found nesting in the Liberty Project area.

4.9.3.3 Arctic Peregrine Falcon

The Arctic Peregrine Falcon (*Falco peregrinus tundrius*) had been listed as a threatened species, but was delisted by the U.S. Fish and Wildlife Service on 5 October 1994 (59 *Federal Register* 50796). This species is not likely to occur in the Liberty Development Project area. The center of abundance in the Beaufort Sea area for the Arctic Peregrine is the Colville River drainage.

4.10 TERRESTRIAL MAMMALS

Although there has been extensive research on wildlife in both the Prudhoe Bay oil fields and the Arctic National Wildlife Refuge (ANWR), little has been done in the proposed project area. During 1993 to 1995, LGL Alaska Research Associates, Inc. (LGL), conducted aerial reconnaissance surveys in the Liberty Development Project onshore area that focused on caribou, muskoxen, and grizzly bear. Surveys of Arctic fox dens were also conducted in the proposed development area during 1992 (Burgess and Banyas 1993). Moose occur infrequently within the study area (Clough et al. 1987). In addition, the Alaska Department of Fish and Game has conducted surveys of grizzly bears in the Prudhoe Bay oil field since 1991, and in August 1994 extended the survey to the east into the proposed development area. Table 4-7 provides a list of selected mammal species with the periods in which they are likely to occur within the proposed development area.

4.10.1 Caribou

Descriptions of caribou occurring across the Alaskan Arctic Coastal Plain are presented in the FEISs for Lease Sale 97, 109, 124, 144 and 170 (MMS 1987a, 1987b, 1990b, 1996a, 1997a, respectively) and are incorporated here by reference. The Porcupine Caribou Herd (PCH) and the Central Arctic Caribou Herd (CAH) occur near or in the onshore portion of the proposed development area. The summer range of the PCH extends from Canada westward to the Staines River. PCH studies conducted over the past 20 years have shown that little, if any, calving occurs in the Liberty Development area, and that the area is not used by large numbers of PCH caribou during post-calving and dispersal periods (Clough et al. 1987). Spring and fall migration routes are generally to the east and south of the Liberty Development Project area (Clough et al. 1987).

The CAH ranges north of the Brooks Range, although in recent years they have wintered further south on the southern slopes of the Brooks Range (Woolington 1995) to the Beaufort Sea coast, and from the Colville and Itkillik rivers eastward to the Canning River (Cameron and Whitten 1979). A few hundred caribou winter on the coastal plain

TABLE 4-7

SELECTED MAMMAL SPECIES OCCURRING WITHIN THE LIBERTY DEVELOPMENT PROJECT AREA

Species	Period
Caribou *(Rangifer tarandus)*	Late April to Early September
Muskox *(Ovibos moschatus)*	All year
Grizzly Bear *(Ursus arctos)*	All year, In hibernation November to April
Arctic Fox *(Alopex lagopus)*	All year
Moose *(Alces alces)*	Infrequently May to September
Polar Bear *(Ursus maritimus)*	All year, Primarily August to April
Arctic Ground Squirrel *(Spermophilus parryi)*	All year

during most years (Cameron and Whitten 1976; Gavin 1983; Carruthers et al. 1984, 1987).

The CAH is separated into eastern and western segments by the Sagavanirktok River, based on low frequency of crossing the Sagavanirktok River and Trans-Alaska Pipeline corridor (Cameron and Whitten 1977) and based on the locations of two consistently used calving concentration areas, one on each side of the river (Lawhead and Curatolo 1984). The amount of exchange between the two segments is unknown. The eastern segment of the CAH, estimated at 6,459 animals in 1995 (P. Valkenburg, ADF&G, pers. comm.), occurs within the Liberty Development Project area and uses a broad summer range along the Arctic Coastal Plain between the Sagavanirktok River and the Hulahula River (located 36 miles east of the Staines River, Clough et al. 1987).

4.10.2 Muskoxen

Muskoxen were exterminated from the North Slope of Alaska by the late 1800s, but were reintroduced into the Arctic National Wildlife Refuge (ANWR), located east of the study area, in 1969, and into the Kavik River area in 1970 (Clough et al. 1987). The population has grown since 1974 and numbered close to 800 animals in 1995 (P. Reynolds, USFWS, pers. comm.). In recent years, emigration of muskoxen to the west has resulted in establishment of resident muskoxen populations on the Arctic Coastal Plain between the Kuparuk and Canning rivers, including the Liberty Development Project area.

Muskoxen are considered non-migratory, but do move in response to seasonal changes in snow cover and vegetation. Generally, little movement occurred during winter, although some mixed-sex groups moved relatively long distances during this period (Reynolds 1992). Major summer (mid-June to October) distribution shifts occur in the eastern portion of the Arctic Coastal Plain in ANWR, while in the western portion, less shifting between winter and summer range was apparent (Reynolds 1992). In summer, the majority of muskoxen have been observed along rivers. Few muskoxen are seen within the Liberty Development Project area until June or July. Only 14 muskoxen occurred within the Liberty Development area in 1995 (Pollard and Noel 1995). Mixed-sex groups moved up and down the major rivers throughout the summer, using riparian habitat. The Shaviovik and Kadleroshilik rivers are used by muskoxen as travel routes and browse habitat.

4.10.3 Grizzly Bear

Little information exists about grizzly bear use of the proposed development area before 1991. Grizzly bear were present in the Liberty Development Project area, as indicated by unconfirmed reports from Bullen Point North American Air Defense

Command, Distant Early Warning System personnel in the 1970s, and the reported harvest of two bears in 1969 from sites along the Kadleroshilik River (ADF&G files). Since 1991, 17 bears have been found in the vicinity of the Liberty Development Project. An additional adult female with two dependent offspring has been observed just south of the proposed development area and in the Sagavanirktok River delta. She undoubtedly uses areas adjacent to the Kadleroshilik and Shaviovik rivers. ADF&G has also reported the sighting of a sow with three cubs (R. Shideler, ADF&G, pers. comm.). During the LGL aerial surveys conducted during summers 1993, 1994, and 1995, grizzly bears were sighted twice. Both sightings were during 1994, and were near the Badami pipeline crossing at the Shaviovik River.

Use of the proposed development area by grizzly bears varies as bears move to areas where nutritious forage or prey becomes more available. Long-distance movements of over 30 miles in one day are not uncommon for bears in this region, and large home ranges allow individual bears and family groups to exploit the best food sources. Extensive movements and home ranges of 1,500 square miles are typical of other bears in the region, suggesting that grizzly bears over a large area may use portions of the Liberty Project Development area. Within the Liberty development area, most foraging habitat is concentrated in riparian areas or along the coast (e.g., foraging for marine mammal carcasses or preying on waterfowl nests and young). Grizzly bears in the arctic also feed on sedges (especially *Carex* and *Eriophorum*) and other graminoids, ungulates, Arctic ground squirrels, microtine rodents, root plants, berries, and anthropogenic foods.

With the exception of selection of denning sites, most grizzly bear habitat use is in response to foraging for vegetation, prey, carrion, or anthropogenic food.

Grizzly bear dens on the thaw-lake coastal plain have been found in pingos, river banks and terraces, low-based mounds, and raised areas around drained lake basins. These habitats are abundant within the proposed project area, suggesting that grizzly bear denning could occur throughout the area. The most important criteria for den selection appear to be a southern exposure and deep snow accumulation. Grizzly bears in this area generally enter dens from early October to late November, with pregnant females entering first, followed by independent females and subadults, then adult males. Exit from the dens generally occurs from early April to mid-May in approximately the reverse order of entry.

4.10.4 Arctic Fox

Arctic foxes occur across the Arctic Coastal Plain, moving between summer breeding habitats in tundra and winter habitats along the Alaskan coast (Clough et al. 1987). Foxes choose as den sites well-drained areas that have warmer soil temperatures than surrounding areas (Smits et al. 1988). They commonly den in pingos, cutbanks along streams and rivers, and low mounds and ridges associated with high-centered polygon tundra (Eberhardt et al. 1983; Burgess and Banyas 1993). Available denning substrate is not limiting in the proposed development area. Female Arctic foxes enter dens during late April or May and whelp mid-May (Burgess et al. 1993). They are highly adaptable and tolerant of disturbances, readily habituate to the presence of humans, will den in and near facilities, and can carry rabies, which is endemic in the North Slope population (Crandell 1975; Robards et al. 1996).

Food habits of the Arctic fox vary seasonally depending on the distribution and abundance of prey species. Lemmings are the primary prey of Arctic fox throughout the year (Chesemore 1967; Eberhardt 1977), but other small mammals such as voles and ground squirrels are also taken. Carrion is especially important in winter. During the summer months, birds and eggs become an important food source, although lemmings continue to be the major prey during this period (Chesemore 1967). Arctic foxes also consume fish, insects, berries, and carrion (such as caribou and marine mammals), but these are usually not major components of their diet (Fine 1980). Where Arctic foxes come into contact with human activities and associated developments such as construction camps and oil facilities, artificial food in the form of garbage and handouts may be extensively used (Urquhart 1973; Eberhardt 1977; Eberhardt et al. 1982; Fine 1980; Rodrigues et al. 1994). The availability of artificial dens and food in developed areas may affect the survival, reproduction, and disease transmission in local populations of Arctic fox (Garrott et al. 1983).

Studies of Arctic foxes in the Liberty Development Project area in 1992 found at least 23 dens (Burgess and Banyas 1993). In 1992, 10 of these dens were used as natal dens, while the other 13 dens were inactive.

4.10.5 Moose

In recent years, no formal surveys of moose have been conducted on the Arctic Coastal Plain in the area between the Sagavanirktok and Canning rivers by state or federal agencies (K. Harms, ADF&G, pers. comm.; F. Mauer, USFWS, pers. comm.). Most of the information that does exist on moose abundance and distribution on the Arctic Coastal Plain comes from studies that have been conducted in the 1002 area of ANWR. These studies have shown seasonal variation in moose distribution north of the Brooks Range. In winter, moose concentrations occur in the foothills of the Brooks Range along the Canning and Kongakut rivers, running from approximately 40 to 130 miles southeast of the proposed development area (Clough et al. 1987). In late spring-early summer, moose move northward along riparian systems. They use a variety of habitats during the summer, but the number of moose using coastal plain habitats in the 1002 area at any one time is relatively low (i.e., < 25 animals) (Clough et al. 1987).

No moose were observed in the Liberty Development Project area during 1993 and 1995 aerial surveys. However, in 1994, four bull moose were sighted during three surveys.

4.11 VEGETATION AND WETLANDS

The Liberty Development Project area (Exhibit A) is within what has been termed a gently rolling thaw-lake plain landscape (Walker and Acevedo 1987). Since tundra in the area gradually rises 20 to 25 feet above the level of streams and river channels, the landscape has a gently rolling appearance. Many areas are well-drained because of this topographic relief, and hence moist and dry tundra vegetation types are common throughout the area, typically on terrain with high-centered ice-wedge polygons. Drainage is poor, however, away from fluvial gradients; and in these wetter areas, low-centered ice-wedge polygons, strangmoor (string bogs and discontinuous peat ridges), thaw-lakes and ponds, and drained lake basins are common. Wet tundra vegetation types predominate in many of these areas.

The onshore portion of the Liberty Development Project area is characterized by large expanses of moist sedge and dwarf shrub dominated tundra (primarily *Carex*, *Eriophorum*, and *Salix* spp.) which are interrupted by areas of drier, well-drained tundra, thaw-lakes and ponds, drained lake basins, and several streams. Along the coast, eroding bluffs and sand beaches alternate with lower tundra areas which receive occasional saltwater intrusions, as well as small areas of sand dunes, sandy spits, and estuarine areas at the mouths of streams. Drier (and acid-tolerant) vegetation types typically occur on well-drained plateaus above streams, at the margins of drained lake basins, and in scattered small patches throughout the area. Thaw-lakes and ponds are scattered throughout the area, and these often support emergent vegetation (dominated by *Arctophila fulva* and *Carex aquatilis*) in the shallow water margins, especially in lakes and ponds with complex, irregular shorelines. Drained lake basins occur throughout the area and are characterized by non-patterned ground, low-centered ice-wedge polygons, and strangmoor in complexes with smaller thaw-lakes. and ponds within the drained basins. These areas are dominated by wet sedge tundra.

Clusters of small ponds and extensively thermokarsted (formed through melting of permafrost and associated ground ice) polygon troughs often occur over broad areas within a matrix of mixed moist and wet tundra. These areas are characterized by mixed high- and low-centered ice-wedge polygons and strangmoor. Along the streams are both typical wet and moist tundra types (on terraces), as well as dry, partially vegetated gravel bars and mostly barren gravels in active channels. The Sagavanirktok, Kadleroshilik and Shaviovik deltas support a complex mix of wet arctic saltmarsh vegetation, drier coastal barrens, salt-killed tundra, typical moist and wet tundra, and dry, partially vegetated gravel bars.

4.12 CULTURAL RESOURCES

Historic and cultural resources include artifacts, and more importantly, archaeological sites and places with important cultural significance due to past use or other traditional associations. Subsistence use is a component of most such North Slope sites. Cultural resources can be prehistoric or historic in nature, the differentiation relating to the time of occupation or use. Several periods of human cultural and historical development are presently recognized for northern Alaska (Hall 1981; Kunz 1982; Kunz and Reanier 1995; Lobdell 1996). The Alaska Heritage Resource Survey (AHRS) file indicates that documented cultural resource sites located in the study area are mostly historic in age.

The cultural resources of the mid-Beaufort Sea region are well documented through two main research efforts. The first is the Traditional Land Use Inventory (TLUI), which the NSB initiated soon after its formation. This social-anthropological study has been continually refined, and what started as a listing of important sites and subsistence use areas has become an integral component of much ongoing research on the North Slope. The core of this effort remains the traditional knowledge and accounts of Elders (NSB n.d., 1976, 1977, 1978, 1980, 1981; Nielson 1977; Okakok 1981; Hall 1981; Libbey 1981), which has been applied to the land use history and patterns of individual communities. One result has been documentation of patterns of subsistence resource use. Information concerning the village of Nuiqsut (Hoffman et al. 1978; Brown 1979; Ito-Adler and Hall 1985; and IAI 1990a), and overviews of cultural resources of concern (Pedersen n.d., 1995; Galginaitis et al. 1984; Pedersen and Coffing 1984; Coffing and Pedersen 1985; IAI 1985, 1990a) are described extensively in the literature. Cultural resource information for the community of Kaktovik is also available (Jacobson n.d.; Wentworth and Jacobson 1982; Pedersen et al. 1985; and IAI 1990b). All of this research relied heavily on the NSB TLUI data base and the traditional knowledge of local residents.

The second main research effort has been associated with oil exploration and development, and has two purposes. The first was to collect information funded by and/or developed for the federal government, principally as part of the EIS process. There have been six major federal lease sales in the Beaufort Sea, each of which resulted in an EIS document (BLM 1979, 1982; MMS 1984, 1987a, 1990b, 1996a), a planned 1998 lease sale (170; MMS 1997a) as well as the Endicott EIS (USACE 1984). Each of these documents contained a section which reviewed the potential effects of the oil development on cultural resources. In addition, the oil industry has commissioned a large number of focused survey reports, primarily as part of the permitting process for individual wells and other exploratory/development projects, which discuss potential effects upon cultural resources within much more constrained geographical areas (the most pertinent to the Liberty Development Project are Lobdell 1980, 1990, 1991, 1993, 1996; WCC 1981; Duane Miller and Associates 1997). It should also be noted that as part of the EIS process, there have been many public hearings conducted which have documented oral traditional knowledge concerning historical land use patterns.

The potential effects of the Liberty Development Project on cultural resources will be limited to any sites potentially contacted by the proposed island or subsea pipeline, as well as any resources found in the area around the landfall of this pipeline from the production facility and the tie-in of this pipeline with the Badami Sales Oil Pipeline. Historic ship remains are unlikely (Tornfelt and Burwell 1992). However, the FEIS for lease sale 144 (MMS 1996a) notes that, while 14 Beaufort Sea shipwrecks have been documented, they have not been located precisely. If any exist within the project area, they will be readily detected by side-scan sonar and other geophysical instruments during a site-specific geohazard survey. BPXA conducted side-scan and multibeam surveys in 1997 and did not locate archaeological evidence in the project area. Underwater prehistoric cultural resources are unlikely because of coastal erosion (Dixon et al. 1978); they are unlikely to be encountered except, perhaps, in areas already documented through traditional accounts (MMS 1996a, Friedman and Schneider 1987). In the Foggy Island Bay area, the probability of locating submerged land forms that might contain prehistoric cultural resources is negligible due to the erosional nature of this coast (Duane Miller and Associates 1997). Ice scour and erosion are both destructive forces in the coastal and submerged portions of the project area most likely to contain cultural resources, which makes encountering such resources less likely.

The documented cultural resources of the area to be avoided can be described as follows:

1) An historic site (XBP-022) at Point Brower (Lobdell 1980). Three sod houses were documented, one of which was partially destroyed by waves overtopping the coastal bluffs (in 1980), and another of which was filled with modern refuse. The current condition of the site is not known. This site is associated with a Native Allotment application. The site will not be directly affected by any of the project alternatives.

2) A documented use area (Agligvuarak or Foggy Island, IAI 1990a) to the south of XBP-022. Although there is no AHRS documentation for this area, Native informants for the TLUI reported sod house ruins and gravesites. It was used as a habitation site during the 1920s, 1930s, and perhaps into the 1940s. The site will not be directly affected by any of the project alternatives.

3) Two historic sites (XBP-023, XBP-024) on the mainland coast of Foggy Island Bay, west of the Kadleroshilik River (Lobdell 1980; IAI 1990a). XBP-024 has the remains of sod houses, while XBP-023 had a small wooden structure. The TLUI reports graves near this site, and perhaps the remains of a sod house. XBP-023 appears to be associated with Koganak Inaat (Quganam Inaa) of the TLUI (see directly below). The area around XBP-024 is near the approximate location of the landfall for the pipeline.

The site has been accurately mapped since 1989, and several surveys since that date have not encountered any additional cultural resources in the area (Lobdell 1980; Lobdell pers. comm.). The site will not be adversely affected, as it will be separate from the proposed landfall by approximately 1/4 mile. The State Office of History and Archaeology (equivalent to other states' Office for Historic Preservation) will not require any specific mitigation measures for clearance of the proposed landfall, except for designation in the Oil Discharge Prevention and Contingency Plan as an area to be protected during any needed spill response activities (Lobdell pers. comm.).

4) A documented use area (Koganak Inaat or Quganam Inaa, IAI 1990a) centered near XBP-023. This was reported as a 1920s habitation site, with ruins and graves. It is very likely that this TLUI area and XBP-023 are, in fact, two references to the same site.

5) An historic site (XBP-025) on the west side of the mouth of the Kadleroshilik River (Lobdell 1980). Remains of a sod house and a possible gravesite were reported.

6) A documented use area (Qalgusilik, IAI 1990a) directly to the east of the mouth of the Kadleroshilik River. It is directly east, across the river, from XBP-025. TLUI documents clearly indicate this as a significant area, with habitation ruins and possible graves. TLUI documents are somewhat inconsistent in how they refer to or name this location (see IAI 1990a).

7) A documented use area (Sikiagruum Inaa, IAI 1990a) south of (5) above, but still near the mouth of the Kadleroshilik River. The two may in fact be next to each other, or may be two names for the same area. This area was associated with Harry and Lucy Sikiagruk in the TLUI. The proximity of XBP-025 with these two documented use areas indicates that the mouth of the Kadleroshilik River was in fact a significant use/habitation area in the past.

8) An historic site (XBP-026) on the east side of a small creek flowing into Foggy Island Bay east of the Kadleroshilik River (Lobdell 1980). There are the remains of at least three historic sod houses and evidence of at least one grave site.

9) A documented use area (Kisim Inaa, IAI 1990a) to the southwest of XBP-026 and Native Allotment F 11943. All three of these may in fact refer to the same site, as three different ways of referring to the same general area.

10) A documented use area (Ekoolook Inaat or Ikuluum Inaa, IAI 1990a) on a point on the coast near the middle of Foggy Island Bay, east of the mouth of the Kadleroshilik River. This was a habitation site and may have some sod structures and associated graves. No archaeological site is registered for this location. Various TLUI documents identify this and other locations (6 and 9, above) with the same set of names, but match them in different combinations (that is, they place the same name in different

places). This is not unexpected and is discussed in IAI (1990a). The area around use area (10) is the approximate location for the landfall of the eastern route pipeline alternative. A recent survey of the area encountered no cultural resources that would be affected by the proposed landfall (Lobdell pers. comm.).

11) Three Native Allotment applications are discussed below in Section 4.13.3 (Land Ownership). One, just west of the mouth of the Kadleroshilik River, could be associated with XBP-025 and use areas (6) and (7) above. The easternmost of these three Native Allotment applications is contiguous to a documented archaeological site (XBP-026) and to use area (9) above. Again, these could be associated, and at the least seem to indicate that this was a significant use area. No cultural resources have been reported for the area around the other Native Allotment application, but its status as a Native Allotment contains a strong presumption of long-term historical use.

4.13 SOCIOECONOMICS

Considerable information exists in the literature on the history and current dynamics of the socioeconomics of the North Slope (IAI 1990c; McNabb and Galginaitis 1992). All past Beaufort Sea sale EISs include information available up to the point of their respective publications and provide at least summary descriptive information and analysis (BLM 1979, 1982; MMS 1984, 1987a, 1990b, 1996a, 1997a).

The Liberty Development Project is adjacent to, and partly within, the NSB. The NSB contains eight communities recognized under the Alaska Native Claims Settlement Act, the unincorporated community of Deadhorse, and small military installations along the coast. A home-rule borough encompassing 85,000 square miles, the NSB was incorporated July 1, 1972; and in 1992, the resident population was 8,578 (ADCRA 1993). The majority of residents are Inupiat Eskimos; and most live in Barrow (population 3,469), approximately 322 km (200 miles) west of Deadhorse. Kaktovik and Nuiqsut are second class cities, with 1992 populations of 224 and 354, respectively. The population of Deadhorse and the adjacent oil field community, consisting primarily of non-residents, is variable, but in September 1993 was estimated at 2,500 to 3,000. During new construction projects, an additional 500 to 600 people may be present.

Much of the NSB's resident population is dependent on subsistence hunting and fishing (ADF&G 1993). The oil and gas industry has been the primary employer near the study area since construction started on the Trans-Alaska Pipeline System in 1974. In 1993, half of ARCO Alaska, Inc.'s and BPXA's employees worked at North Slope facilities. An estimated 1,500 people work in one- or two-week shifts. By the early 1980s, two-thirds of the NSB's revenue was obtained from property taxes paid by the owner companies in the Prudhoe Bay area (USACE 1984). In 1993, about 85 percent of the State of Alaska's revenues were obtained from taxes and royalty interests collected on oil production.

Communities closest to the study area are Deadhorse, Nuiqsut, and Kaktovik. Deadhorse is an industrial enclave adjacent to the Prudhoe Bay oil field, with few (if any) "permanent" residents. The village of Nuiqsut, on the Colville River, is about 97 km (60 miles) west of Deadhorse and 32 km (20 miles) south of the Beaufort Sea coast. The village of Kaktovik is located on Barter Island off of the Beaufort Sea coast approximately 193 km (120 miles) east of Deadhorse. Housing for visitors and other transients is limited in all three communities. Accommodations have also been available at the U.S. Air Force Distant Warning line station at Bullen Point. Public airports are located at Deadhorse, Nuiqsut, and Kaktovik. The James Dalton Highway terminates in Deadhorse, with no public access to the Prudhoe Bay oil field or the Arctic Ocean. During the ice-free season in late summer, barges and other vessels can access coastal areas.

The current population of the NSB, and especially the Native population, is the product of extremely turbulent population dynamics. These dynamics have broadened the kinship networks of individuals, along with their historical ties to specific locations within the region. The Inupiat kinship/social system is quite flexible and versatile in any event, but the population mixture and movement of the historical period accentuated these traits. Historical ties to the land are largely the result of population dynamics instituted after Inupiat contact with Euroamericans, combined with the underlying precontact trading patterns, annual subsistence cycles, and other social/kinship interactions that are also still vital in this identification. After contact, the Inupiat population became more settled in fewer centers of population, with the encouragement of traders, missionaries, government, and others. Communities became more diverse (in terms of the origin of their residents) in part because of the population movement induced by the great reduction in the Inupiat population after contact (primarily due to disease). The interior of the North Slope was, for a while, essentially depopulated, with most people moving to coastal communities. Economic opportunities and government incentives reinforced this dynamic. The result of this large amount of population movement is that residents in many North Slope (and other) communities have some association with the project area. The two communities closest to the proposed Liberty Development Project, and most likely to be affected, are Nuiqsut and Kaktovik.

All NSB residents are greatly concerned about the potential effects of offshore oil development in general, and especially those effects close to their specific community of residence. The proposed Liberty Development Project will be located on the margins of the current Kaktovik subsistence use area (Wentworth and Jacobson 1982; Pedersen et al. 1985; IAI 1990b; and Pedersen 1995). Thus, Kaktovik residents should not be directly affected. However, the Liberty Development Project will be located in a central part of Nuiqsut's subsistence use area for marine resources. Detailed information on Nuiqsut can be found in Galginaitis et al. (1984), Hoffman et al. (1978), IAI (1990a), Pedersen (n.d.), and Pedersen (1995).

4.13.1 Area Use Patterns and Subsistence

Subsistence has been the traditional land use in the study area and is at least a component of all cultural resources discussed in Section 4.12. A detailed discussion of subsistence economy is presented in part 4.13.2.2 later in this Section. The most current land use and subsistence information available for Nuiqsut (and Kaktovik) is from Galginaitis et al. (1984), Impact Assessment Inc. (1990a, 1990b), and Pedersen (n.d., 1995). Land use and subsistence information is also available in Brown and Opie (1997), MMS (1996a, 1996b, 1996d, 1997a, 1997b), and BLM and MMS (1997). Impact Assessment Inc. (1990b) indicates that the project area is not used regularly by Kaktovik residents for subsistence purposes, but the area is crucially important to Nuiqsut residents who harvest marine mammals (Figure 4-8) (IAI 1990a). The Liberty Development Project is located inshore of the broad area described by Nuiqsut whalers as most important to them. This area also has been used on occasion as a sealing area (Figure 4-8), and the onshore area is also used on occasion as a hunting/trapping area for furbearers. Most documented seal harvest by Nuiqsut hunters takes place closer to the community (with a primary use area centered on Thetis Island in Harrison Bay, extending from Fish Creek on the west to Pingok Island on the east) (IAI 1990a; Pedersen 1995). The project area has been reported by villagers to be one that is important for the taking of seals while whaling, and as a place to look for seals in the summer.

Nuiqsut's whaling area (Figure 4-8) can be generally described as extending from the Midway Islands in the west to Flaxman Island in the east, and from the coast to about 40 miles offshore. Cross Island is used as a logistical base camp for most Nuiqsut whaling crews, while others have used Narwhal Island. These islands, among others, comprise the barrier islands which separate the waters of the Beaufort Sea from shoreward waters of Stefansson Sound and Foggy Island Bay. Whaling further to the west is reportedly not very productive, and further to the east would require too long a tow to a location where the whale could be butchered (IAI 1990a). All recorded strikes by Nuiqsut whaling crews have, in fact, occurred in a more limited area seaward of the barrier islands in the vicinity of Cross Island, with a few exceptions.

One strike in 1973, the first whale taken by a Nuiqsut crew that year, occurred to the east of Cross Island, in shallow water, within the barrier islands, and about a mile from shore when the whale died (IAI 1990a, Point Thomson State Lease Sale testimony of Thomas Napageak [1978]). The location of this strike resulted in the spoiling of the meat. Most Nuiqsut whales are taken near the base camp on Cross Island on the seaward side of the barrier islands (Figure 4-8), and at least one was taken quite far offshore (beyond 70°45'N, MMS 1996a). Commercial whaling near and within the barrier islands during the late 1800s has also been documented (Point Thomson State Lease Sale testimony of Thomas P. Brower, Jr.[1978]). The Beaufort Sea east of Point Barrow was used for commercial whaling for only a relatively brief period near the end of the nineteenth century (steam-powered whaling ships were required, but stocks were limited and soon depleted and prices were too low to support continued whaling – Bockstoce 1986).

Nuiqsut seal harvest activity is not as well documented (Figure 4-8), but all indications are that, while seals are taken in the project area, most seals are harvested from areas closer to the community (IAI 1990b; Pedersen n.d., 1995). The sharing of marine mammal harvest is widespread (nearly 97 percent of Nuiqsut households used marine mammals and reported receiving marine mammal shares from other households), but only 37 percent of Nuiqsut households report taking part in marine mammal harvest activities (Pedersen 1995). Nuiqsut seal hunters report using the project area, but documented harvest is relatively low and occurs mostly during the open-water season.

There are some indications that current oil exploration and development activities have deterred subsistence activities generally, when oil industry activities occur in areas used for subsistence (Galginaitis et al. 1984; IAI 1990a, 1990b; S. Pedersen, ADF&G, pers. comm.; Haynes and Pedersen 1989). That is, villagers state that one of the reasons these areas are not used as much as in the past is due to oil industry activities. Most frequently these effects are not expressed in terms of declines in the abundance of subsistence resources, although some villagers express opinions that they think the quality or safety of such resources has been compromised. Most commonly, hunter access has become more difficult, because of the need to cross roads and navigate among other oil industry infrastructure, or the Inupiat perception that they are not welcome in that area. These comments are most commonly made relative to terrestrial resources (caribou, furbearers) in the Kuparuk and Prudhoe Bay areas. This seems to be mainly because this is where oil development has so far occurred. These concerns have also been expressed as potential effects of ARCO Alaska, Inc.'s Alpine Development (M. Galginaitis, Applied Sociocultural Research, pers. comm.).

Some hunters report that they now hunt seals less often in the Prudhoe Bay area, and certainly Inupiat hunters believe that seismic and construction activities interfere with marine mammal hunting (MMS 1997b). The distance of Foggy Island Bay from present-day communities can also be cited as a reason why current subsistence use of these areas is less now than in the past. This potential "displacement" of subsistence hunters from previously used areas has not been much studied to date, and it is unknown whether such displacement has occurred in Foggy Island Bay. There are some ongoing research efforts which may contribute to an examination of this issue. The NSB Wildlife Department is conducting a quantitative long-term harvest assessment program for all villages of the North Slope. While focusing on actual harvest, it also incorporates a spatial component. ADF&G intends to examine possible displacement effects that oil exploration and development have had on subsistence activities in Nuiqsut and Kaktovik (S. Pedersen, ADF&G, pers. comm.).

4.13.2 Economy

This section, by discussing hourly employment, income, and taxation separately from subsistence, makes the pragmatic distinction between "economic" issues and "subsistence" issues. This is only an analytical convenience and should not obscure the reality that both are vital components of the North Slope socioeconomic system. This is also discussed in Section 5.6.4.

4.13.2.1 North Slope Borough Economy

The NSB encompasses the entire northern coast of Alaska and is composed of about 88,281 square miles (15 percent of Alaska). The borough was organized in 1972 and adopted a home rule charter in 1974. The predominantly Inupiat residents of the borough have historically relied on subsistence activities, but a major motivation for the formation of the borough was to maintain some local control of regional economic development and to provide a taxing mechanism through which NSB residents could benefit from the developing regional petroleum industry (at that time confined for the most part to Prudhoe Bay). The taxing authority of the NSB was ultimately defined by the courts and the Alaska State Legislature.

Population data for the NSB region are provided in Table 4-8. These data are from decadal census figures for the period 1939-1990. More recent data from the Alaska Department of Labor are provided in Table 4-9.

Petroleum industry development is still centered at Prudhoe Bay, while at the same time spreading more broadly. Few North Slope residents are employed directly by the oil industry, and by far the most important economic linkage between petroleum activities and permanent residents of the NSB is the NSB government, through its taxing ability. The NSB's total revenues in fiscal year (FY) 1995 were approximately $326 million. Property taxes provided about 71 percent of these funds. Nearly all property tax, 95 percent, is paid by the petroleum industry. State and Federal revenue-sharing programs provide most of the rest of the NSB budget. About half of the budget is for operations, and half is for debt service, primarily on bonds sold to fund the Capital Improvements Program (CIP).

Property values fluctuate, depending on world-energy prices. However, property value is not considered to be the constraining factor for future NSB revenues. Rather, such constraining factors include (1) existing and potential State-imposed limits on NSB taxing authority, (2) NSB residents' willingness to assume higher property-tax burdens, and (3) State and Federal revenue-sharing policies.

Total NSB employment in 1994 was estimated at about 7,000, from a peak of over 10,300 in 1983. Oil industry jobs comprised about 5,000 of the 1994 jobs (7,800 in 1983). Most if not all oil industry jobs are held by people residing outside of the NSB in

TABLE 4-8

POPULATION DATA FOR THE NORTH SLOPE BOROUGH, 1939-1990

	STATE OF ALASKA		NSB		BARROW		NUIQSUT		INDUSTRY	MILITARY
YEAR	NATIVE	NON-NATIVE	NATIVE	NON-NATIVE	NATIVE	NON-NATIVE	NATIVE	NON-NATIVE		
1939	32458	40066	-	-	409		89		-	-
1950	33863	94780	-	-	951		-	-	-	-
1960	43081	183086	1926		1215	99	-	-	-	-
1970	51712	250461	3027		1909	195	175	0	282	194
1980	64357	337494	3208	617	1720	487	181	27	3747	222
1990	85698	464345	4336	1643	2217	1352	328	26	-	-

NOTES:

- Most population figures are from the U.S. Census.
- The North Slope Borough was not incorporated until 1972, so population figures for the region prior to that time are derived from the aggregation of smaller enumerated units, and are probably approximate at best.
- Nuiqsut was refounded as a community in 1973. The 1970 population figure refers to the 1973 population. From 1940 to 1973 one Inupiut household lived in the Nuiqsut area for a good part of the time, and several others were seasonal residents. One non-Inupiat household lived at the mouth of the Colville River (and continues to the present).
- Industry/military population figures are quite difficult to estimate. They tend to vary according to method used and assumptions that are made. Figures in this table are from Table 1 of Alaska Consultants et al. 1984. 1970 industry figures are from the U.S. Census, but 1980 figures are from the NSB. Census numbers reflect people fairly permanently stationed at Prudhoe Bay/Deadhorse, with more transient workers attributed to other parts of the state or nation. NSB industry estimates count actual people present - the NSB special census of 1982 enumerated an industrial population of 6,620.

TABLE 4-9

POPULATION DATA FOR NORTH SLOPE BOROUGH, NUIQSUT, AND DEADHORSE, 1990-1997

Source: Alaska Department of Labor

	POPULATION							
	1990	1991	1992	1993	1994	1995	1996	1997
North Slope Borough	5979	6184	6466	6593	6796	6945	7119	7263
Barrow	3569	3607	3778	3897	4055	4197	4257	4380
Nuiqsut	354	387	422	403	411	412	427	435
Deadhorse/Prudhoe Bay	73	73	73	72	72	71	71	71

other parts of Alaska, and some from outside of Alaska. The ARCO-BPXA "shared services" charter flights are almost exclusively from Anchorage to the Deadhorse-Kuparuk oil complexes. Service to and from Fairbanks has been decreased to once a week. For employment outside of the oil industry (NSB resident employment), the NSB is most important, employing 62 percent of all working residents in 1994 (including the NSB School District). Most of the other residential workforce is employed by the regional or village Alaska Native Claims Settlement Act (ANCSA) corporations (or subsidiaries and joint ventures) or local community governments. Only a very few NSB residents are directly employed by the oil industry. However, most NSB employment is indirectly dependent on oil industry activity (through taxation) and much ANCSA corporation employment is dependent on oil industry support activities and services.

Employment in the NSB is expected to continue to decline, both in the oil industry as well as among NSB residents who do not work directly in the oil industry. Declines in the oil industry are due to consolidation of operations and the decline in production from the Prudhoe Bay, Endicott, and Kuparuk oil fields. Exploration and production from new fields partially offsets these declines, but will not require the same labor force as has been historically employed. As few NSB residents are employed in the oil industry, this area-wide decline will not directly affect them. Property values may go down, but as previously mentioned, property values are not at present the constraining factor for NSB revenue. NSB revenues and expenditures are projected to decline over time, which will reduce employment opportunities for NSB residents. The NSB has historically funded a very ambitious CIP program, employing a large number of residents, through selling bonds. As these projects are completed and the bonds retired, more of the NSB's budget will be shifted to operations. CIP-related employment is projected to decline significantly, and operational employment slightly (even with a somewhat larger overall budget).

NSB Revenues and Expenditures

The North Slope Borough relies primarily upon property tax receipts to fund its operations and pay interest and principal on its bonds, and this tax base consists overwhelmingly (95 percent) of petroleum-industry-related property. While the establishment of a NSB "permanent fund" has diminished the reliance on the property tax in recent years, in FY 1995 the NSB still collected 71 percent of its revenue from the property tax. The NSB is still, and will continue to be, dependent on the oil industry for the major part of its budget. In turn, the NSB is the largest employer and the principal capital investor in the region. The NSB's ability to sell bonds for revenue to fund capital investments, and the maintenance of facilities and the provision of services, has been the main driver of local community economies on the North Slope since the incorporation of the NSB.

NSB revenues peaked in 1987 at $249 million, and declined in 1991 to $221 million. Revenues for 1992 through 1995 were roughly stable, ranging from $224 million to $235 million. These figures are projected to decline somewhat, barring substantial new investment by the petroleum industry, due to depreciation of the existing tax base. The NSB is actively seeking to reduce its operating budget, and has become more conservative in the amount of bonds that are sold to finance capital improvements. The years 1981 through 1985 were the years of the greatest capital improvements budgets, peaking at $302 million in 1983.

While the NSB mill rate (in 1994) of 4.78 mills for operational expenses is at the legal limit, it only taxed at a rate of 13.72 mills to service its bonded debt, and so could raise taxes to fund a larger debt. The main problem facing the NSB, however, is one of operational expenses. Anything that it builds it must somehow maintain under the legal operational cap of 4.78 mills. Thus, although short-term revenue constraints do not drive current expenditures, when capital improvements are included in the overall budget, there are clear constraints on NSB operational expenditures due to a stagnant or declining property tax base.

NSB Employment

Resident civilian employment in the NSB was about 1,600 in 1975, increased to about 2,000 in 1978 (pipeline boom), decreased to 1,400 in 1980, increased to 2,700 in 1986, and has ranged from 2,800 to 3,000 people between 1987 and 1995 (MMS 1997a:III-C-1). Non-resident employment is more difficult to measure, and although figures are available from the Alaska Department of Labor, they caution against comparing them directly with resident employment numbers. Regardless, NSB Census Area employment was approximately 9,400 people in 1985, decreased to 6,600 in 1986 and 1987, and increased in 1993 to 7,600 and to 8,243 in 1994. In terms of economic sector employment, mining employment in the NSB was about 3,400 people in 1991, decreased to 2,800 in 1993, and increased to 3,300 in 1994. "Mining" is a NSB category that reflects primarily employment in the petroleum industry, and is overwhelmingly non-Inupiat. Construction employment fluctuated between 500 and 600 people from 1991 to 1994, and local government employment rose from about 1,800 in 1991 to 2,200 in 1994.

Based on the 1993/94 NSB survey (Harcharek 1995), in 1993 the NSB directly employed more than 45 percent (897) of all employed residents. The NSB School District employed another 17 percent (346) of all employed NSB residents. The school budget is controlled by the NSB government and a large part of it is derived from NSB sources (with state funds as well). Native corporations employ 16 percent (308) of employed residents. Much Native corporation employment is derived from contracts with the NSB. Construction workers on all NSB CIP projects for 1989 to 1994 were 64 percent NSB residents.

Unemployment is another concept which is difficult to discuss in terms of the NSB workforce. Official statistics are not always meaningful, since to be counted as "unemployed" a person must be actively seeking work. "Discouraged workers" who are not actively seeking work are thus not counted; and seasonal workers, who do not desire full-time work, also may not be counted. The 1993/94 NSB survey computed an unemployment rate borough-wide of 11 percent, with 22 percent of the workforce reporting that they worked less than 40 weeks in the previous year (does not include school district employees). Also, 24 percent of the total workforce identified itself as underemployed.

Very few NSB Inupiat residents are employed directly by the petroleum industry, although many are employed indirectly in service functions contracted to Native corporations. A primary goal of the NSB and other Native economic institutions has been to create employment opportunities in NSB communities for local residents which allow them to remain in their communities of residence and provide them with the flexibility to maintain subsistence and other cultural activities. Pay scales offered by the NSB tend to be equal to or better than those offered by the petroleum industry, and are quite favorable compared to those offered in other parts of the state.

Employment and Income -- Nuiqsut

In 1994, Nuiqsut had a labor force of 193 (total population 403). Information presented in this section is drawn from the NSB's survey of 1993/94 (Harcharek 1995), which itself is based on responses from 96 people, or somewhat less than half of the labor force. Unemployment was officially 5.2 percent, but underemployment is locally perceived as an important issue, with 30 percent of employed respondents identifying themselves as underemployed, and almost 40 percent reporting less than 40 weeks of work in the preceding year. Many jobs are seasonal, primarily those in construction (NSB for the most part) or with oilfield service companies (ice road building and maintenance). Unemployment and underemployment are identified as persistent and serious problems by members of the workforce.

Approximately 63 percent of regularly employed Nuiqsut residents work for the NSB. The village corporation, Kuukpik Corporation, employs approximately 20 percent of the workforce. The city has three employees, the state none, and the federal government one (the postmaster). All other employers account for approximately 13.5 percent of total employment.

Non-Inupiat households in Nuiqsut are generally smaller than Inupiat households, consisting primarily of salaried school teachers (most commonly one or two adults with no children). Average non-Inupiat household income in Nuiqsut was $49,999 ($33,333 per capita), while average Inupiat household income is $37,999 ($8,745 per capita). Inupiat households are generally comprised of more members and fewer wage earners.

The range and variability of Inupiat household income is also greater than for non-Inupiat households. Approximately 36 percent (32 of 90) of Inupiat households qualified as very low income households under federal regulations. Approximately 18 percent (16 of 90) Inupiat households had low to moderate incomes, while about 46 percent of Inupiat households had moderate or above incomes. Subsistence resources also are an important component of Inupiat household economies (Tables 4-10, 4-11, 4-12), but cannot be easily quantified, either in terms of contribution to diet or cost of production (harvest). While subsistence production contributes significantly to Nuiqsut household economies, cash expenditures for subsistence activities are also quite high. Of 69 Inupiat households responding to this area of the NSB survey, 31 spent between $500 to $4,000 each year on subsistence activities, while 25 spent more than $4,000 each year. Seven of these 25 households spent more than $10,000 each year (probably in connection with whaling).

Living expenses in Nuiqsut are quite high compared to both State of Alaska and national averages. Various federal and NSB subsidy programs tend to equalize some major categories of expenditure, such as rent and mortgage payments, but other costs (heat and utilities, transportation, cost of imported goods) are often twice those of state averages.

4.13.2.2 Local Nuiqsut Economy

Nuiqsut's population grew from a total of 175 when it was re-established in 1973 to about 340 in 1985. Since then, the community's population has been more or less stable (Pedersen 1995). There have been significant changes in socioeconomic characteristics, however. The average household income has increased from $32,125 to $56,743 (not adjusted for inflation). Average household size decreased, as population remained about the same, while the number of households increased. This was a result of the NSB's building plan, which allowed larger, complex, multigenerational households to split up into several smaller family units (Galginaitis et al. 1984 discuss this dynamic at an earlier stage of Nuiqsut's development). Housing has become better through time on a number of measurable indices—space per household member, heating systems, water system, waste disposal, construction and insulation quality, and so on. In short, the community is more affluent in 1995 than it was in 1985. Galginaitis et al. (1984) and IAI (1985) discussed the dynamic of households beginning to invest in larger boats, and Pedersen (1995) indicates that this has continued. With a greater number of larger boats than before, more time and effort devoted to whaling (and presumably to other water hunting activities) is being made, resulting in increases in marine mammal harvests. There are clear indications that Nuiqsut residents are investing more resources (both time and money) in these activities than they did in 1985, and this is probably true for all subsistence activities in general. Summary information comparing 1985 and 1993 Nuiqsut harvest of subsistence resources is presented in Table 4-10.

TABLE 4-10

NUIQSUT SUBSISTENCE HARVEST: COMPARISON OF 1985 AND 1993 ADF&G HOUSEHOLD SURVEYS

Sources: Pedersen 1995, Figure XXII-5; ADF&G 1993

	1985 Survey	1993 Survey
Per capita harvest (pounds)	399	742
Percent fish	44	34
Percent terrestrial mammal	42	33
Percent marine mammal	8	32
Percent bird	5	2

Note: Percentage totals may not add to 100% due to rounding.

TABLE 4-11

NUIQSUT 1993 SUBSISTENCE HARVEST SUMMARY

Source: ADF&G Community Profile Database, 1995, adapted from BLM and MMS 1997

		EDIBLE POUNDS HARVESTED		
	TOTAL NUMBER HARVESTED	TOTAL	HOUSEHOLD HARVEST MEAN	PER CAPITA
	MARINE MAMMALS			
Total Marine Mammals	113	85,216	936.44	236.01
Bowhead Whale	3	76,906	845.12	213.00
Belukha Whale	0	0	0.00	0.00
Walrus	0	0	0.00	0.00
Polar Bear	1*	0	0.00	0.00
Bearded Seal	98	7,277	79.96	20.15
Ringed Seal	6	1,033	11.35	2.86
Spotted Seal	4*	0	0.00	0.00
	TERRESTRIAL MAMMALS			
Large Land Mammals	691	87,306	959.40	241.80
Brown Bear	10*	734	8.06	2.03
Caribou	672	82,169	902.95	227.57
Moose	9	4,403	48.38	12.19
Muskox	0	0	0.00	0.00
Dall Sheep	0	0	0.00	0.00
Small Land Mammals/Furbearers	599[§]	84	0.92	0.23
Arctic Fox	203	0	0.00	0.00
Red Fox	63	0	0.00	0.00
Marmot	0	0	0.00	0.00
Mink	0	0	0.00	0.00
Parka Squirrel	336	84	0.92	0.23
Weasel	10	0	0.00	0.00
Wolf	31	0	0.00	0.00
Wolverine	19	0	0.00	0.00
	FISHES			
Total Fish	71,897	90,490	994.39	250.92
Total Salmon	272	1,009	11.08	2.79
Total Non-Salmon	71,626	89,481	983.30	247.83
Smelt	304	42	0.46	0.12
Cod	62	7	0.07	0.02
Burbot	1,416	5,949	65.37	16.48
Char	618	1,748	19.20	4.84
Grayling	4,515	4,063	44.65	11.25
Total Whitefish	64,711	77,671	853.53	215.12
Cisco	51,791	34,943	383.98	96.78
Arctic Cisco	45,237	31,666	347.97	87.70
Least Cisco	6,553	3,277	36.00	9.08
	BIRDS			
Total Birds and Eggs	3,558	4,325	47.53	11.98
Migratory Birds	2,238	3,540	38.90	9.80
Ducks	772	1,152	12.66	3.19
Eider	662	1,059	11.63	2.93
Oldsquaw	78	62	0.68	0.17
Geese	1,459	2,314	25.43	6.41
Brant	296	356	3.91	0.99
Canada Geese	691	830	9.11	2.30
White Fronted	455	1,092	12.00	3.02
Swan	7	73	0.80	0.20
Ptarmigan	973	681	7.48	1.89
Bird Eggs	346	104	1.14	0.29

Note: Number of households in the sample = 62; number of households in the community = 91.
Footnotes: *Not eaten. [§]Some not eaten.

TABLE 4-12

SUBSISTENCE HARVEST BY MONTH FOR NUIQSUT, JULY 1, 1994 TO JUNE 30, 1995

Source: Brower and Opie 1997, adapted from BLM and MMS 1997

	1994						1995						TOTAL	EST. TOTAL
ITEM	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	71 HHs*	83 HHs
Arctic Char	0	8	0	0	0	0	0	0	0	0	0	0	8	8
Arctic Cisco[1]	0	0	37	5,737	2,400	1,050	262	0	0	0	0	0	9,486	9,842
Broad Whitefish	1,535	25	75	855	500	0	0	0	0	0	0	130	3,120	3,237
Burbot	0	0	0	9	76	3	0	0	0	0	0	0	88	91
Fish Unidentified	0	0	0	0	0	0	0	0	0	0	0	75	75	78
Grayling	0	24	225	110	84	0	0	0	0	0	0	2	445	462
Humpback Salmon	10	0	0	0	0	0	0	0	0	0	0	0	10	10
Humpback Whitefish[1]	0	0	0	150	25	0	0	0	0	0	0	0	175	182
Least Cisco	0	0	0	0	0	750	0	0	0	0	0	0	750	778
Northern Pike	0	0	0	0	0	0	0	0	0	0	0	18	18	19
Whitefish Unidentified	0	0	0	50	425	0	0	0	0	0	0	0	475	493
Caribou	63	32	6	80	13	4	9	5	13	7	2	15	249	258
Moose	1	1	1	1	0	0	1	0	0	0	0	0	5	5
Wolf	0	0	0	0	1	1	3	0	12	1	0	0	18	19
Wolverine	0	0	0	0	1	1	2	1	1	2	0	0	8	8
Arctic Fox	0	0	0	0	0	1	1	1	3	0	0	0	6	6
Fox Unidentified	0	0	0	0	4	0	0	0	0	0	0	0	4	4
Red Fox	0	0	0	0	0	1	1	1	1	1	0	0	5	5
Polar Bear	0	0	0	0	1	0	0	0	0	0	0	0	1	1
Tundra Swan	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Geese Unidentified	0	0	0	0	0	0	0	0	0	0	409	48	457	474
Eider Unidentified	0	0	0	0	0	0	0	0	0	0	50	40	90	93
Ptarmigan	0	0	0	0	0	0	0	0	0	33	23	0	56	58
Sandhill Crane	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Ringed Seal	2	10	0	0	0	0	0	0	0	6	0	5	23	24
Salmonberries (gal)	0	9	0	0	0	0	0	0	0	0	0	0	9	9
Cranberries (gal)	0	.5	0	0	0	0	0	0	0	0	0	0	.5	1
Bueberries (gal)	0	2.5	0	0	0	0	0	0	0	0	0	0	2.5	3
Blackberries (gal)	0	.5	0	0	0	0	0	0	0	0	0	0	.5	1

*Households.

[1]The harvest of Arctic cisco and humpback whitefish is under represented: one household provided evidence of a significant, but unquantifiable, harvest by saying that "sled loads" were "every couple of days during October and November."

Harvest information for 1985 was developed as part of a community baseline study of Nuiqsut by ADF&G. A similar ADF&G survey is the source of the 1993 harvest information. The data are available in ADF&G's Community Profiles Database (ADF&G 1995; Pederson 1995.; Pedersen in prep). The NSB collected some systematic community harvest information as part of a borough-wide economic survey in 1992-93, but this is not readily available or easily comparable (Harcharek 1995). Table 4-11 summarizes the 1993 harvest data in more detail. The NSB has initiated a program to collect systematic community harvest information, with the most recent information for Nuiqsut being for the period of July 1994 to June 1995 (Brower and Opie 1997). These new harvest data were presented in the NPR-A DEIS (BLM and MMS 1997) and are summarized in Table 4-12. Indications are that, for this period, terrestrial mammals were a significantly greater proportion of the total edible pounds of all subsistence resources harvested than for the two previous periods. No whale was taken in this period (as was true of 1985), and the harvest of fish appeared to be much lower than for previous years (but the harvest of fish may also have been underreported -- see Brower and Opie 1997). Given that Nuiqsut whalers have, for the most part, been successful in recent years, and the uncertainties in the 1994-95 figures for fish harvest, the most useful subsistence data for the evaluation of potential effects of the Liberty project would appear to be those of 1985 and 1993.

In terms of general patterns, Nuiqsut has a relatively high per capita harvest of subsistence resources (Table 4-10). In years of a successful bowhead whale hunt, the per capita harvest average is higher than in years when a bowhead is not taken, for obvious reasons. Each bowhead represents a very large total amount of food whose presence or absence greatly affects the yearly averages. Fish and terrestrial mammals are fairly stable, and roughly equivalent, in terms of their contributions to Nuiqsut's annual subsistence harvest. In years when Nuiqsut successfully harvests at least one whale, marine mammal resources, fish, and terrestrial mammals each contributes about a third of the community's subsistence harvest. Birds and eggs provide a small percentage, and plants yet a smaller amount. Whales are the primary marine mammal resource harvested. Seals are also taken, but at a much lower level in the past. In years when a whale is not taken, fish and terrestrial mammals are more important, and some substitution may take place. Muktuk and whale meat from other communities are shipped into Nuiqsut in such years, although not in the quantities that would be consumed in the community if they had harvested their own whale(s). It should be noted that information on harvest of subsistence resources does not totally represent the actual pattern of consumption of subsistence resources. Sharing, both within and between communities (both within and outside of the NSB), is an important social dynamic about which systematic information is still lacking.

The largest change in Nuiqsut subsistence use between 1985 and 1993 has been with marine mammals. Whales are the principal component, given their size. In 1985, the village did not take a whale, whereas in 1993, hunters took three whales. There are a number of factors which may help explain this increase. One is the increase in investable resources available since 1985. Another is that the community has had an additional eight years to document the variability in its use of its subsistence area. In 1985, Nuiqsut was still a very young community (resettled in 1973) and while some residents were intimately familiar with local subsistence resources from their experience of living on the land prior to 1973, many were not. While they had a strong identification and historical relationship with the local area, many did not have a great personal knowledge of it (and especially with the marine subsistence areas). The doubling of per capita subsistence harvest from 1985 to 1993 will indicate that both factors (increased capital investment in subsistence activities and continued transmission of traditional knowledge) probably played a part in the increased subsistence use of marine resources. This trend is expected to continue.

Pedersen (1995) indicates that the average Nuiqsut household reported it spent close to $800 a month for food, while at the same time 63 percent of Nuiqsut households obtain over half of their meat, fish, and birds from wild foods. Only one person surveyed did not consume wild foods, while 63 percent had consumed such food as recently as the day before the interview. Roughly 67 percent mentioned that one reason they ate wild foods was the high cost of "store" food—and 93 percent considered wild foods to be healthier than store food. Additional information on the mixed cash/subsistence economy and cash income in Nuiqsut and other NSB villages is described in ADNR (1997).

Recreation and tourism may occur in limited parts of the study area, but there are few participants and minimal revenues are derived from these activities. Oil field workers are not allowed to hunt or hike over tundra during summer. Fishing is allowed with a fishing license. Tourists can drive or fly to Deadhorse, but can only access the Prudhoe Bay Unit and adjacent unitized operating areas with approved tour operators. Public access is allowed on state lands that are not in unitized operating areas, but there are no facilities. River rafting occurs on the Canning River east of the study area (Clough et al. 1987; USFWS 1993).

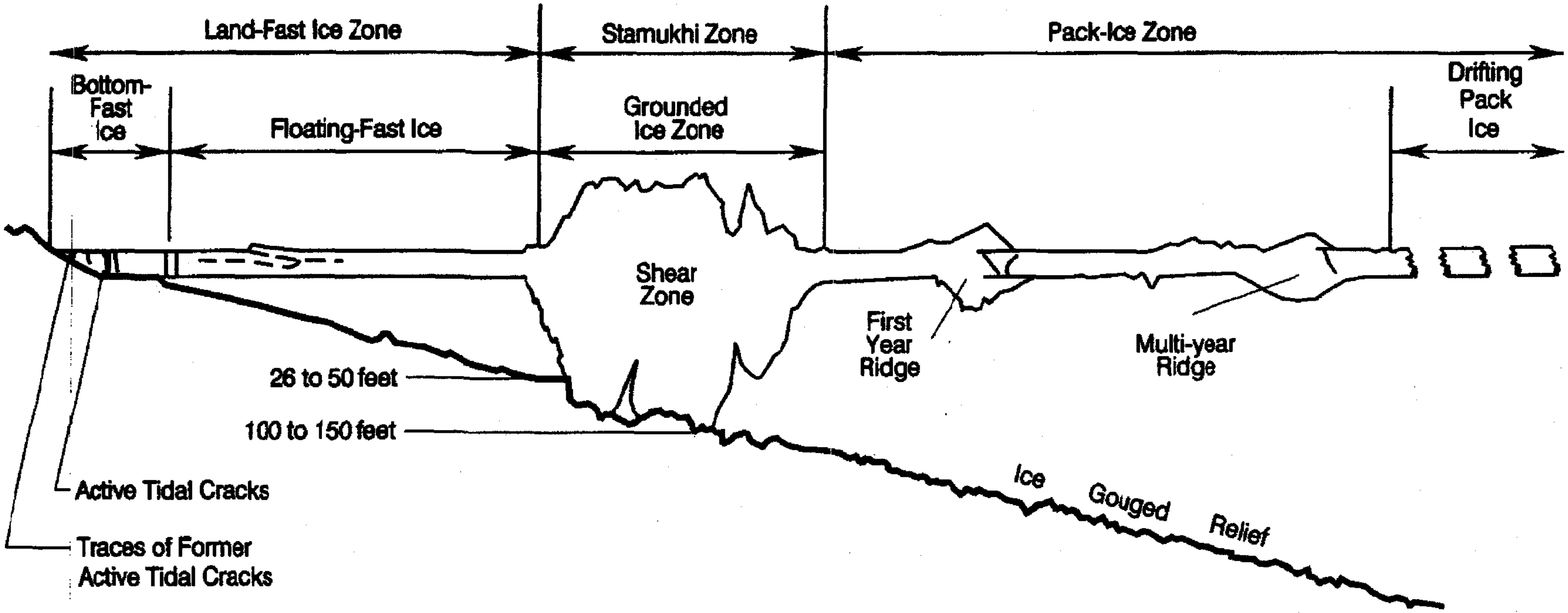
Oil and gas exploration and production are the primary developed (non-subsistence) land uses in the study area. The NSB has zoned the project area as Conservation District. The Badami pipeline corridor has been zoned as a Resource Development District. Rezoning for the segment of offshore pipeline in State waters, and the onshore pipeline intersecting the Badami Sales Oil Pipeline, will be requested from the NSB.

4.13.3 Land Ownership

Most of the study area shown on Exhibit A is patented to the State of Alaska, although actual production will be in federal waters. The state owns both the surface and subsurface (mineral) estates and has issued a number of oil and gas leases in the area. Under the terms of state oil and gas leases, the mineral lessee has a right to use as much of the surface as is reasonably necessary to develop and produce the minerals. The surface estate is reserved by the state, and such reservation allows for the issuance of road and pipeline rights-of-way to the extent that such rights-of-way do not interfere with the rights of the underlying mineral owner.

The proposed island, pipeline route, and support pads are, for the most part, free from land status encumbrances. There are, however, three encumbrances in the study area. They are all Native Allotment applications and are tentatively approved for patent to the State of Alaska. The Bureau of Land Management is currently seeking title recovery from the state so that the lands can be certificated to the applicant. Native allottees are granted surface rights only. Underlying minerals remain the property of the State of Alaska. These lands are described as follows:

1) *Bureau of Land Management, Fairbanks District File (F) 12053 USS8120:* Land located within S24, T10N, R17E, UM and S19 and S30, T10N, R11E, UM on the Beaufort Sea coast, about 2 miles west of the mouth of the Kadleroshilik River.
2) *F11943 USS 9490:* Land located within S25, T10N, R18E UM on the Beaufort Sea coast, about 4 miles east of the mouth of the Kadleroshilik River.
3) *F14632A USS 8083:* The site is on the tip or end of Brower Point, and may be associated with site XBP-022.

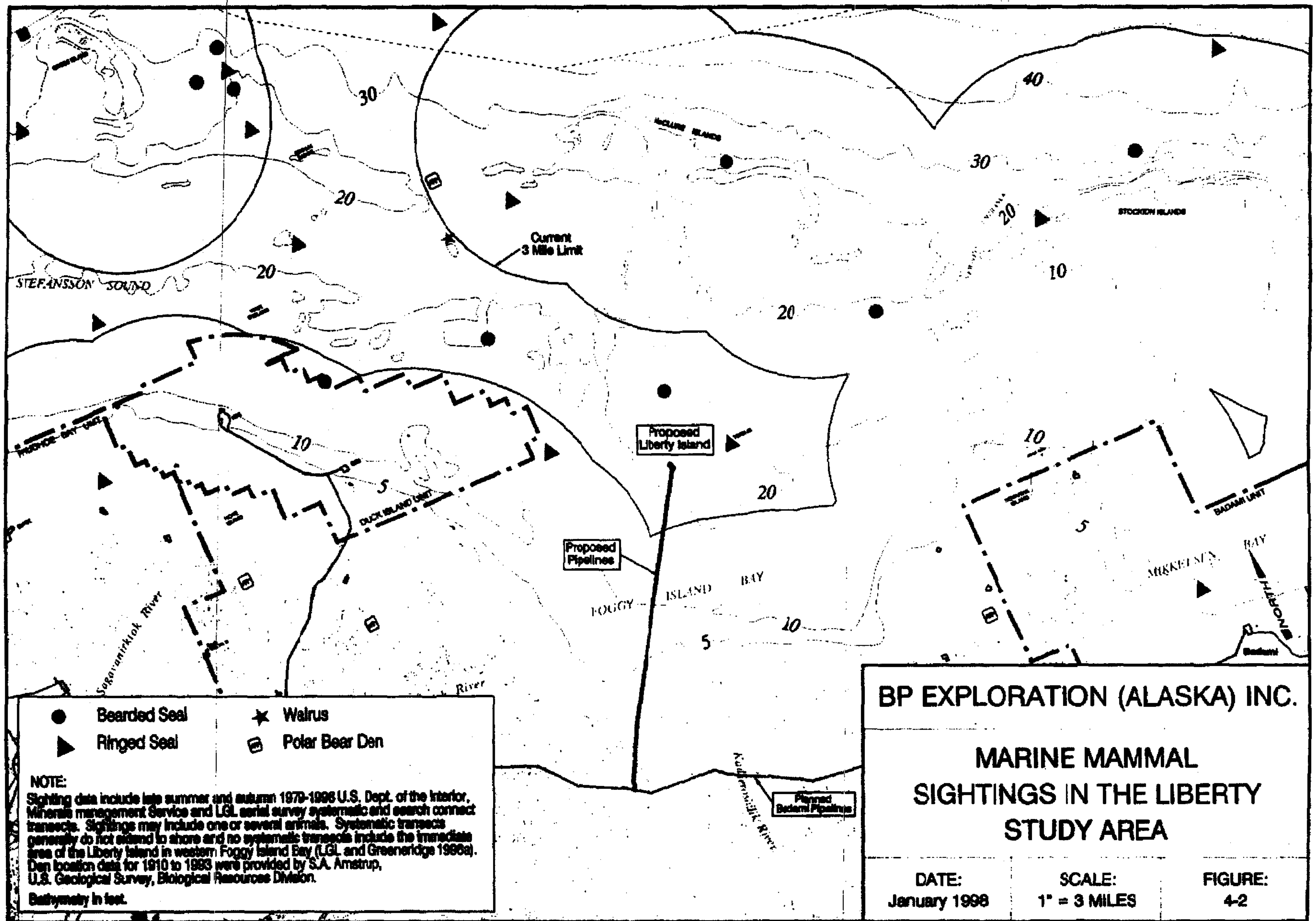


Adapted from: USDOC, NOAA 1978

BP EXPLORATION (ALASKA) INC.

WINTER-ICE ZONATION OF BEAUFORT SEA COAST

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	4-1


BP EXPLORATION (ALASKA) INC.
MARINE MAMMAL SIGHTINGS IN THE LIBERTY STUDY AREA
DATE: January 1998
SCALE: 1" = 3 MILES
FIGURE: 4-2
Bearded Seal
Ringed Seal
Walrus
Polar Bear Den
NOTE:
Sighting data include late summer and autumn 1979-1996 U.S. Dept. of the Interior, Minerals management Service and LGL aerial survey systematic and search connect transects. Sightings may include one or several animals. Systematic transects generally do not extend to shore and no systematic transects include the immediate area of the Liberty Island in western Foggy Island Bay (LGL and Greeneridge 1996a). Den location data for 1910 to 1993 were provided by S.A. Amstrup, U.S. Geological Survey, Biological Resources Division.
Bathymetry in feet.
Current 3 Mile Limit
Proposed Liberty Island
Proposed Pipelines
Planned Badami Pipelines
STEFANSSON SOUND
FOGGY ISLAND BAY
MIKKELSEN BAY
STOCKTON ISLANDS
DUCK ISLAND UNIT
BADAMI UNIT
Sagavanirktok River
Kadleroshilik River
NORTH
Badami
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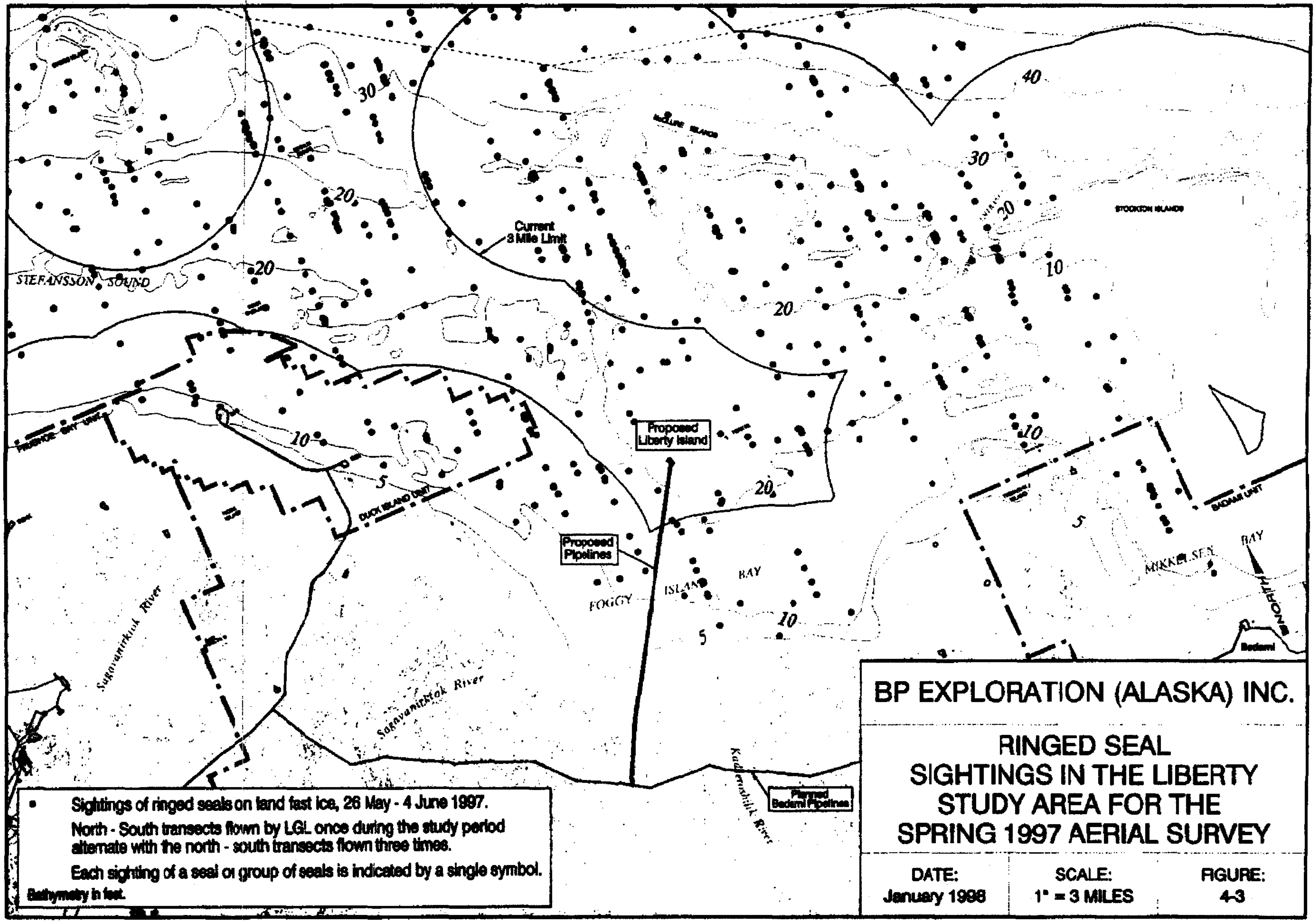


• Sightings of ringed seals on land fast ice, 26 May - 4 June 1997.

North - South transects flown by LGL once during the study period alternate with the north - south transects flown three times.

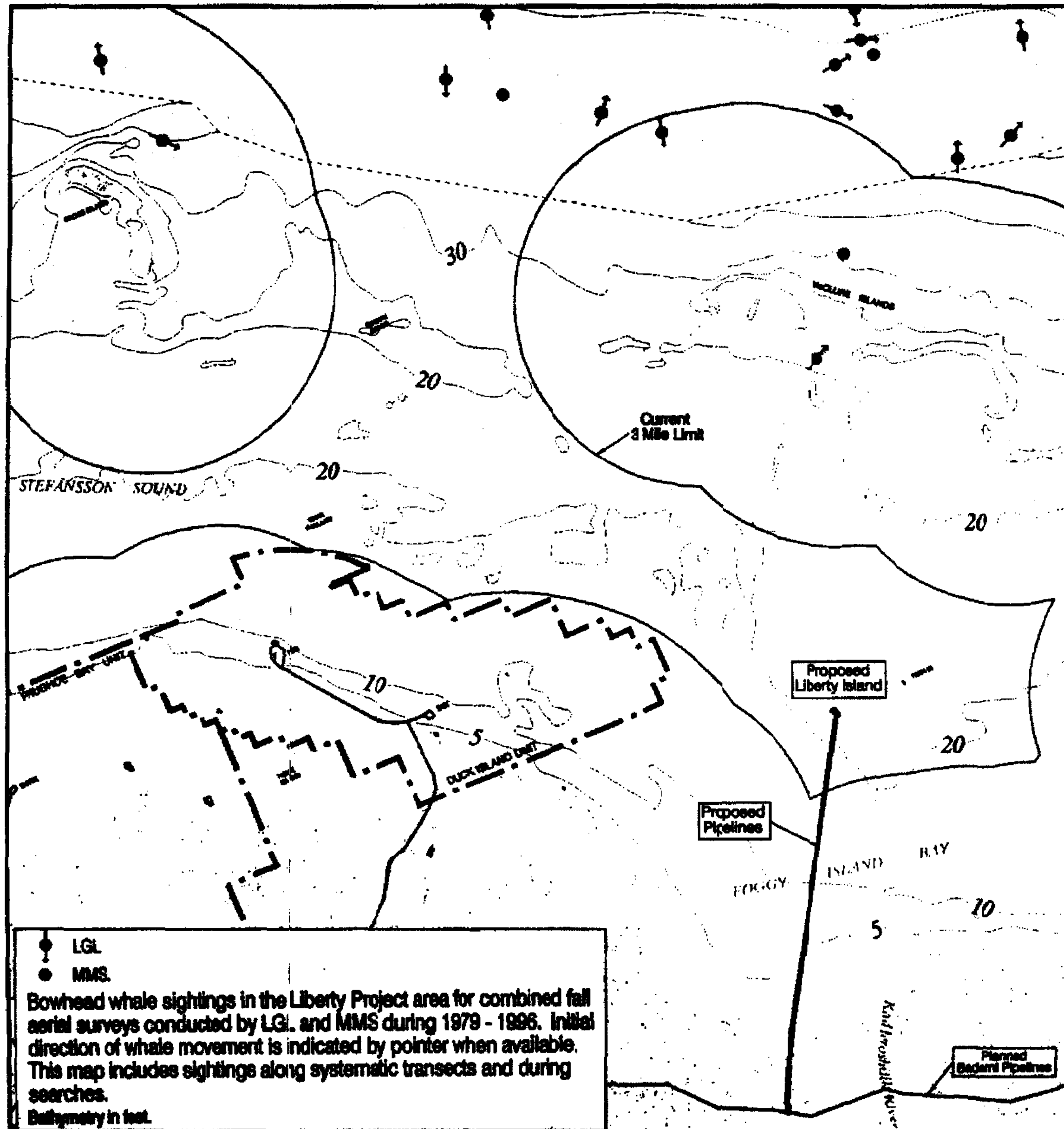
Each sighting of a seal or group of seals is indicated by a single symbol.

Bathymetry in feet.

BP EXPLORATION (ALASKA) INC.

RINGED SEAL SIGHTINGS IN THE LIBERTY STUDY AREA FOR THE SPRING 1997 AERIAL SURVEY

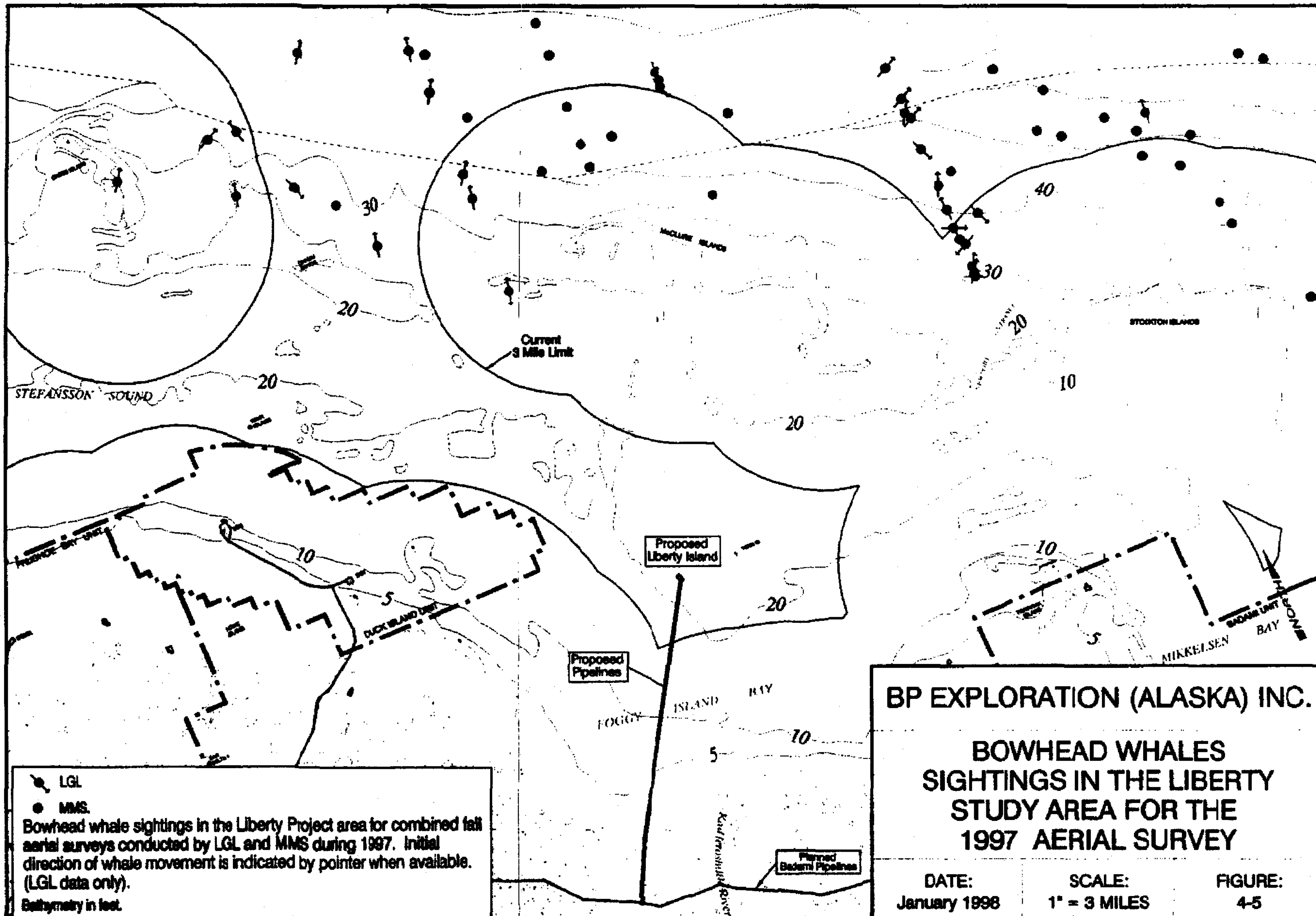
DATE:	SCALE:	FIGURE:
January 1998	1" = 3 MILES	4-3



BP EXPLORATION (ALASKA) INC.

BOWHEAD WHALES SIGHTINGS IN THE LIBERTY STUDY AREA FOR THE 1979 - 1996 AERIAL SURVEY

DATE:	SCALE:	FIGURE:
January 1998	1" = 3 MILES	4-4



LGL

MMS.

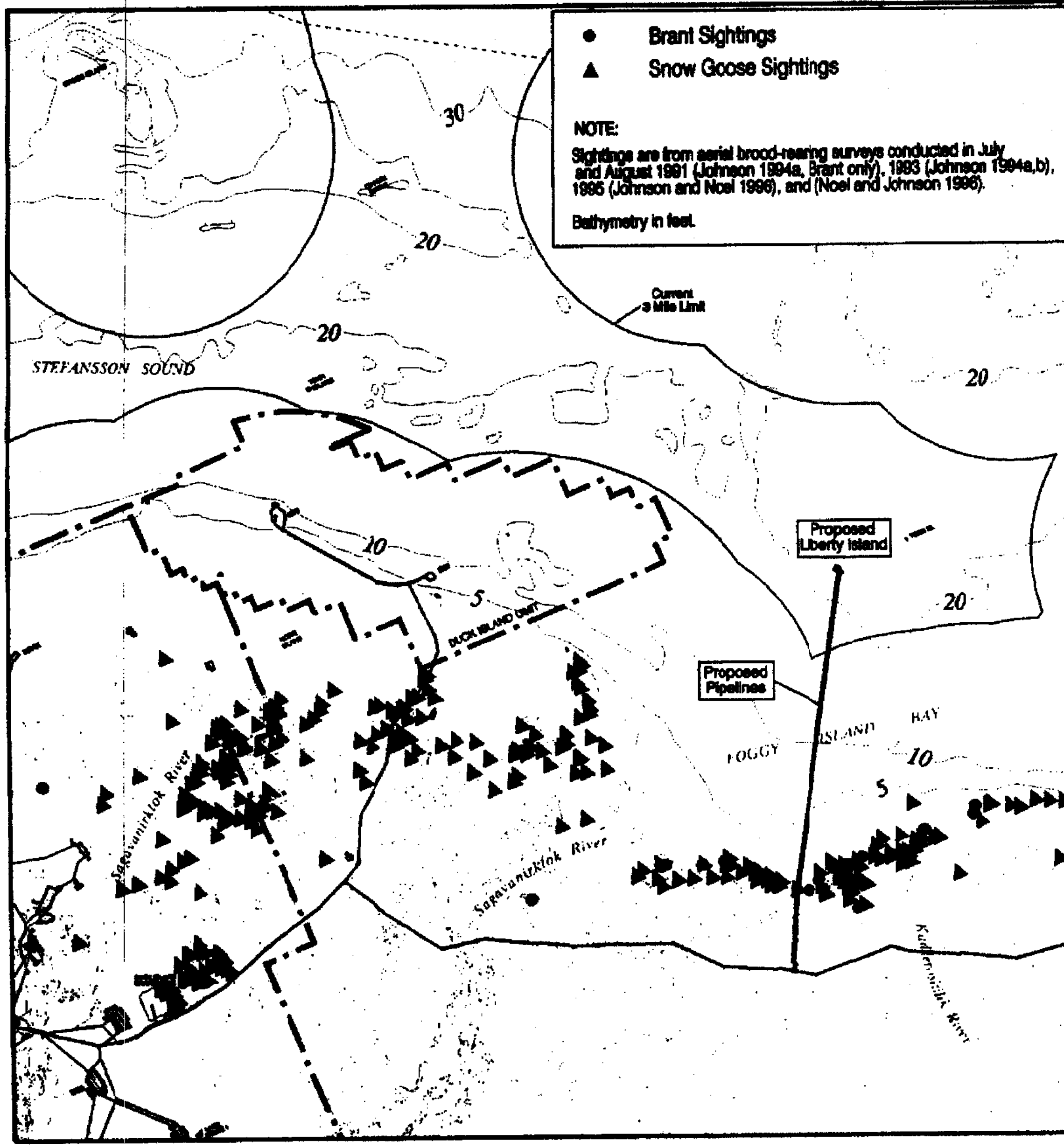
Bowhead whale sightings in the Liberty Project area for combined fall aerial surveys conducted by LGL and MMS during 1997. Initial direction of whale movement is indicated by pointer when available. (LGL data only).

Bathymetry in feet.

BP EXPLORATION (ALASKA) INC.

BOWHEAD WHALES SIGHTINGS IN THE LIBERTY STUDY AREA FOR THE 1997 AERIAL SURVEY

DATE:	SCALE:	FIGURE:
January 1998	1" = 3 MILES	4-5

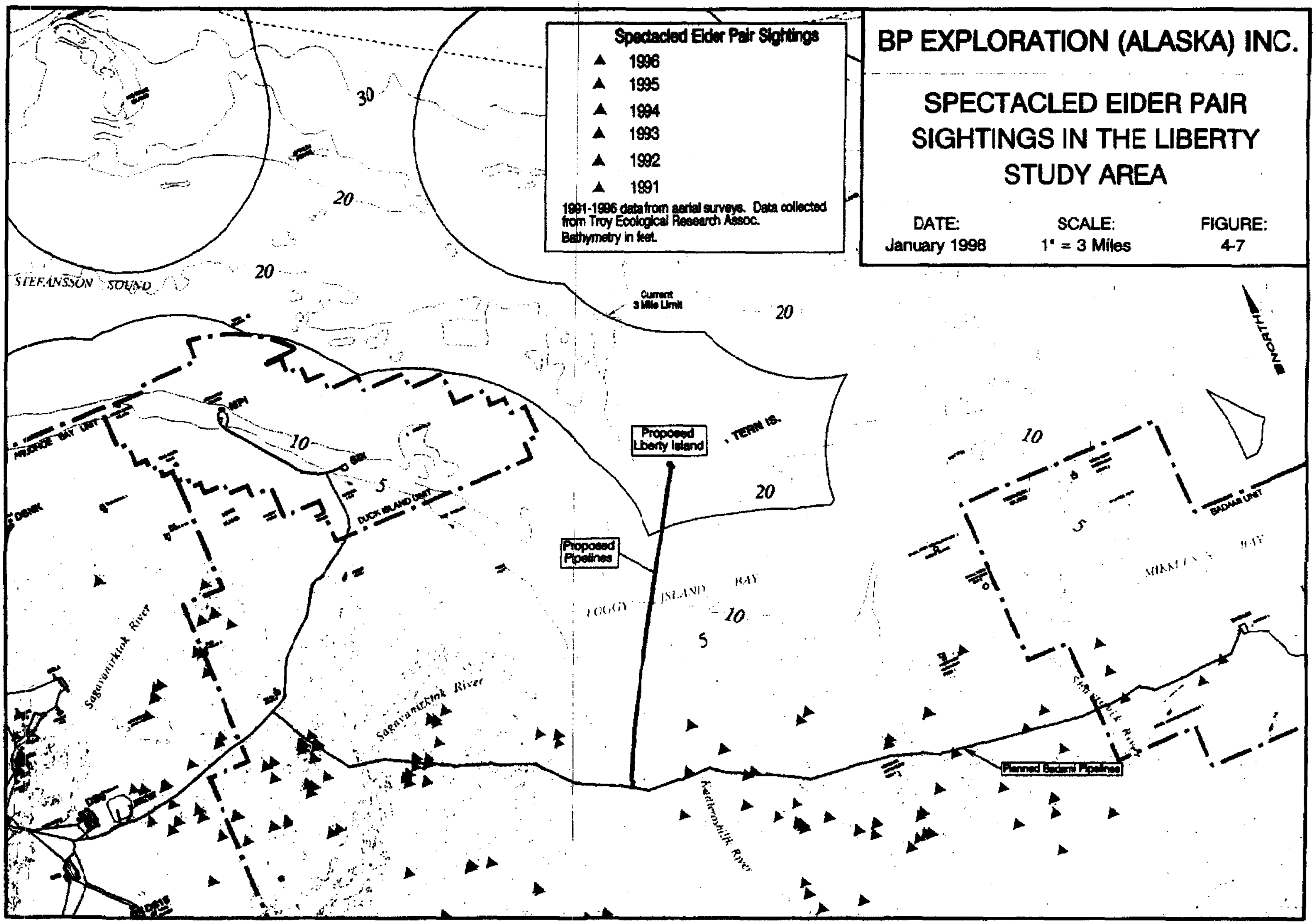


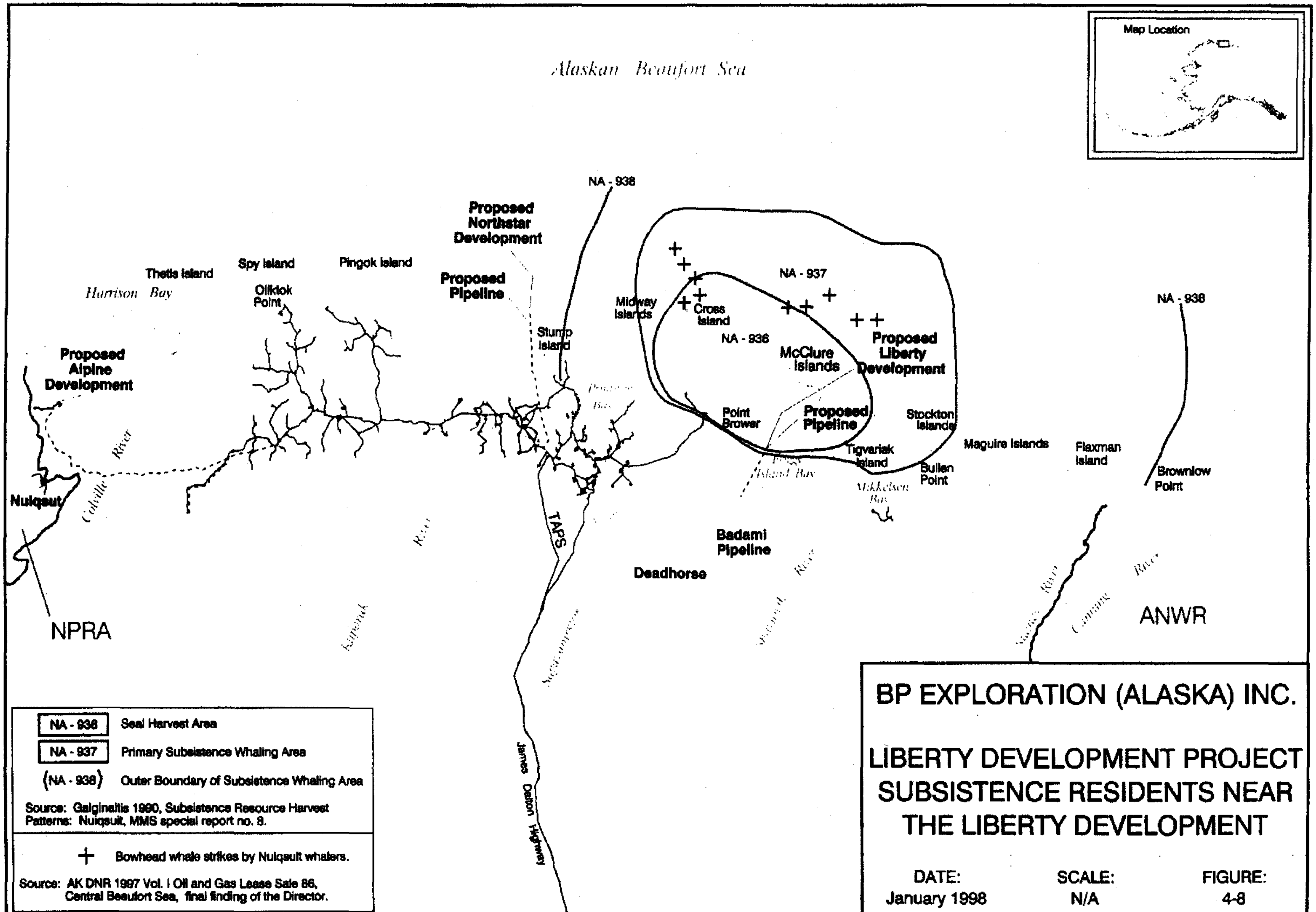
BP EXPLORATION (ALASKA) INC.

SNOW GEESE SIGHTINGS AND BRANT SIGHTINGS IN THE LIBERTY STUDY AREA

DATE:	SCALE:	FIGURE:
January 1998	1" = 3 MILES	4-6

bc13458.dgn


BP EXPLORATION (ALASKA) INC.
SPECTACLED EIDER PAIR SIGHTINGS IN THE LIBERTY STUDY AREA
DATE: January 1998
SCALE: 1" = 3 Miles
FIGURE: 4-7
Spectacled Eider Pair Sightings
1996
1995
1994
1993
1992
1991
1991-1996 data from aerial surveys. Data collected from Troy Ecological Research Assoc.
Bathymetry in feet.
STEFANSSON SOUND
Current 3 Mile Limit
Proposed Liberty Island
TERN IS.
Proposed Pipelines
FOGGY ISLAND BAY
PRUDHOE BAY UNIT
DUCK ISLAND UNIT
BADAMI UNIT
MIKKELSEN BAY
Sagavanirktok River
Kadleroshilik River
Planned Badami Pipelines
NORTH
30
20
10
5



BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
SUBSISTENCE RESIDENTS NEAR
THE LIBERTY DEVELOPMENT

DATE:	SCALE:	FIGURE:
January 1998	N/A	4-8

5. ENVIRONMENTAL CONSEQUENCES

The development plans for the proposed Liberty Development include the following activities that may potentially affect the environment:

- Offshore fill placement during island construction
- Barge traffic and human activity on floating camp during island construction
- Offshore excavation and fill during subsea pipeline construction
- Onshore fill placement during pipeline construction and tie-in
- Oil production operations
- Airborne and underwater noises
- Discharges and emissions
- Onshore gravel mining
- Project termination

5.1 OFFSHORE ISLAND CONSTRUCTION

The proposed island location was based on a number of factors, including optimum reservoir development. An important design objective was to avoid placing the island within known Boulder Patch communities. Gravel island construction will commence with placement of the island core using fill material hauled from the Kadleroshilik River mine site. Sea ice in the area of the island will be cut and removed to a site on grounded ice. Fill material will be placed through the hole to create the island's working surface. Slope protection work will then proceed. Most work will occur during the winter with open water work limited to minor sideslope shaping adjustments prior to operations. The following sections describe the potential impacts to the affected environment as described in Section 4.0.

5.1.1 Air Quality

Potential air emissions during the island construction phase include:

- Combustion products from diesel generators and construction equipment and vehicles
- Fugitive dust from fill material hauling and vehicle traffic

Two 1,500-kW diesel generators will provide full-time service during the installation phase (when modules are installed) prior to drilling. There also will be emissions associated with the use of boats and helicopters as limited construction activity continues through breakup to the open water season. Emissions from these modes of transport are likely to be greater than emissions from light trucks used to transport personnel over ice. It is expected that island construction activities will occur over a six- to nine-month time period; therefore, construction emissions will be temporary and will not contribute to long-term air quality issues. Emissions will be quickly dispersed by the frequent winds common to the area. Anticipated emissions from construction equipment, vehicles, and vessels operating on the OCS will be identified in an EPA Part 55 air quality permit (40 CFR Part 55). There will be no significant adverse impacts from the emissions.

Fill material for the Liberty Development will be obtained from a new mine site located in the Kadleroshilik River floodplain. Since the island will be constructed offshore during the winter, effects of increased dust on terrestrial plants or the tundra ecosystem in the vicinity of the mine site are not expected. In addition, the fill material will be frozen and less likely to generate extensive dust when excavated. The amount of dust that may settle out of the air and onto the ice surface is not expected to be of sufficient quantity to reduce ice transmissivity in the immediate vicinity of the construction site. It will be a small or negligible addition to the normal sediment load deposited on nearshore ice during river breakup. Overall, any short-term increases in dust levels at either the mine or construction site are not expected to have negative impacts on the environment.

5.1.2 Sediment Suspension and Transport

Winter construction of the offshore gravel island could cause increased suspended sediment concentrations in marine waters during placement of fill material. Suspended sediment concentrations and physical dimensions of the turbidity plume generated by the construction activities depend on a number of factors including:

- Timing of the construction activities
- Physical characteristics of the fill material
- Water depth at the construction site
- Current speed
- Circulation patterns in the vicinity of the site

NORTEC (1981) measured suspended sediment concentrations occurring as a result of summer construction activities at Endeavor Island, located in about 3.7 meters (12 feet) of water. The study showed increases in suspended sediment concentration of about 70, 30, and 10 mg/L at downstream distances of about 30, 180, and 1,830 meters (100, 600, and 6,000 feet), respectively. Effects of the winter construction of islands in the general area have been reported by Toimil and England (1982) and Toimil and

Dunton (1983, 1984). These studies report the environmental effects of winter gravel island construction at Exxon's BF-37 island located north of Endicott in 6 meters (20 feet) of water. Results of the work showed the concentration of suspended sediments, measured at radial distances of 170 and 140 meters (560 and 460 feet) from the island center, did not noticeably increase during the first seven days of fill material placement. The highest suspended sediment concentrations measured were within 3 mg/L of the ambient level of 6.7 mg/L. Three factors were suspected to restrict formation of a turbidity plume:

- Low current velocity
- Ice-bonding of fine fractions
- Formation of silt/ice agglomerates

Therefore, increases in water turbidity and sediment deposition in the downstream plume area from winter island construction are likely to be at lower levels than from construction in the summer. However, during winter, marine water beneath the ice cover becomes clear due to settling of suspended sediments in the more quiescent conditions and lack of river-borne turbid inflow. Introduction of gravel and associated sediment will likely be more noticeable in winter than in summer, when river-borne and wave-induced resuspended sediment typically create very turbid conditions in the area. The effects of turbidity increases due to extensive tug and barge traffic required for summer construction, although less noticeable because of existing turbid conditions, will be eliminated with winter island construction. Since the fill material will be frozen at the time of placement, reshaping of island side slopes may be required. This would occur before or just after breakup during the subsequent summer. Any effects of reworking the fill material in summer could result in turbidity increases similar in magnitude, but of shorter duration, as those effects described for winter construction.

The Lisburne Offshore Project Environmental Assessment determined that most of the fill material used for construction in the Prudhoe Bay area has a maximum of 10 percent fines (i.e., fine particles), and assumed that 10 percent of the fines in the fill material below mean water level will be washed out during construction (Dames and Moore 1988). However, others contend that the construction standard for gravel in the Prudhoe Bay area is only 5 percent fines (Dames and Moore 1988), and the material used to construct Tern Island in Foggy Island Bay had an average of only 2 percent fines (WCC 1982). NORTEC (1981) estimates that up to 12 percent of fines contained in fill material placed below water during open water conditions may be entrained during construction.

To analyze the case of Liberty Island, an upper planning range quantity of gravel for island construction was assumed to be approximately 577,500 m^3 (750,000 yd^3) of fill material, with a maximum of 15,500 m^3 (20,000 yd^3) placed per day in two, 12-hour shifts over a period of about 45 days. Therefore, a worst-case analysis can be developed which assumes that fines (silt and clay-sized particles) account for approximately 5 percent of the fill materials and a 12 percent resuspension of the fine materials. Under this scenario, 92 m^3 (120 yd^3) of material will be released to the water column per day. Using a typical specific gravity of 2.6 g/ml for the material, this corresponds to 240,000 kg/day or 2.7 kg/s. For comparison purposes, a best-case scenario was developed where fines were assumed to account for 2 percent of the fill material (WCC 1982), and 10 percent of the fines will be resuspended (Dames and Moore 1988). With this scenario, 31 m^3 (40 yd^3) would be released per day. This calculates to 104,000 kg/day or 1.2 kg/s. It is likely that the actual amount will vary but will be somewhere between these two amounts.

To determine a suspended solids concentration created by the input of this material, the following simple model equation was used:

$$C_o = M/Q \qquad (1)$$

Where:

C_o is the concentration of suspended material at the island
M is the mass flux of material (mass per unit time); this was calculated previously (2.7 kg/s worst case, 1.2 kg/s best case)
Q is the flow rate (volume per unit time)

To calculate Q the following equation was used:

$$Q = \mu DH \qquad (2)$$

Where:

μ is the current speed (2 cm/s)
D is the average diameter of the island (183 m)
H is the depth of the water column (6.1 m)

Therefore:

$$Q = 22.3 \text{ m}^3/\text{s} \qquad (2)$$

For the worst case:

$$C_o = \frac{2.7 \text{ kg/s}}{22.3 \text{ m}^3/\text{s}} \qquad (1)$$

$$= 0.121 \text{ kg/m}^3 \text{ or } 121 \text{ mg/L}$$

And, for the best case:

$$C_o = \frac{1.2 \text{ kg/s}}{22.3 \text{ m}^3\text{/s}}$$

$$= 0.054 \text{ kg/m}^3 \text{ or } 54 \text{ mg/L}$$

This is the best-/worst-case concentration range (50-120 mg/L) of suspended material (over ambient) at the island location that could be attributed to placement of construction materials, assuming a current speed of 2 cm/s (0.04 knots), a water depth of 6.1 meters (20 feet), an island average diameter of 183 meters (600 feet), and placement of 15,300 /m^3 (20,000 yd^3) per day.

To calculate the probable maximum particle migration from the island, Stokes' Law is first used to calculate the fall velocity (w) of discrete particles in water. Stokes' Law describes the flow of fluid past a spherical body under conditions known as "creeping" flow. For example, the fall velocity of small particles through a water column is given accurately by Stokes' Law because the particles are so small that they fall slowly enough to meet speed requirements of "creeping" flow (Vanoni 1975; Tritton 1977). Use of Stokes' Law is acceptable since under-ice conditions approximate quiescence:

$$w = \frac{gd^2(\gamma_s - \gamma / \gamma)}{18\nu} \qquad (3)$$

Where:

g is the acceleration of gravity or 9.75 m/s^2

d is the diameter of the particle

g_s is the specific gravity of the particle

g is the specific gravity of seawater

ν is the kinematic viscosity of seawater (in m^2/s)

The effective theoretical downstream distance required to capture all suspended particles can be calculated using the following equation:

$$D = \mu/wH \qquad (4)$$

Where:

μ is the current speed (2 cm/s)

w is the fall velocity for a given particle size (calculated in equation #3)

H is the height of the water column (6.1 m)

Assuming that the grain size for these fine materials ranges from 5 to 100 μm (very fine silt to very fine sand), the under-ice currents are 2 cm/s (0.04 knots), and the water depth is 6 meters (20 feet), the majority of the material will have fallen out of the water column within 1 km (1,100 yds) downstream of the island (Figure 5-1). This is a worst-case estimate for settling distance downstream in 6 meters of water, since much of the fill material will be placed near the bottom of the water column and will not have to settle through the entire water column (expected to be 4 to 5 meters deep under ice cover), and the number of particles (suspended solids concentration) also decreases with distance, as settling removes particles from the water column.

Under-ice currents are not directly affected by meteorological processes (i.e., not by wind stress, but as the result of the small Beaufort Sea tides and atmospheric pressure variations over the ice sheet). The current is consistently westerly/northwesterly. Therefore, the materials are likely to be deposited in a narrow band to the northwest, following bathymetric contours. Since distance from the island (D) is dependent on both μ and H (current speed and water depth), changing either of these variables will affect the calculated settling distance. For example, as the sediment plume moves into more shallow water, the settling distance will decrease. Since water depth decreases to the west and northwest of the island, it is likely that all materials larger than clay-size particles (5 μm) will have settled out within 5 to 8 km (3 to 5 miles) of the island. Using the planned island construction site location, the potential worst-case area of influence from fill placement during island construction is shown on Figure 5-2.

Figure 5-2 and Table 5-1 show that about 0.2 square miles (about 130 acres) has the potential to be affected by sediment deposition of particles larger than 15 μm. Of the 0.2 square miles, 0.10 square miles may consist of boulder and cobble substrate and may support a boulder patch community. Figure 5-2 provides the expected areas of boulder substrate as referenced in Reimnitz and Ross (1979) and Lee and Toimil (1985). The potential area of impact for particles < 5 μm is about 4 square miles (about 2,500 acres), with about 0.3 square miles (about 200 acres) consisting of > 25 percent boulders. However, a very small percentage (< 1 percent) of the fill material is expected to consist of clay size particles < 5 μm.

5.1.3 Oceanography

Due to the small footprint of the proposed Liberty Island (less than 0.04 square miles or 22.9 acres), the presence of the offshore island is not expected to have any impact on regional oceanography or on the oceanography of Foggy Island Bay.

TABLE 5-1

POTENTIAL SEDIMENT PLUME AREAS FROM LIBERTY ISLAND CONSTRUCTION AND PIPELINE TRENCHING

Activity			Detailed Survey[1]				Original Survey[2]			
			Boulder Patch Coverage 10%-25%		Boulder Patch Coverage >25%		Scattered Boulders and Cobbles		Boulders and Cobbles	
	Plume Area (mi²)[3]	Plume Area (acre)[3]	Plume Area (mi²)[3]	Plume Area (acre)[3]	Plume Area (mi²)[3]	Plume Area (acre)[3]	Plume Area (mi²)[3]	Plume Area (acre)[3]	Plume Area (mi²)[3]	Plume Area (acre)[3]
Island Construction										
15 µm grain size	0.2	130	N/A	N/A	N/A	N/A	0	0	0.1	60
5 µm grain size	4.0	2,500	1.0	600	0.3	200	1.0	600	1.0	600
Pipeline Trenching										
Proposed Project	1.0	600	N/A	N/A	N/A	N/A	0.1	60	0	0
Eastern Pipeline Route	1.0	600	N/A	N/A	N/A	N/A	0	0	0	0

[1] Lee and Toimil 1985

[2] Reimnitz and Ross 1979

[3] Approximate areas based on worst-case plume model.

Construction will occur during the winter when ice cover is present and under-ice currents are usually westerly at less than 5 cm/s (0.1 knot).

Toimil and Dunton (1984) determined that the seafloor (and biota) may be affected over an area equivalent to twice the island footprint as a result of gravel placement and displaced sediments. Assuming this factor of two, the area of significant effects for physical parameters is estimated to be less than 0.08 square miles or 55.2 acres). This is about half of the area calculated to be potentially affected by sediment particles larger than 15 μm (0.2 square miles, Table 5-1). As shown on Figure 5-2, areas with the most potential to be affected during island construction activities are expected to lie primarily west and northwest of the island (downstream of the island given the predominant under-ice current direction).

5.1.4 Marine Water Quality

Total suspended solids (TSS) in the immediate vicinity of the island could increase as much as 120 mg/L over ambient during winter construction of the island, assuming worst-case conditions. This increase is temporary and expected to occur only during the 25 or so days of gravel placement (see Section 5.1.3). Ambient winter TSS values under ice are generally very low due to the quiescent conditions and the lack of sediment input from the rivers. During open water conditions, freshwater river inflow provides a flux of suspended sediments into Foggy Island Bay. Typical TSS measurements in nearshore Beaufort Sea locations ranged from 34 to 324 mg/L (see Section 4.5.3); therefore, the expected TSS increase from construction of the island is not likely to be greater than typical summer TSS values in the nearshore region.

During construction, there could be small spills of gasoline, diesel fuel, and/or hydraulic fluids from construction equipment and vehicles. A spill potential is associated with fueling of construction equipment. Any spills to the ice surface are expected to be very small and will be cleaned up immediately. It is unlikely that such spills will extend beneath the ice, or off the island surface to reach marine waters.

5.1.5 Benthic and Boulder Patch Communities

During island construction, a maximum of 0.04 square miles (27.6 acres) of the sea floor will be covered by placement of gravel. Existing infauna within this area will be permanently affected by gravel cover. Summer 1997 Boulder Patch surveys indicate that the proposed island location does not contain Boulder Patch communities.

Additional impacts on benthic communities adjacent to the island will include temporary sedimentation and reduced primary productivity caused by increased turbidity within an area of approximately 0.16 square miles (105 acres), primarily to the west and northwest of the island (Table 5-1). Since it is estimated that the area of potential effects is about 0.10 square miles (67 acres) based on mapping from Reimnitz and Ross (1979) and Lee and Toimil (1985), the 0.16-square mile figure should be considered a worst-case estimate for impacts to the adjacent area. The amount of Boulder Patch actually affected would be much less, given the broken and discontinuous pattern of boulder aggregations in this region.

The sediment plume resulting from the winter construction of the island could extend as far as 4.3 miles to the west/northwest, with the heavier sediments resettling within approximately one-half mile of the island (Figure 5-2). Such sedimentation would be a transient event occurring only during the winter of construction. No major changes in summer turbidity levels would be expected to occur because installation of filter fabric will greatly reduce additional fine sediments from being purged from the island. However, increased turbidity during the winter of construction could temporarily affect kelp growth if clear ice conditions occur during late winter in the year of construction. Although less than 10 percent of annual solar input for Boulder Patch kelp is received during the eight-month period of ice cover (Dunton 1990), this light is particularly important in spring if the ice is clear as opposed to turbid and relatively snow free. Under these conditions light can reach the bottom and result in a 30 to 40 percent increase in annual kelp, depending upon carbohydrate reserves (Dunton 1984, 1990). Increased turbidity would decrease solar irradiance and possibly growth during winter construction. This effect would be temporary and falls within the natural perturbations experienced by Arctic kelp communities. Winter growth rates of kelp regularly fluctuate in response to yearly variations in ice opaqueness and snow cover, both of which govern the level of winter irradiance of kelp beds. Reduced growth during the winter of construction would be similar to a year of heavy ice and snow cover, conditions with which the Boulder Patch kelp community regularly contends.

Sediment could accumulate on Boulder Patch communities downstream of the island, as well as from natural wave action, but once construction is completed during the open-water season, silt accumulation would likely be purged by current and wave action. Increased turbidity will not continue during subsequent years since filter fabric will prevent resuspension of fines associated with the gravel used for island construction. Boulder Patch communities located in the shadow of the Sagavanirktok River plume are quite viable (Martin and Gallaway 1994). No permanent sedimentation effects are expected to occur in the area encompassed by the extended winter construction plume.

In addition, it is anticipated that benthic organisms in adjacent areas are not likely to be affected by increases in sedimentation that may result from the presence and maintenance of the proposed structure. This conclusion is based on the results of a five-year study of drilling discharges from the Endicott drilling islands (ENSR 1991) and more than 6 years of study on development effects upon the Boulder Patch (Martin and Gallaway 1994). ENSR (1991) showed that drilling mud and cuttings discharges from the Endicott MPI have extended approximately 500 meters to the northwest, with no effects on the composition of the benthic community in the impacted area. Martin and Gallaway (1994) measured kelp health and growth and taxa diversity of the Boulder Patch community offshore from the Endicott Development and found no adverse effects.

5.1.6 Fish

Gravel fill will be placed through the ice during winter, with completion by March–April 1999. Anadromous species will be overwintering in freshwater habitats and will not be present at this time. Marine species, especially Arctic flounder, fourhorn sculpin and Arctic cod, will be present. Localized increases in turbidity and suspended sediments may cause decreased visibility for fishes foraging within the area during this period. Local reduction in available benthic forage species is not expected to be significant unless a localized high density area is covered. Increased turbidity may result in local decreases in abundance and reduced primary productivity of plankton communities due to decreased light availability; however, plankton levels are generally low from November through March within the area (Horner and Schrader 1984).

The filter fabric installed over the gravel island will minimize leaching of fine particulate materials from the island in subsequent open-water seasons. Any increased turbidity after construction will be very localized (within 0.15 square miles, or 105 acres, primarily to the west and northwest), and fish will be able to avoid these areas. No significant alteration of water movement is expected within the area, and therefore there will be no associated impact on wind-induced dispersal of amphidromous species during open water periods. Turbidity alterations associated with construction of Liberty Island are dwarfed by periodic resuspension of benthic sediments from wave action during summer and fall storms and by the dynamic turbidity plume emitted by the Sagavanirktok River, conditions under which fishes of all ages and species regularly and successfully contend.

Gravel removed from the Kadleroshilik River mine site will leave a depression in the floodplain which will fill with water during subsequent summer seasons. Fish will likely use this mine pit as an overwintering area. Organic materials and soils that are not needed to restore or backfill the pipeline shore approach trench, or are cleared during mine site excavation, will be placed in the mine site pit. It is likely this organic material will gradually decompose and be utilized as a source of nutrients by freshwater organisms, particularly those invertebrates that utilize peat or other organic materials for an energy source.

5.1.7 Marine Mammals

5.1.7.1 Pinnipeds

Of the three seals found in the region, only ringed seals are expected to occur within the proposed development area during winter island construction. Densities of ringed seals hauled out on ice in the general area, including the proposed Liberty Development Project area, have ranged from 0.58 seals/km^2 to 1.17 seals/km^2 (2 to 4 seals per square nautical mile [nm^2]) from 1985 to 1987 (Frost and Lowry 1988). More recent surveys are underway to update ringed seal densities (for 1996-1998). Based on the initial year's (1996) surveys, fast ice areas in survey sector B-3 (Oliktok Point to Flaxman Island) yielded 0.38 seals/km^2 (Frost et al. 1997). BPXA conducted an aerial survey of seals in the Liberty Development Project area during the spring of 1997 to provide updated and more site-specific density estimates. This study showed relatively low maximum seal densities south of the barrier islands (0.43 seals/km^2), and only slightly higher maximum densities north of the barrier islands (0.51 seals/km^2), during surveys conducted in late May and early June 1997 (Figure 4-4).

Inupiat hunters continually stress that all marine mammals are sensitive to noise, and take pains to make as little extraneous noise when hunting as possible. Seals are also said to be cautious of any unusual visual stimulus, especially if it is in motion. At the same time, seals are said to be curious and will sometimes investigate unusual objects, and can be attracted by imitating the normal, non-vocal sounds that seals make on the ice. In short, seals are sensitive to their surroundings, are especially responsive to sound, and tend to avoid unusual sounds. Industry and peer review findings are consistent with these traditional and local observations, and provide some quantified measure, in terms of distance, of this sensitivity to noise and other disturbance.

Green and Johnson (1983) found seals apparently were displaced from the area within a few kilometers of Seal Island during the island's construction during the winter of 1981-1982. Frost and Lowry (1988) similarly found seals avoiding areas within 3.7 km (2 nautical miles or 2.65 statute miles) of artificial islands, and that avoidance was stronger, a 50 to 70 percent reduction in seal density, when island activity was high. Two of three islands were under construction during their study. Based on these observations, there will probably be some displacement of ringed seals from the area adjacent to the Liberty Island construction area (1 to 2 seals per square nautical mile) and in areas where ice roads are constructed for hauling gravel. However, displacement will be local and overall effects on ringed seals from island construction will be negligible (Richardson et al. 1995a).

Seal reactions to construction are probably in part related to construction noise. Greene (1983) studied the underwater noise produced during construction of Seal Island, which was built in 12 meters of water compared to 6 meters for the proposed Liberty

Island. He found that at ≥€3.6 km from the Seal Island construction site, there was no evidence of propagation of noise components above 1000 Hz, and little propagation of components below 1000 Hz (Greene 1983). Thus, winter construction sounds do not propagate far in waters as shallow as those at Seal Island (12 meters), and would propagate even less well at Liberty (6 meters). Also, the likely radii of response by seals would be notably shorter than the maximum detection radius, which is already short. Ice road construction produced potentially-detectable low-frequency (< 200 Hz) underwater noise as much as 800 meters from the source (Figure 5-3; Greene 1983). During early island construction for an exploratory well, when ice is being cut and moved, noise from this construction operation at frequencies < 500 Hz was detectable to 0.8 km, and a single tone near 60 Hz was detectable to 1.6 km (Figure 5-4; Greene 1983). During late island construction, low-frequency sounds were detectable underwater to 0.8 km (Figure 5-5; Greene 1983).

Detectability of man-made noise is determined, in part, by natural background noise levels. Some limited measurements of ambient noise under the ice near Liberty were obtained during February 1997 (Greene 1997). Spectrum and 1/3-octave levels were well below the Knudsen sea state zero fiducial at all frequencies between 25 Hz and 5000 Hz. This is typical for an area of stable fast ice.

Direct measurements of acoustic transmission loss were made under the ice of Foggy Island Bay near Liberty during February 1997 (Greene 1997). At ranges between 0.2 and 2+ km and frequencies below 150 Hz, transmission loss was about 35 log (Range) plus an additional linear absorption term. This is a high rate of attenuation, as expected for waters only 6 to 7 meters deep. Attenuation rates could not be measured at higher frequencies, but were also expected to be high (Greene 1997). As a result of this rapid attenuation, noise from a drilling operation on Tern Island (near Liberty) generally was not detectable under the ice at distances beyond about 2 km notwithstanding the low ambient noise levels in the area. Under-ice noise from construction activities would also attenuate rapidly.

The hearing abilities of these mammals are another factor affecting their potential responses to man-made noise. The hearing abilities of ringed seals have not been measured at frequencies below 1 kHz (*cf.* Terhune and Ronald 1975). Based on data from other species, e.g., the harbor seal, hearing sensitivity is expected to deteriorate with decreasing frequency to a threshold of about 96 dB re 1 μPa at 100 Hz (Kastak and Schusterman 1995; Richardson et al. 1995b). This means that the radius of audibility of low-frequency construction sounds to seals will be smaller than the radii within which they are detectable by sensitive hydrophones under low ambient noise conditions.

During the late phase of island construction, sheet piles will be driven by vibratory and diesel hammers. Low-frequency impulse sounds will emanate from this activity, scheduled for completion by early to mid-August, and may disturb seals. During transport of the production modules to the island, some disturbance to seals is possible from vessel noises or other machinery. This disturbance will be short term and localized, and will occur during one season only.

Increased suspended sediments from the construction probably will not affect these mammals which commonly inhabit turbid waters (Richardson et al. 1989).

Some localized displacement of seals is possible, but overall population effects would be minimal. Similarly, some localized displacement of seal hunting activities may also be possible, but would be minimal in terms of the overall pattern of Nuiqsut seal hunting. The affected area is used seasonally (mainly during open-water) at a relatively low level, and alternative nearby hunting areas are likely to be as productive. As island construction activities will occur mainly in the winter, potential subsistence effects on seal hunting are expected to be low.

5.1.7.2 Cetaceans

Spring migration of bowheads and belugas through the Western Beaufort Sea occurs from April to June far north of the barrier islands. Whales, including bowhead, beluga, and gray whales, will not be within the proposed project area during winter and, consequently, will not be affected by the island construction. Placement of sheet piles for the island docking area will be completed by early to mid-August, and will generate noise during one season, but the sounds will not propagate far due to shallow waters and the barrier islands that lie between Liberty and the migration corridor used by the great majority of the bowheads. During studies of sound emanating from exploratory drilling on Sandpiper Island in the nearshore Beaufort Sea, sound rapidly attenuated within a few kilometers, probably due to the shallow waters (Greene and Moore 1995). Sound, especially at low frequencies, attenuates rapidly in shallow nearshore waters (Miles et al. 1987; Section 4.4 *in* Richardson et al. 1985). Direct measurements of sound transmission loss at Liberty were conducted in the 1997 open-water season, and results will be available soon (C.R. Greene, in prep.). Regardless, whales will not be present in the area during that time.

5.1.7.3 Polar Bears

Most polar bears will be casual visitors to the study area. Polar bears feed on seals and seal kills may attract other bears. Local whalers report that polar bears commonly scavenge whale carcasses left on Cross Island after the fall hunt. Potential impacts of island construction are disturbance, encounters with humans, and ingestion of harmful substances. Most denning polar bears are likely to be on the multiyear pack ice, north of the construction area. Four historic polar bear dens have been located within a 20 km radius of the proposed development area (Figure 4-3). All were occupied only once. Three were in the Shaviovik River Delta area (1912, 1992 and 1993), and one was on fast ice between Cross and Narwhal islands (1975; Figure 4-3). In addition, one other den site was located in the Sagavanirktok River delta in 1988, just west of the proposed development area. As with the other historical den sites, it apparently was used only once. Denning polar bears are apparently tolerant of disturbances, especially later in denning during winter and spring (Amstrup 1993). Should new den locations be suspected, BPXA will verify their locations and avoid the sites.

Subsistence hunting of polar bear in and near the project area is almost all associated with fall whaling activity. Island construction activities will have little or no effect upon this pattern of activity.

For island construction, as well as for pipeline construction, and for drilling and production operation, BPXA will develop and implement a wildlife interaction plan. This plan will include measures to avoid wildlife attractants and will address human/wildlife interaction.

5.1.8 Waterfowl and Marine Birds

Most birds occur seasonally in the Prudhoe Bay area, and very few overwinter in the area. During winter, a few Snowy Owls are known to occur in the offshore Beaufort Sea, where they prey on Black Guillemots (*Cepphus grylle*) that overwinter in unfrozen cracks and leads (Johnson and Herter 1989). Leads generally form well offshore of the proposed development area, and these species are not expected within the construction area. Snowy Owls, ptarmigan and Common Ravens may winter onshore in coastal areas and, similarly, are not expected within the proposed construction area. On occasion, ravens may be attracted to nearby seal kills on the ice.

Because the Kadleroshilik River gravel mine site is upstream from coastal salt marsh habitats, few brood-rearing/molting geese are likely to be present at the site or to be disturbed at the site during summer reclamation activities. Similarly, because the mine site is situated on a gravel island, and not on adjacent wetland tundra, few tundra-nesting birds are likely to be present at the site and disturbed at the site during summer reclamation activities. Any summer 1999 reclamation at the mine site would be scheduled to avoid disturbance of any nesting or brood-rearing waterfowl in the area (e.g., limit activity to early spring before broods leave Howe Island). Limited summer sprigging (vegetation planting) at the mine site will be scheduled to avoid snow goose disturbance. After mine site reclamation, there will be minimal human activity in this area.

5.1.8.1 Threatened and Endangered Species

Spectacled Eiders and Steller's Eiders will not be present within the proposed development area during winter construction. Bowhead whales will not be present.

5.1.9 Terrestrial Mammals

Most mammals occur seasonally within the proposed development area (e.g., caribou, muskoxen, fox, bear during summer; muskoxen, fox during winter) and will not be affected by winter construction activities offshore. Some disturbance to muskoxen is possible from development or reclamation activities at the Kadleroshilik River mine site. Arctic foxes may be attracted to island construction areas, but standard measures will be taken to avoid creating potential attractants.

5.1.10 Wetlands and Vegetation

Offshore island construction requires development of a gravel source. Two gravel sources were considered for this project: the existing Duck Island Gravel Mine located along the Endicott access road, and a new mine site in the Kadleroshilik River floodplain. The Kadleroshilik site was selected due to its proximity to the island location. It will be a one-time use site (although a reserve area will be permitted as a source of gravel for emergency construction of an island for relief well drilling, if ever required). Site development and reclamation will follow the Alaska Department of Fish and Game's North Slope gravel pit performance guidelines (McLean 1993), and will be similar to the East Badami Creek Mine Site and the Northstar Mine Site plans. Mine site placement will avoid or minimize the area of tundra vegetation affected. Gravel extraction will occur during winter, and the site will be accessed by ice roads. These measures ensure minimal impacts to tundra vegetation during gravel extraction and transport. The mine pit will likely fill with water during subsequent seasons and may provide habitat for fish, particularly in winter.

The 37.9 acre Primary Mine Site covers approximately 40 percent dry dwarf shrub/lichen tundra (15.1 acres); 20 percent dry barren/dwarf shrub, forb grass complex (7.6 acres); 10 percent dry barren forb complex (3.8 acres); and 30 percent river gravels (11.4 acres). The 7.2 acre Mine Expansion Area covers approximately 60 percent dry dwarf shrub/lichen tundra (4.3 acres) and 40 percent dry barren/dwarf shrub, forb grass complex (2.9 acres). The entire 45.1 acre Kadleroshilik River Mine Site covers approximately 43 percent dry dwarf shrub/lichen tundra (19.4 acres); 23 percent dry barren/dwarf shrub, forb grass complex (10.5 acres); 9 percent dry barren forb complex (3.8 acres); and 25 percent river gravels (11.4 acres). See Table 5-2 for plant communities likely to occur within these vegetation units based on Schick and Noel (1995). Wetlands at the mine site are 70 to 80 percent PEM1/SS1A and 20 to 30 percent R2US/OW (see Table 5-3 for descriptions of NWI wetlands classifications).

TABLE 5-2

VEGETATION TYPES AT ALTERNATIVE LIBERTY PIPELINE LANDFALL AND TIE-IN SITES AND THE KADLEROSHILIK RIVER GRAVEL MINE SITE

LEVEL C PHOTO-INTERPRETED VEGETATION UNITS (after Walker 1983)	LEVEL D TYPICAL PLANT COMMUNITIES (Schick and Noel 1995, taxanomic nomenclature follows Hulten 1968)
IIId. Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex (wet patterned-ground complex)	Primarily wet sedge tundra, with moist sedge, dwarf shrub tundra on polygon rims or stangmoor ridges. Wet *Carex aquatilis, Carex rotundata, Carex saxatilis, Eriophorum angustifolium* sedge tundra; and moist *Eriophorum angustifolium, Carex misandra, Carex aquatilis, Carex bigelowii, Carex atrofusca, Salix pulchra, Salix arctica, Salix reticulata, Dryas integrifolia* sedge, dwarf shrub tundra.
IVa. Moist Sedge, Dwarf Shrub/Wet Graminoid Tundra Complex (moist patterned ground complex)	Mixed high- and low-centered polygons dominated by moist sedge, dwarf shrub tundra, but with abundant low lying areas dominated by wet sedge tundra. Species are those of IIId.
Va. Moist Sedge, Dwarf Shrub Tundra	Well drained high-centered polygons. Moist *Eriophorum angustifolium, Carex misandra, Carex aquatilis, Carex bigelowii, Carex atrofusca, Salix pulchra, Salix arctica, Salix reticulata, Dryas integrifolia* sedge, dwarf shrub tundra at inland locations. *Eriophorum vaginatum* occurs sporadically at inland sites, but infrequently enough to classify as tussock sedge tundra. In coastal areas communities are *Poa arctica, Eriophorum angustifolium, Carex aquatilis, Luzula arctica, Salix rotundifolia x phlebophylla, Salix pulchra* and *Saxifraga cernua.*
Vc. Dry, Dwarf Shrub, Crustose Lichen Tundra (*Dryas* tundra, pingos, river bars)	Well drained vegetated river bars. Dry *Dryas integrifolia, Astragalus alpinus, Oxytropis borealis, Salix reticulata*, dwarf shrub forb, lichen tundra.
Vd. Dry Dwarf Shrub, Fruticose Lichen Tundra (dry acidic tundra)	Well-drained, high-centered polygons, common on plateaus above stream and river channels, at the margins of drained lake basins, and on reticulate patterned slopes where snowbanks build during winter. Dry *Salix rotundifolia x phlebophylla, Salix reticulata, Salix pulchra, Dryas integrifolia* dwarf shrub tundra with common graminoids *Carex misandra, Carex membranacea, Carex bigelowii, Eriophorum angustifolium, Luzula arctica, Poa arctica* and common forbs *Saxifraga punctata, Saxifraga hieracifolia, Pedicularis kanei, Polygonum bistorta,* and *Papaver macounii.*
IXb. Dry Barren /Dwarf Shrub, Forb Grass Complex (forb rich river bars)	Partially vegetated river bars above the active river channel with gravel substrates and probably only infrequently flooded. Dry *Dryas integrifolia, Salix rotundifolia x phlebophylla, Salix reticulata, Salix ovalifolia, Astragalus alpinus, Potentilla biflora, Arnica frigida, Artemisia arctica, Papaver lapponicum, Epilobium latifolium, Aster sibiricus, Deschampsia caespitosa, Alopecurus alpinus, Poa glauca Arctagrostis latifolia, Trisetum spicatum* dwarf shrub, forb grass tundra.
IXc. Dry Barren/Forb Complex (active river channels)	Partially vegetated gravel river bars in the active river channel regularly flooded during spring breakup. Dry *Artemisia arctica, Artemisia borealis, Artemisia glomerata, Epilobium latifolium, Sagina intermedia, Wilhelmsia physodes* and *Deschampsia caespitosa* forb barren.
IXe. Dry Barren/Grass Complex (coastal sand dune grassland)	Small pockets of sand dunes dominated by *Elymus arenarius*, along the immediate coast.
Xa. River Gravels	Completely barren river gravels or with sparse IXb or IXc communities.
BS. Barren Sand	Completely barren coastal beaches or with patches of community Ixe.

TABLE 5-3

DEFINITION OF NWI MAP CODES AND EQUIVALENT WALKER (1983) CATEGORIES FOR WETLAND TYPES OCCURRING AT ALTERNATIVE LIBERTY PIPELINE LANDFALL AND TIE-IN SITES AND GRAVEL MINE SITE

TYPE	NWI DESCRIPTION [1]	WALKER (1983) EQUIVALENTS
	Estuarine (E) System	
E2USP	Intertidal, unconsolidated shore, irregularly flooded. [Unvegetated mud and sand flats in low-energy, brackish water environments.]	IXh, IXi; Wet or Dry Coastal Saline Barrens
	Riverine (R) System	
R2US/OW	Lower perennial, unconsolidated shore/open water. [Complexes of 50%–70% river bars/flats and open-water channels.]	Ia, IXc, Xa; River Bars/Water
	Palustrine (P) System	
PEM1E	Emergent, persistent, seasonally flooded/saturated. [Sedge meadow in low-centered polygons, large depressions and drained lake basins with shallow standing water remaining through early summer.]	IIIa, IIIc, IIId; Wet Sedge or Graminoid Tundra
PEM1F	Emergent, persistent, semipermanently flooded. [Sedge marsh in lake basins, ponds and lake shoreline with standing water most years from August–September.]	IIb, IId; Aquatic Graminoid Tundra, Pond Complexes
PEM1/SS1A	Emergent, persistent/scrub shrub, broad-leaved deciduous, temporarily flooded. [Areas on river flood plains with mix of herbaceous emergent vegetation and broad-leaved deciduous shrubs.]	Vc, IXb; Dry Dwarf Shrub, Forb Grass Complex
PEM1/SS1B	Emergent, persistent/scrub shrub, broad-leaved deciduous, saturated. [Saturated graminoid/dwarf shrub tundra, usually without standing water; includes sedge tussock tundra.]	IVa, Va, Ve; Moist/Wet, Moist or Dry Sedge/Dwarf Shrub Tundra
PEM1/SS1E	Emergent, persistent/scrub shrub, broad-leaved deciduous, seasonally flooded/saturated. [Saturated polygonal tundra with a mix of herbaceous emergent vegetation in basins and dwarf shrubs on ridges. Also refers to non-polygonal tundra with a mosaic of seasonally-flooded sedge meadow and saturated graminoid/dwarf shrub tundra.]	IIIa, IVa
PSS1/EM1B	Scrub shrub, broad-leaved deciduous/emergent, persistent, semipermanently flooded. [Dwarf shrub/graminoid tussock tundra with shrub cover 50%–70%. Commonly called "moist tundra."]	IVa, Va, Ve; Moist/Wet, Moist or Dry Sedge/Dwarf Shrub Tundra
POWH	Open water (less than 20 acres), permanently flooded.	Ia; Water

[1] National Wetlands Inventory 1989; Cowardin et al. 1979; USFWS no date.

NOTE: The pipeline alternatives are generally located in the shaded types.

5.1.11 Cultural Resources

There is little probability of adverse effects on cultural resources from the proposed offshore island construction.

In terms of the proposed location for the island, historic shipwreck remains are unlikely (Tornfelt and Burwell 1992). However, the FEIS for Lease Sale 144 (MMS 1996a) does note that there are 14 Beaufort Sea shipwrecks which have been documented but not precisely located; therefore, some could possibly be in the project area. No shipwrecks in Foggy Island Bay were detected by side-scan sonar and other geophysical instruments during the site-specific survey conducted during summer 1997. While underwater prehistoric cultural resources are possible, because of coastal subsidence (Dixon et al. 1978), they also are unlikely to be encountered, except perhaps in areas already documented through traditional accounts (MMS 1996a; Friedman and Schneider 1987), and certainly not as far offshore as the location of the proposed island. The Beaufort Sea's erosional coastal processes would have reworked any land forms, and none are likely in the offshore project area.

The preferred gravel mine site avoids known cultural resources. The onshore ice road system from this mine site and water sources to the proposed island site will avoid known cultural resource sites.

5.2 SUBSEA PIPELINE CONSTRUCTION

Two potential pipeline routes for the Liberty Development Project were considered in project planning (see Figure 3-1):

- The proposed project pipeline route (application filed with Alaska State Pipeline Coordinator's office on 8 August 1997) is a straight, approximately 6.1-mile south–southwest route to a landfall located about 1.5 miles west of the Kadleroshilik River; from here the route continues 1.5 miles south to a tie-in with the Badami Sales Oil Pipeline.
- The alternative is a straight, approximately 5.6-mile south–southeast route from the island to a landfall point located about 2 miles east of the Kadleroshilik River; from here the route continues 3 miles south to a tie-in with the Badami Sales Oil Pipeline.

A third alternative pipeline route (Liberty Island to the Endicott Development) was considered and rejected in part because of potential significant impacts on the Boulder Patch communities along its route. This analysis considers impacts of both route alternatives; these impacts are similar for each route. Boulder Patch habitat (10 percent or more rock cover) was not detected on either route by the 1997 summer studies. The proposed route was selected on the basis of overall length, avoidance of the need for drag-reducing agents to achieve productivity on the eastern route (and associated issues of chemical storage and handling), and minimal effects on benthic habitats.

5.2.1 Air Quality

Construction emissions during laying of the subsea pipeline, for both routes, are expected to consist of vehicle and equipment emissions. Emissions from construction equipment will be transitory and will not have a significant impact on air quality in the region due to frequent winds. As discussed in Section 5.1.1, an EPA Part 55 permit application will address emissions from construction vessels, vehicles, and equipment operating on the OCS.

Fugitive dust is not expected to be generated during trenching or backfilling operations as it is removed as wet or frozen material.

5.2.2 Sediment Suspension and Transport

As discussed in Section 5.1.2, it is possible to calculate the probable maximum particle migration from the pipeline trench using Stokes' Law (equation #3 in Section 5.1.2) to determine the fall velocity (w) of discrete particles in water. The effective theoretical downstream distance required to capture all suspended particles is then calculated using equation #4 in Section 5.1.2.

Material excavated from the bottom during trenching operations along the proposed project (western) route and the alternative route is expected to consist of fine sand, silt and clay down to about 2.4 meters (8 feet) (see Section 4.3.1). Most of the sediments along the pipeline route are smaller than 70 μm. The clays tend to be cohesive and form large clumps when disturbed. The large clumps fall out of the water column at the location of disturbance (D. Miller, Duane Miller and Associates, pers. comm.). Using a typical mean grain size of 30 μm, a typical under-ice current of 2 cm/s (0.04 knots), and a water depth of 6.1 meters (20 feet) at the island site (which would be 1 to 2 meters less due to ice thickness), the possible extent of increased sedimentation from trenching is about 300 meters (about 1,000 feet) west/northwest (downcurrent) of the trenching activity. This is a worst-case estimate. In shallower water, this distance will be reduced. For example, in 3 and 1.5 meters (10 and 5 feet) of water, the effective downstream distances could be about 150 and 75 meters (about 500 and 250 feet), respectively. The potential turbidity plume from each alternative pipeline corridor under the assumptions provided above is shown on Figure 5-6. Figure 5-6 and Table 5-1 show that, for the proposed project, an area of 1.0 square miles (about 600 acres) has the potential for increased turbidity due to trenching. Of this area, approximately 0.1 square miles (about

60 acres) exhibits scattered boulders and cobbles (based on Exhibit A and Reimnitz and Ross 1979 and Lee and Toimil 1985).

5.2.3 Oceanography

Construction of a pipeline trench, along either of the two alternative routes, is not expected to affect oceanographic conditions in Foggy Island Bay. Because the pipeline trench will be backfilled as the pipeline is placed, bathymetry in the immediate vicinity of the trench will be minimally changed by the presence of the subsea pipeline.

Ice slots opened to allow placement of the pipeline may not refreeze prior to breakup, and the ice that is thickened for the ice road may take longer to melt. These impacts will be seasonal and are not expected to affect regional ice dynamics beyond very minor local changes during the first breakup following construction.

5.2.4 Marine Water Quality

It is possible that TSS in the immediate vicinity of either alternative pipeline trench will be increased as much as 50 mg/L above ambient. This value is based on data obtained in the Northstar Development area during an under-ice trenching study (Montgomery Watson 1996). This study found increases of 20 to 30 mg/L TSS within 46 meters (150 feet) of the trench. Sediments in the Northstar Development are expected to be of similar grain size as those at the Liberty Development. BPXA may need to request a water quality variance from ADEC addressing increased turbidity in State waters during construction.

Small spills and leaks of fuels and hydraulic fluids as described in Section 5.1.4 may also occur during trench construction. Since trench construction will occur during winter, it is unlikely that any contaminants will reach the water. These spills will be handled as described in Section 5.1.4.

5.2.5 Benthic and Boulder Patch Communities

Effects on the benthic environment from pipeline trenching and backfilling will include disturbance or removal of benthic habitat, temporary turbidity, and sedimentation. Materials excavated during trenching will be replaced as backfill. Linear distances traversed by subsea pipeline alternatives, by water depth, are listed in Table 5-4. Effects on benthos inhabiting the nearshore area from the shoreline to the 6-foot depth contour will be expected to be minor because this area is recolonized annually and is subject to frequent disturbances because of storm-induced wave action and ice movements during the open-water season. Between 6-foot and 16-foot depths, benthic communities (infaunal

TABLE 5-4

LIBERTY PIPELINE ALTERNATIVE LENGTHS AND AREAS OF SEAFLOOR DISTURBED BY TRENCHING

	Shore to 8 feet		8 to 18 feet[1]		>18 feet[1]		Totals	
Alternative (See Figure 5-6)	Length (ft)	Impact Area (acre)	Length (ft)	Impact Area (acre)	Length (ft)	Impact Area (acre)	Length (ft)	Impact Area (acre)
Proposed Project	14,900	20.1	12,500	37.8	4,900	15.0	32,300	72.9
Eastern Pipeline Route	3,000	4.2	7,100	21.5	20,300	61.5	30,400	87.2

[1] Boulder Patch communities may occur at depths greater than 6 feet (Lee and Toimil 1985; Reimnitz and Ross 1979; LGL and Dunton 1989, 1990, 1991, 1992).

and epibenthic invertebrates) are generally low in density; beyond the 16-foot depth, these benthic communities are more diverse and abundant (WCC 1996).

Boulder Patch communities, however, are not well developed along the pipeline route. The proposed pipeline route does not appear to contain Boulder Patch habitat based on previous maps depicting the extent of this habitat in Stefansson Sound (e.g., Reimnitz and Ross 1979; Toimil and Dunton 1983). To confirm this, in summer 1997 BPXA conducted side-scan sonar and underwater video surveys of the proposed route. Some potential rough bottom conditions, which could be cobble materials comprising less than 10 percent cover, were noted along the route (totaling about 4,700 feet). These areas of reflectivity from the sonar surveys were investigated using a remotely-operated vehicle (ROV) with a video camera. Visibility was poor, and the results of the visual inspection were inconclusive concerning the nature of the targets. Whatever the composition of the targets, coverage of the bottom was far less than 10 percent, and these targets were in shallow water (<12 feet). Boulder Patch communities do not thrive in this area in water depths less than about 12 feet because of sediment deposition processes (see Section 4.6.3). The sediments over much of the island site and pipeline route appear to be soft silts, with only a few shallow (approximately 2 feet deep or less) surface expressions of sandy areas. Collectively these observations support the conclusion by Reimnitz and Ross (1979) that Boulder Patch habitat is absent in the area of any of the Liberty Development facilities. Under-ice underwater surveys will be conducted in these areas in winter 1998 by an ROV to ground-truth the side-scan sonar information.

Increased fine-grain sedimentation from trenching may extend up to 300 meters (984 feet) west/northwest of the pipeline corridor. Such sedimentation would be a transient event occurring only during the winter of construction with no major changes in summer turbidity levels expected. For the reasons discussed above in Section 5.1.5, increased turbidity during the winter of construction could temporarily affect kelp growth in isolated Boulder Patch outcroppings that may lie in the shadow of the plume. This effect would be limited to the winter of construction, and no permanent effects would be expected. Sediment could accumulate on Boulder Patch communities downstream of the pipeline corridor but, once construction is completed, any residual silting would likely be purged by current and wave action. No permanent sedimentation effects are expected to occur from trenching activity. Trench backfill will be reworked and smoothed by wave action in subsequent summers, and turbidity will fall within normal ranges.

5.2.6 Fish

Effects of pipeline construction (both routes) will be the same as island construction. Turbidity plumes will be produced during construction, which may affect the marine species present. The extent of benthic forage habitat disturbed will be larger than for island construction, but benthic habitats will not be permanently affected by pipeline construction. These habitats and associated epifaunal and infaunal organisms are adapted to disturbances caused by ice breakup and wave action, and will likely return to pre-construction productivity and diversity levels within one season following pipeline installation.

5.2.7 Marine Mammals

The effects of subsea pipeline construction (both routes) during February to May on ringed seals and polar bears (the only marine mammals expected to be within the development area) will be similar to the effects of island construction. Character and transmission of noise produced by the proposed equipment will be similar to those measured by Greene (1983) during early island construction. Those sounds were measurable at Seal Island to a maximum distance of about 1.6 km (Figure 5.4, from Greene 1983). The maximum detection distance near Liberty would be less because of the shallower water (6 vs. 12 meters).

Potential effects on subsistence resource use patterns will be minimal.

5.2.7.1 Pinnipeds

Potential impacts of pipeline construction (both routes) will generally be the same as those for island construction. Ringed seals are the only pinnipeds expected to be within the proposed construction area. Some displacement within several kilometers of the ice roads and pipeline construction route may occur. Responses will be primarily to noise produced by machinery during construction which will be similar to the early island construction noise recorded at Seal Island (Figure 5-4; Greene 1983) and to disturbance associated with machinery and equipment operations. Responses of seals will be limited, given the poorer sound propagation conditions at Liberty (6- vs. 12-meter depth) and the limited hearing sensitivity of seals at low frequencies (Kastak and Schusterman 1995; Richardson et al. 1995b). Localized displacement will have negligible impact on ringed seals.

5.2.7.2 Cetaceans

No whales will be within the area during winter construction.

5.2.7.3 Polar Bears

Potential impacts to polar bears from subsea pipeline construction (both routes) will be the same as those for island construction. Ice roads and ice road construction may encounter polar bear denning habitat in the Shaviovik River delta. BPXA will coordinate its activity with the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game.

5.2.8 Waterfowl and Marine Birds

As with island construction, overwintering birds are not expected to be encountered within the proposed pipeline construction areas.

5.2.8.1 Threatened and Endangered Species

Spectacled Eiders and Steller's Eiders will not be within the proposed development area during winter construction. Bowhead whales will not be present during winter.

5.2.9 Terrestrial Mammals

As with island construction, most mammals occur seasonally within the proposed development area (e.g., caribou, muskoxen, bear, fox during summer; muskoxen, fox during winter) and will not be affected by winter construction activities. Arctic foxes are the only terrestrial mammals likely to venture near the proposed subsea pipeline construction area. These animals are attracted to activity which may result in localized concentrations. However, an environmental awareness plan for the project will emphasize measures to minimize wildlife interactions.

5.2.10 Cultural Resources

There is little probability of potential effects on cultural resources from the proposed subsea pipeline construction. As discussed previously in Section 5.1.11, historic ship remains are unlikely but could possibly be in the project area. Underwater prehistoric cultural resources are possible but are unlikely to be encountered (MMS 1996a, Volume 1:III-C-22; Friedman and Schneider 1987), and almost certainly only in nearshore areas. Since these areas will be avoided by the pipeline landfall (see Section 5.3.11), any such potential effects will be avoided. The Beaufort Sea's erosional processes would have reworked any submerged remnant land forms, and none are likely in the offshore project area. Thus, any offshore archeological remains would have been destroyed and would be difficult or impossible to recognize (Duane Miller and Associates 1997).

5.3 ONSHORE CONSTRUCTION

Construction of onshore pipeline segments will be required. The proposed overland route (landfall west of the Kadleroshilik River) avoids major lakes, river crossings, salt marsh, and other ecologically sensitive areas. The transition from the buried offshore segment to the onshore segment will be trenched, with the vertical transition made through a cased riser. The overland segment will be constructed using conventional North Slope techniques. All onshore construction will be carried out during winter from ice pads and ice roads.

5.3.1 Air Quality

Placement of fill materials for pads associated with the onshore portion of the pipeline is not likely to greatly increase airborne dust concentrations. Because pipeline construction is expected to occur during the winter months, minimal dust will be generated from the frozen materials. In addition, due to the winter construction, impact to vegetation and wetlands is not expected from airborne particulates.

As described previously for offshore pipeline and island construction, combustion products from diesel fuel and gasoline burning engines will be released during the onshore construction portion. However, since this construction is not expected to last longer than five months, any impact will be short term and localized.

5.3.2 Hydrology

For either route, two small gravel pads will be constructed. These pads will be sited to minimize disturbances to local drainage patterns. There will be no overland road associated with the pipeline. All onshore portions of the pipeline will be elevated on VSMs. Therefore, the short overland portions of either are not expected to alter natural tundra drainage patterns.

5.3.3 Fish

Neither the proposed route nor the alternative pipeline route involve any buried stream crossings. Both pipeline alternatives will be designed as an elevated pipeline. Construction will be in winter from an ice road (or gravel pad at the tie-in and landfall). The western (proposed project) pipeline route does not cross currently-designated streams or waterbodies containing freshwater or anadromous fish. The eastern alternative crosses a small beaded, intermittent tributary to the Kadleroshilik River that may contain ninespine stickleback. Effects of the ice roads used to access the area will be negligible as the ice will melt in place; some thickened areas over rivers will melt slightly later than river ice, but are not expected to affect fish movements.

As mentioned in Section 5.1.6, excess overburden from the onshore pipeline trench or from mine site development will be placed in the Kadleroshilik River mine site. These materials will be a nutrient source to the mine pit when it fills with water, possibly benefiting freshwater organisms for one or more seasons.

5.3.4 Marine Mammals

Onshore pipeline construction will have no effect on walrus, seals, or whales.

5.3.4.1 Polar Bears

Onshore pipeline construction and associated access ice roads over the tundra may encroach on polar bear denning habitat within the Kadleroshilik River delta. BPXA has incorporated all historical den locations into its project design and work plans. In the event a new den is located, BPXA will consult with the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game to determine the most appropriate mitigation measures.

Subsistence hunting of polar bear in and near the project area is almost all associated with fall whaling activity. Pipeline construction activities will have little or no effect upon this pattern of activity.

5.3.5 Waterfowl and Marine Birds

Waterfowl and marine birds are seasonal North Slope residents and are not expected to occur within the development area during winter onshore pipeline construction. Snowy Owls, Common Ravens and ptarmigan do overwinter in tundra areas on the North Slope, but are expected to be few in number.

5.3.5.1 Threatened and Endangered Species

Spectacled Eiders and Steller's Eiders overwinter in marine environments and will not occur within the proposed development area during winter construction. Gravel placement for both pipeline alternatives at landfall and tie-in sites are primarily on moist and dry tundra habitats. Spectacled Eiders nest and brood-rear primarily in wet and aquatic tundra habitats. No Spectacled Eider pairs have been sighted in recent survey years near the proposed gravel placement sites, or within drained lake basin habitats adjacent to proposed sites (Figure 4-6). Steller's Eiders have not been observed during aerial surveys within the proposed development areas.

A Spectacled Eider pair was sighted during the 1994 aerial survey in a pond approximately 100 meters from the proposed mine site (Figure 4-6). Nesting may have occurred at this site but was unconfirmed. None were observed at this site during the 1995 aerial survey.

5.3.6 Terrestrial Mammals

Most mammals occur seasonally within the proposed development area and will not be affected by winter construction activities. Arctic fox, ground squirrels, and grizzly bears may occur within the proposed development during winter. Onshore pipeline construction could affect denning grizzly bears. Most grizzly bear dens are located inland or to the east of the project area.

Construction activity can cause short-duration but intense disturbance for bears denning very near the center of activity. However, evidence to date suggests that most denned bears are very tolerant of construction and seismic activities more than 0.5 to 1.0 miles away, and some bears have not abandoned dens in response to disturbances at much shorter distances. A bear abandoning a den during the early denning period may be able to successfully establish a new den. Later in the denning period, abandonment will be more critical, especially to pregnant females, which give birth to cubs in late December or early January and which cannot move newborn cubs to new sites.

The onshore project area, because of its distance from NSB villages, is little used for the harvest of terrestrial subsistence resources.

5.3.7 Wetlands and Vegetation

NWI maps prepared by the U.S. Fish and Wildlife Service (Cowardin et al. 1979) at a scale of 1:63,360 (1 inch = 1 mile), and July 14, 1995 1:18,000 scale natural color aerial photography, were used to assess wetland types for areas affected by trenching, gravel placement, and gravel extraction. Overlays scaled to fit NWI maps at 1:63,360 scale for pipeline alternatives and the gravel mine site were used to identify wetland types at these locations.

Vegetation units were assessed from 1:6000 and 1:7200 scale natural color and color infrared aerial photography. Ground data and natural color photo enlargements used in developing the *Badami Site Area Vegetation Types Map* (Schick and Noel 1995) were referenced during identification and delineation of vegetation units. Overlays of trench, gravel pad and mine site placements were scaled to fit the natural color photo enlargements. Vegetation units were then tabulated and percent coverage by vegetation unit was visually estimated for each placement. Site visits were not conducted, and vegetation analysis was based on aerial photo interpretation. Plant community data are as described for the Badami Development (BPXA 1995) at areas east of the proposed onshore Liberty Development alternatives (Schick and Noel 1995) (Table 5-2).

Onshore pipeline segments will be elevated above the tundra surface on VSMs. This will result in minimal disturbance to tundra vegetation in the area surrounding the VSMs. Construction will occur during winter from ice roads to minimize impact to tundra vegetation. Gravel pad placement at the pipeline landfall and tie-in sites with the Badami Sales Oil Pipeline will cover no more than 0.6 acres of tundra vegetation with gravel. Pad placement will be optimized to prevent alteration of surface drainage patterns during spring runoff, further minimizing impacts to tundra vegetation.

The pipeline landfall will require a trench from the buried offshore segment to the elevated onshore segment. The trench will be about 200 feet long and could be as much as 150 feet wide, for a maximum impact area of 0.7 acres. The pipeline trench will cut through the coastal bluff. After laying the pipeline, the trench will be refilled, with organic layers from the top of the trench replaced on the surface. It is expected that, at the shore crossing, the backfill will be topped with a veneer of fine-grained soils and organics, and seeded as needed to promote revegetation. Coarser granular material from the gravel mine or the excavation will be used as a veneer to achieve erosion resistance similar to the adjacent, undisturbed material. This plan minimizes any increase in erosion due to construction through coastal bluffs and is intended to replicate the natural strength and character of the landform.

NWI wetland types for the pipeline trench, pipeline landfall pad and tie-in pad sites for both the eastern and western pipeline routes are presented in Table 5-5. Vegetation units based on aerial photo interpretation (Table 5-2) and estimated coverage for the two pipeline alternatives are presented in Table 5-6.

The area affected by digging a trench where the subsea pipeline comes ashore will cover approximately 0.7 acres. A small gravel pad (approximately 0.1 acres) will be placed at the point where the Liberty pipeline changes from a buried to an elevated line. A gravel pad large enough for helicopter landing (approximately 0.5 acres) will be placed at the tie-in of the Liberty and Badami pipelines. The area that will be covered by trenching and gravel pad placement will not exceed 1.3 acres. Summaries of the predominant wetland types affected at landing and tie-in sites are presented in Table 5-5. National Wetlands Inventory (NWI, Cowardin et al. 1979) categories are defined, described and cross referenced in Table 5-3. Vegetation units (after Walker 1983) and typical plant communities (Schick and Noel 1995) within areas affected by pipeline trenching, gravel pad placement, and gravel extraction are described in Table 5-2.

TABLE 5-5

SUMMARIES OF PREDOMINANT NWI WETLAND TYPES AT ALTERNATIVE LIBERTY PIPELINE LANDFALL AND TIE-IN SITES AND GRAVEL MINE SITE

SITE	DESCRIPTION
Alternative Pipeline Route	
Landfall	The pipeline trench will cross a narrow section of beach (E2USP[1]). The trench will then continue, cutting through a small tundra bluff, approximately 4 feet high. Gravel placement will be within PEM1/SS1B[1] wetland.
Tie-in	Wetlands at this tie-in site are primarily PSS1/EM1B[1].
Proposed Pipeline Route	
Landfall	The pipeline trench will cross a narrow section of beach (E2USP[1]), and cut through a small tundra bluff, approximately 5 feet high. Gravel placement will be within PEM1/SS1E[1] wetland.
Tie-in	Wetlands at this tie-in site are primarily PEM1/SS1B[1] and PEM1E[1].

[1] See Table 5-6 for definitions.

TABLE 5-6

ESTIMATED VEGETATION COVERAGE BY ONSHORE LIBERTY PIPELINE TRENCH AND GRAVEL PADS

	ESTIMATED PERCENT COVER BY VEGETATION UNIT (see Table 5-2 for Vegetation Unit Descriptions)						
	IIId	**IVa**	**Va**	**Vd**	**IXe**	**BS**	**APPROXIMATE ACREAGE**
Alternative Pipeline Route							
Landfall Trench			70		20	10	0.7
Landfall Pad			100				0.1
Tie-in Pad		50		50			0.5
Approximate Acreage	0.0	0.3	0.1	0.3	0.0	0.0	1.3
Proposed Pipeline Route							
Landfall Trench			20	70		10	0.7
Landfall Pad			100				0.1
Tie-in Pad	10	60	30				0.5
Approximate Acreage	0.1	0.1	0.3	0.0	0.00	0.0	1.3

5.3.8 Cultural Resources

The coast of Foggy Island Bay has several documented archaeological sites, several Native Allotments, and several documented culturally-significant use areas (Sections 4.12, 4.13.3). Both pipeline route alternatives potentially affect one or more of these resources. The western (proposed project) route could have a higher risk of adverse effects than the eastern route, since it will come onshore near a documented archaeological site (XBP-024) as well as a Native Allotment (FF 12053). Further west is an additional archaeological site (XBP-023) and a documented use area. Based on a recent survey and communications with representatives of the State Office of History and Archeology (SHPO), however, an adequate buffer zone will exist between the pipeline and XBP-024 to afford resource protection (J. Lobdell, Lobdell & Associates, Inc., pers. comm.). SHPO has requested that XBP-024 be designated in the Oil Discharge Prevention and Contingency Plan as an area to be protected during any needed spill response activities.

The eastern route proposes a landfall in a documented use area which may contain the remains of some sod structures and graves. Further east (approximately 1 mile) from this proposed landfall is a documented archaeological site (XBP-026), a Native Allotment (F 11943), and another documented use area. BPXA conducted archaeological surveys in the summer of 1997 and found no cultural resources that would be affected by the eastern landfall (J. Lobdell, Lobdell & Associates, Inc., pers. comm.).

The short onshore pipeline connection required to reach the Badami pipeline will not affect any archaeological, historical, or other culturally-significant use sites (J. Lobdell, Lobdell & Associates, Inc., pers. comm.).

If cultural resources not discovered during archeological surveys are discovered during construction, work will be halted and the State Historic Preservation officer will be contacted. In addition, the NSB Inupiaq History, Language, and Culture Commission will be consulted. Following their discussion, appropriate action will be taken based on the State's and Commission's recommendations.

Secondary impacts to cultural resources include damage from increased visitation (whether authorized or unauthorized), which may cause increased natural erosion from increased pedestrian traffic, looting, or contamination of the site. These effects may occur to sites not directly affected by project siting but which are in fairly close proximity. All project personnel will receive training on the importance of cultural sites and will be instructed to avoid such sites. The lack of permanent access along the pipeline route will limit year-round access. Thus, mitigation measures will minimize or eliminate these potential effects. These sites will be identified for protection in the project's oil spill response plan.

5.4 OIL PRODUCTION OPERATIONS

Oil production operations will consist of two primary activities: drilling and production. Both will start about the same time. Drilling is likely to occur full time for about 2 years. Production operations are anticipated to last for 15 years. Drilling and production operations are expected to overlap for about 15-16 months. In later field life, infill wells may be drilled or there may be drilling activity associated with well workovers.

5.4.1 Air Quality

Once production facilities are installed and operational, gas-fired, turbine generators will provide power for operations and drilling. Emergency power will be available from the two, 1,500-kilowatt (kW) diesel generators which also will provide a portion of the power during the construction phase.

Vehicle and vessel emissions associated with transport of personnel to and from the island during the life of the project could minimally affect local air quality. Under both the proposed development plan and the eastern pipeline route alternatives, summer island access will be by helicopter or marine vessel. Each winter, an ice road will be constructed to allow island access. During freezeup and breakup periods, access to the island will be by helicopter. Housing for drilling and production crews will be provided on the island. Crews will change out about every 14 days, with only incidental travel between changes.

With enactment of the Clean Air Act Amendments of 1990, the U.S. Environmental Protection Agency (USEPA) has jurisdiction for air quality over blocks leased under this lease sale (MMS 1996a). BPXA filed an application for a Part 55 Air Permit in 1997.

Lease operators are required to comply with the requirements promulgated by USEPA for Outer Continental Shelf (OCS) sources, including the provisions of Title I, Part C, of the Clean Air Act (Prevention of Significant Deterioration of Air Quality). Section 328 states that, for a source located within 25 miles of the seaward boundary of a State, requirements would be the same as those that would be applicable if the source were located in the corresponding onshore area. Therefore, air emissions for the drilling and production activities at the Liberty Island were evaluated to determine if they exceed Prevention of Significance Deterioration (PSD) levels. For any pollutant that exceeds significant levels, the permit application demonstrated that anticipated project emissions will be below applicable National Ambient Air Quality Standards and PSD increments. An assessment of air quality effects will be conducted using the dispersion model approved by the USEPA. Air quality-related values (AQRV), such as visibility, local vegetation, threatened and endangered species, and population growth, also were reviewed; and a Best Available Control Technology (BACT) assessment was conducted on emissions sources.

In accordance with BPXA corporate policy, process design incorporated measures to reduce the emissions of "greenhouse gasses," notably carbon dioxide. These measures include the selection of efficient turbine drivers, minimizing flaring during operation upsets, waste heat recovery, seawater deaeration using vacuum stripping rather than fuel gas stripping, and fuel gas pretreatment to reduce carbon dioxide content.

5.4.2 Sediment Suspension and Transport

Concerns over sediments in marine waters from the island construction were addressed in Section 5.1.2. Long-term erosion from the island will be minimal because of the protection afforded by filter fabric and island slope armoring. Small quantities of sediments could wash from the island during summer storms and wave action, but will be negligible; resuspension of bottom sediments during storms likely will mask any further sediment input from the island.

Some runoff from the island can be expected during the warmer months. This runoff (deck drainage) will be controlled as described in BPXA's application for an individual NPDES permit.

5.4.3 Oceanography

Due to the small footprint of the island (0.04 square miles, 27.6 acres), it is not expected to affect oceanography in Foggy Island Bay any more than in a very localized sense. The presence of the island will alter the direction of currents in its immediate vicinity. When currents are strong (~1 m/s), a small wake may be created downstream of the island, affecting a distance of 2 to 3 times the island diameter. There will be no effects expected on temperature and salinity.

Thickened ice to support seasonal ice roads may take longer than the surrounding ice to melt during spring breakup each year. The overall impact of the remaining ice is expected to be negligible.

5.4.4 Marine Water Quality

Oil production operations at Liberty Island could produce any or all of the following discharges to the marine environment: waterflood strainer backwash effluent, desalination unit effluent, temporary discharge from sanitary and domestic wastewater systems, fire control test water, deck drainage, and construction dewatering. All discharges will be addressed in a National Pollutant Discharge Elimination System (NPDES) permit. The permit will set effluent limits at levels designed to protect the receiving waters. Present engineering design anticipates that the effluent will contain detectable levels of residual chlorine and could have increased total suspended solids (TSS), salinity and temperature as compared to the receiving waters. However, treatment prior to discharge, and other engineering controls that use Best Available Control Technology (BACT), will reduce these changes such that no deleterious effects on marine organism populations are expected. This will be assured by meeting the NPDES permit effluent limits.

Other marine water quality issues during operations include fuel spills and hydraulic fluid which may reach the marine environment and spills of crude oil which reach marine waters. Issues associated with spilled crude oil are presented in Section 5.5.

5.4.5 Benthic and Boulder Patch Communities

Normal operation of the Liberty Development Project will not affect benthic communities. All effluent from process discharges will meet NPDES requirements as stated in Section 5.4.4. It is anticipated that effluent limitations will be set low enough to protect potential nearby benthic communities. Filter fabric will provide a barrier between the gravel and open water and will minimize leaching of fine sediments from the gravel by wave action or periodic storms.

In the event of a pipeline leak, resulting spilled oil will be released within the benthic environment from subsea portions of the pipeline (see Section 5.5 on effects of oil spills). Pipeline leakage in the subsea portion of the pipeline will require excavation and repair of the pipeline. These repairs will have effects similar to pipeline construction. Access to the pipeline leak will involve seafloor excavation to provide access to the pipe. Some increased turbidity and sedimentation will result, but will be localized. Since there is little Boulder Patch community adjacent to the pipeline, these effects are expected to be minimal.

5.4.6 Fish

Under normal operations, the Liberty Development Project, and all of its ancillary activities (e.g., subsea pipeline, boat traffic, discharges), will have no effect on anadromous or marine fishes in the region. Wastewater from island processes will either be injected or will meet NPDES permit requirements. Although salinity, temperature and other parameters could be increased over ambient levels in the immediate vicinity of the outfall, deleterious effects to fish populations are not expected. The development represents an extremely localized disturbance offshore of summer fish habitat. The mobile nature of fishes in the area will allow them to easily circumvent point disruptions. Adult anadromous fishes can range hundreds of kilometers along the coast each summer, and navigate across coastal topographic irregularities far more extensive than the Liberty Development Project.

5.4.7 Marine Mammals

As during construction, most effects of production activities on marine mammals will be in response to underwater and airborne noise produced during operations. Production will require transportation to the Liberty Island by aircraft (helicopter, Bell Jet Ranger), boats, or trucks (on ice) which will generate additional noise. Non-acoustic effects include exposure to spilled oil and NPDES-permitted wastewater effluent. Since the effluent will be regulated by permit limitations, no deleterious effects on marine mammal populations are expected.

During island construction in winter, 10 vehicle trips per day on an ice road will be needed for personnel and supply transport, supported by occasional helicopter use. During breakup, 10 to 15 helicopter trips per day to the island will be required to support construction; and, during summer, 10 to 29 helicopter or boat trips will be employed for personnel transport each day. Barges also will be used to support construction during summer, with up to 150 trips expected throughout the open water season from Prudhoe Bay or Endicott. One sea lift (two to three barges) will transport production and other modules to the island in one season. Operation of Liberty will require two to three helicopter trips per week, approximately 100 vehicle trips on ice roads each winter, and four to five local barge trips each summer. More details are available in the companion Development and Production Plan. In addition to potential disturbance from helicopters, vehicles, or vessels, the following section describes expected sounds that will emanate from Liberty during drilling and production operations.

5.4.7.1 Drilling and Production Noise

Drilling and production noise, generally < 200 Hz, will be audible underwater within a 0.9 to 1.9 km (0.5 to 1 nm) radius during periods of ice cover, but low-frequency components may be detectable to 7.4-11.1 km (4-6 nm) during unusually quiet periods (Malme and Mlawski 1979; Table 5-7).

In very shallow arctic water, drilling from pads of ice resting on the bottom may generate noise, but it does not propagate far from these rigs. Noise from a rotary-table drillrig on one ice pad was primarily below 350 Hz. In water 6 to 7 meters deep, the noise attenuated rapidly from ~125 dB at range 130 meters to ~85 dB (and barely detectable) at 2 kilometers (ice cover 2 meters; 31 log *R* loss rate; Richardson et al. 1990). Cummings et al. (1981), working in even shallower water, reported an overall received level of only 86 dB re 1 μPa at 480 meters from a rig drilling on ice. There were many tones at 10 to 160 Hz.

TABLE 5-7

MAJOR TONAL COMPONENTS PRODUCED DURING DRILLING AT NIAKUK 3, AN ARTIFICIAL ISLAND WITH DISTANCE FROM THE SOURCE

Source: Malme and Mlawski 1979

	Measurement Position			Tonal Frequency (dB re 1 μPa)		
Station	**Distance (m)**	**Distance (feet)**	**Direction**	**5 Hz**	**23 Hz**	**80 Hz**
1	975	3,200	WNW	95	88	86
1A	1,341	4,400	NW	82	82	51
2	1,890	6,200	NW	80	79	48
2S	1,609	5,280	SW	82	83	64
3	4,267	14,000	NNW	77[1]	56	34

[1] Levels from drilling on both Niakuk and Reindeer Island audible.

Noise measurements also have been made during the open water season near two man-made islands off Prudhoe Bay in water 12 to 15 meters deep: Davis et al. (1985) re Seal Island; Johnson et al. (1986) re Sandpiper Island. Noise levels at distances as close as 450 meters were quite low, comparable to median ambient levels expected for sea state one with no shipping. Underwater sounds from Seal Island, when it was manned but inactive, were not detectable 2.3 kilometers away, even though power generators were in use (Davis et al. 1985).

Drilling on an artificial island (Sandpiper Island) produced notable underwater sound, but its level was low. Median broadband (20 to 1000 Hz) levels at range 0.5 km were 8 to 10 dB higher with drilling. The most obvious components were tones at 20 and 40 Hz, attributed to power generation. There was rapid attenuation (24 to 30 dB) from 0.5 to 3.7 kilometers, no doubt partly because of the shallow water. The effective source level of the 40-Hz tone was low: ~145 dB re 1 μPa-m (Miles et al. 1987).

Impulsive hammering sounds associated with installation of a conductor pipe on Sandpiper Island were as high as 131 to 135 dB re 1 μPa at range 1 kilometer when pipe depth was > 20 meters below the island. In contrast, broadband drilling noise at this distance was only ~100 to 106 dB. During hammering, blows occurred about every three seconds, signal duration was 0.2 seconds, and the transient signals had strongest components at 30 to 40 Hz and ~100 Hz. Similarly, Moore et al. (1984) reported that received levels for transient pipe-driving bangs recorded 1 kilometer from a man-made island near Prudhoe Bay were 25 to 35 dB above ambient levels in the 50- to 200-Hz band. Such sounds might be received underwater as far as 10 to 15 kilometers from the source—farther than drilling sound.

Direct measurements of underwater sounds from drilling on an island in Foggy Island Bay were made under the ice during February 1997 (Greene 1997). The strongest components of the sounds were at frequencies below 170 Hz. Received levels of the strongest components diminished rapidly with increasing distance, and dropped below the ambient noise level (which was low) at ranges of about 2 km. Even at distances as close as 200 meters from the drillrig, the drilling sounds were not evident at frequencies above about 400 Hz (Figure 5-7).

As noted in Section 5.1.7.1, at ranges between 0.2 and 2+ km and at frequencies below 150 Hz, transmission loss was rapid: about 35 log (Range) plus an addition linear absorption term. This rapid attenuation is as expected for waters only 6 to 7 meters deep. Attenuation rates could not be measured at higher frequencies, but were also expected to be high (Greene 1997).

Greene (1997:21) notes that, during production at Liberty, "the types and frequency characteristics of some of the resulting sounds would be similar to those from the drilling equipment that he studied. Electric power generation, pumps, and auxiliary machinery would again be involved, as would a drillrig during the early stages of production. However, the production island would also include additional processing and pumping facilities. If the production equipment requires significantly more electric power, then its generator sounds may be received at greater distances. However, observed high spreading losses (35 dB per tenfold change in range) plus the linear attenuation rates of 2 to 9 dB/km (0.002 to 0.009 dB/m) will diminish the levels rapidly with increasing distances. The presence of the barrier islands to the north, and the associated very shallow water approaching those islands, implies that underwater sound transmission beyond the islands, into the Beaufort Sea, will be especially poor. Transmission within the lagoon (under the ice in winter) can be expected to be as measured."

Underwater sound transmission within the lagoon near Liberty in the open water season was measured during August 1997 by C. Greene (in prep.). Analyses of these data will be available in early 1998.

During the open water season, as in winter, sound propagation from the Liberty area northward into the open Beaufort Sea is expected to be severely limited by the islands and shallow water.

Richardson et al. (1995) summarize: noise associated with drilling activities varies considerably with ongoing operations. The highest documented levels were transient pulses from hammering to install conductor pipe. Underwater noise associated with drilling from natural barrier islands or man-made islands is generally weak, and is inaudible at ranges beyond a few kilometers.

5.4.7.2 Pinnipeds

Aircraft overflights and vessel traffic will, at the most, cause short-term and localized behavioral responses by ringed seals and a small number of bearded and perhaps spotted seals. No significant effects on individuals or the population are expected from the normal course of operating the Liberty Development Project.

Reactions of ringed seals to drilling operations are summarized in Richardson et al. (1995a). Ringed seals may exhibit some tolerance for drilling noise. Ringed seals approached and dove within 50 meters of a source of projected low-frequency (< 350 Hz) drilling sounds and tolerated received levels up to about 50 dB above natural background noise levels (Richardson et al. 1990, 1991; Smultea et al. manuscr.). However, actual operations will also involve airborne sound and non-acoustic stimuli, so avoidance radii could be larger. Frost and Lowry (1988) found that densities of ringed seals on ice in spring were reduced within 3.7 km (2 nm) of artificial islands with active operations. Ringed seal surveys conducted in the area in Spring 1997 indicated that seals were present near the Endicott MPI and SDI, an active oil production facility (Figure 4-3) (LGL and Greeneridge 1997).

There has been little systematic study of the reactions of ringed or bearded seals to aircraft overflights and vessels, and the few data mainly concern seals hauled out on ice. Phocinid seals in the water seem less responsive to aircraft and vessels than seals that are hauled out on land or ice (Richardson et al. 1995a). Ringed seals in open water often dive when overflown by an aircraft at low altitude, but sometimes surface alongside ice pans only minutes after a helicopter lands there.

Ringed seals, most of which were hauled out on ice pans, often showed short-term escape reactions when a ship came within 250 to 500 meters (Brueggeman et al. 1992). However, where boat traffic is heavy, there have been cases where phocid seals habituate to vessel disturbance (Bonner 1982). Ringed seals in the water show considerable tolerance of underwater playbacks of recorded low-frequency sounds, including icebreaker sounds (Richardson et al. 1991; Smultea et al. manuscr.). Even during operation of a towed array of airguns, ringed seals showed only limited avoidance within 150 meters of a tugboat (Harris et al. 1997). During 1997 seismic surveys conducted in the region, ringed seals displayed some avoidance behavior within a few hundred meters of the sound source vessel, but did not appear to abandon the general survey area (LGL and Greeneridge 1997).

Bearded seals hauled out on ice sometimes react to low-altitude overflights by diving into the water. Bearded seals may be more likely to react to a helicopter than to a fixed-wing aircraft (Burns and Frost 1979).

Bearded seals approached and dove within 50 meters of a source of projected low-frequency (< 350 Hz) drilling sounds (Richardson et al. 1990, 1991; Smultea et al. manuscr.). Bearded seals may have some tolerance for drilling noise.

Reactions of bearded seals in water to approaching vessels have apparently not been reported. However, when recorded icebreaker sounds were projected into the Beaufort Sea during spring, there were 10 sightings of bearded seals in the water within 150 meters of the operating projector (Smultea et al. manuscr.).

Few spotted seals occur within the development area, but it is expected that they will be tolerant of drilling noises similar to ringed and bearded seals.

Spotted seals hauled out on land in summer are unusually sensitive to aircraft overflights and boat traffic. They often rush into the water when an aircraft flies by at altitudes up to 1,000-2,500 feet (300-750 m) or more, and at lateral distances up to 0.5 miles (0.8 km) (Frost and Lowry 1990; Frost et al. 1993; Rugh et al. 1993). Spotted seal haul-out locations should be avoided by aircraft. No known spotted seal haul outs are located in the vicinity of the Liberty Development Project. In the past, a few spotted seals have been observed in the Sagavanirktok Delta (S.R. Johnson, LGL Ltd., pers. comm.), but no known sightings have occurred in recent years. No specific information about reactions of spotted seals in the water to aircraft or vessels is available.

Helicopter flights during breakup and freezeup for island crew changes and resupply will be predominantly onshore to avoid potential marine mammal disturbance. If a spotted seal haul-out site is identified near a helicopter corridor, the location will be avoided. Spotted seals seem especially responsive to aircraft.

Some localized displacement of seals is possible, but overall population effects would be minimal. Similarly, some localized displacement of seal hunting activities may also be possible, but would be minimal in terms of the overall pattern of Nuiqsut seal hunting. The affected area is used seasonally (mainly during open water) at a relatively low level, and alternative nearby hunting areas are likely to be as productive.

5.4.7.3 Cetaceans

5.4.7.3.1 Bowhead Whales

It is not expected that drilling and production noise from the Liberty Development Project will reach migrating bowhead whales. Noise is not expected to be transmitted more than a few kilometers from the island. Near the Liberty Development Project, the bowhead migration corridor is approximately 10 km seaward of the barrier islands, although a few whales have been sighted in lagoon entrances and inside the barrier islands (LGL and Greeneridge 1997). In addition, the position of the McClure Islands will provide insulation of drilling and production noises from migration routes. Even in the low-ambient noise conditions prevailing under ice in winter, drilling sounds from Tern Island were rarely detectable 2 km away (Greene 1997). Sounds from a production island could be somewhat stronger, but ambient noise levels in the open-water season also tend to be higher, reducing the effective radius of audibility. Drilling noises and propagation losses in September and October during the autumn migration of bowheads were measured at Sandpiper Island, in water deeper than that at Liberty (Tables 5-8 and 5-9). The shallower water depth and soft sediments at Liberty Island will result in poorer propagation of long wave-length sounds similar to those produced at frequencies of 20 and 40 Hz during drilling operations at Sandpiper Island. Routine production noises will be expected to be less than drilling noises. Sounds with levels above ambient are not expected to reach migrating whales. However, as mentioned in the draft stipulations for the proposed MMS Lease Sale 170, experiences relayed by subsistence hunters indicate that, depending on the type of operations, some whales demonstrate avoidance behavior at distances of up to 35 miles.

Harassment by an aircraft, such as prolonged circling directly overhead at low altitude, often results in dispersal of whales from an area. However, helicopter transport of field crews to the Liberty Island will follow a flight path south of the migration corridor. Also, bowhead reactions to a single helicopter overflight are brief and probably have no lasting consequences (Richardson et al. 1995b; Patenaude et al. manuscr.). In general, few bowheads will be exposed to project aircraft, and any behavioral reactions that might occur are expected to be infrequent and inconsequential.

Similarly, vessels used in the summer for normal island access and resupply will remain within the barrier islands and, therefore, are unlikely to encounter a whale.

TABLE 5-8

COMPARISON OF SOUND LEVELS AT BOTTOM HYDROPHONE ABOUT 0.5 km FROM SANDPIPER ISLAND AT THREE TRANSITIONS BETWEEN DRILLING AND NOT DRILLING (LEVELS IN dB re 1 μPa)

Source: Johnson et al. 1986

			Tones (Hz)		Centre Frequency (Hz), 1/3rd Octave Band Levels													Band Level
Date	**Time**	**Activity**	**20**	**40**	**20**	**25**	**31**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**800**	**20-1000 Hz**
16 Oct.	17:46	Not Drilling	85	87	87	88	90	91	83	76	73	74	74	66	66	71	64	95
"	"	Drilling	91	102	92	91	95	103	88	82	81	82	84	78	77	74	66	104
17 Oct.	12:51	Not Drilling	90	83	91	88	87	89	88	87	85	85	85	85	85	84	80	98
"	"	Drilling	100	107	100	88	90	107	88	88	86	86	86	86	86	85	82	108
17 Oct.	13:19	Not Drilling	88	NP[1]	90	88	90	93	90	90	89	89	90	86	86	83	79	100
"	"	Drilling	99	106	100	89	93	107	92	91	88	89	91	86	87	84	78	108

[1] NP signifies the tone was not present.

TABLE 5-9

COMPARISON OF DRILLING AND NOT DRILLING SOUNDS AS RECEIVED AT BOTTOM HYDROPHONE, ABOUT 0.5 km FROM SANDPIPER ISLAND, ON 17 OCTOBER (LEVELS IN dB re 1 μPa)

Source: Johnson et al. 1986

			Tones (Hz)		Centre Frequency (Hz), 1/3rd Octave Band Levels													Band Level
Time	Sensor	Activity	20	40	20	25	31	40	50	63	80	100	125	160	200	250	800	20-1000 Hz
12:51	Bottom hydrophone	Drilling	100	107	100	88	90	107	88	86	86	86	86	86	86	85	82	108
"	3.7 km sonobuoy	"	76	76	76	67	70	78	74	76	75	74	73	73	71	70	60	85
"	9.3 km sonobuoy	"	NP[1]	NP	86	84	85	84	84	84	83	83	82	81	81	80	77	95
13:19	Bottom hydrophone	Drilling	99	106	100	89	93	107	92	91	88	89	81	86	87	84	78	108
"	3.7 km sonobuoy	"	NP	76	68	68	66	77	72	74	74	72	73	72	71	70	60	84
"	9.3 km sonobuoy	"	NP	NP	84	83	82	82	81	81	82	80	80	79	78	79	75	92
12:51	Bottom hydrophone	Not Drilling	90	83	91	88	87	89	88	87	85	85	85	85	85	84	80	98
"	3.7 km sonobuoy	"	67	64	69	67	66	70	74	76	77	74	74	74	74	71	62	85
"	9.3 km sonobuoy	"	NP	NP	86	86	85	85	85	84	84	82	83	80	80	80	78	95
13:19	Bottom hydrophone	Not Drilling	88	NP	90	88	90	93	90	90	89	89	90	86	86	83	79	100
"	3.7 km sonobuoy	"	NP	NP	69	67	67	69	71	74	74	74	73	73	72	71	61	83
"	9.3 km sonobuoy	"	NP	NP	79	79	78	79	80	80	80	78	80	79	78	79	77	91

[1] NP signifies the tone was not present.

Reactions of bowheads to vessels can include changes in activity, surfacing-respiration-dive cycles, swimming speed, and swimming direction; direct approaches usually lead to obvious avoidance reactions (Richardson et al. 1985; Richardson and Malme 1993). Avoidance reactions sometimes occur at distances > 4 km, but bowheads often tolerate approaches of vessels to within 2 to 4 km. Bowheads sometimes tolerate the approach of a slow-moving vessel to within a few hundred meters, especially when it is not directed toward the whale and when there are no sudden changes in direction or engine speed (Richardson et al. 1995a). Also, given their normal migration route, migrating bowheads are not expected to enter the Liberty Development Project area or to come within 4 km of the transportation corridor within Stefansson Sound. Since little potential exists for interactions between vessels and bowheads, the few disturbance incidents that might occur are not expected to have any significant or long-term consequences for the whales.

The "normal" migratory corridor for bowhead whales passing offshore from the Liberty project area is 10 km seaward of the barrier islands, but whales have been known to occur inshore of the barrier islands (Thomas Napageak took his first whale only 1 mile off the Canning River delta, for example). Thus, local residents believe that the potential for vessel/bowhead interaction exists. However, the normal migration of whales (as shown by the normal hunting pattern of Nuiqsut whalers, which is outside of the barrier islands) would not be affected by inshore activities associated with the Liberty Development. If a very unusual year should occur in the lifetime of the project, where most whales were migrating inshore of the barrier islands, BPXA would discuss this concern immediately with the AEWC.

There is some indication that concentrations of bowhead whales may occur offshore from Narwhal Island during late summer/early autumn, which may indicate feeding habitat for bowhead whales in the vicinity (Point Thomson State Lease Sale testimony of Thomas P. Brower, Jr.[1978]). Because the proposed development will be shoreward of Narwhal Island, there is little potential for disturbance of feeding bowheads by vessel traffic. However, to ensure no encounters, routine vessel traffic for island access and resupply will be restricted to inshore of the islands.

5.4.7.3.2 Gray Whale

Gray whales rarely occur within Stefansson Sound and are even less likely to occur within Foggy Island Bay. Noise from the production island is not expected to reach the offshore areas where gray whales may occur on rare occasions during summer.

5.4.7.3.3 Beluga Whales

Responses of beluga whales to drilling operations are described in Richardson et al. (1995a) and summarized here. Belugas have been seen regularly within 100 to

150 meters of artificial islands in the Mackenzie Estuary (Fraker 1977a, 1977b; Fraker and Fraker 1979 *in* Richardson et al. 1995a). However, it is important to note that belugas are in the region only during late summer/fall and almost all of them are far offshore. Spring migrating belugas showed no overt reactions to recorded drilling noise (< 350 Hz) until within 200 to 400 meters of the source, even though the sounds were measurable up to 5 km away (Richardson et al. 1991). During another study, overt reactions by belugas within 50 to 300 meters involved increased swimming speed (Stewart et al. 1983). The short reaction distances are probably partly a consequence of the poor hearing sensitivity of belugas at low frequencies (Richardson et al. 1991, 1995b).

A minority of migrating belugas (~3 percent) overflown by a Twin Otter aircraft, and a much larger portion (~31 percent) of belugas overflown by a Bell 212 helicopter (typically at lower altitudes), reacted overtly (Richardson et al. 1995b; Patenaude et al. manuscr.). Reactions by belugas tend to be more common when aircraft altitude is low (e.g., at 250 to 500 feet or 75 to 150 meters altitude) than when it is higher (1,000 to 1,500 feet or 300 to 450 meters), but there is much variability. Few, if any, belugas will be overflown during helicopter flights over nearshore waters. Therefore, only small numbers of belugas will react to aircraft, and these reactions will be brief and of no long-term significance to individuals and the population.

Because of the offshore distribution of most autumn-migrating belugas, few, if any, are expected to encounter project vessels. If any such approaches do occur, a small number of belugas may show short-term avoidance reactions that will be of no long-term significance to individuals and the population. There would be little, if any, effect on subsistence activities.

5.4.7.4 Polar Bears

Most polar bears will be casual visitors to the study area. Potential impacts are encounters with humans and ingestion of harmful substances. Most encounters are harmless—the polar bear approaches a facility and then continues on its way. Human safety is the priority of any arctic operation. Polar bears are a valuable resource and important to Inupiat Natives who live and work in the arctic. For these reasons, MMS has published guidelines for oil and gas operations in polar bear habitats (MMS 1993). Simultaneously, BPXA developed its own polar bear policy and interaction plan (BPXA 1993). With these guidelines and plans in effect, few, if any, adverse effects on polar bears are expected as a result of the Liberty Development Project. As stated previously, potential effects on the subsistence use of polar bears also will be minimal. BPXA will acquire a Letter of Authorization for polar bear disturbance. Worker training programs will be part of a project-specific plan to minimize polar bear attraction or encounters. BPXA will continue coordination and cooperation with the USFWS and ADF&G on polar bear protection measures for this project.

5.4.8 Waterfowl and Marine Birds

Potential impacts to waterfowl and shorebirds include loss of habitat, disturbance, and decreased nest success. Impacts are expected to be of greatest concern during the breeding season. Habitat loss includes direct loss from gravel placement and secondary changes to adjacent areas resulting from altered drainage, dust deposition, or thermokarst. In developments with little habitat loss due to small pads, such as the proposed Liberty Development Project, birds displaced by gravel placement and changes in adjacent habitat remain to nest in nearby areas (Troy and Carpenter 1990). Therefore, there are no apparent population level consequences from small scale habitat loss. Impacts from the proposed development are expected to be small scale and limited to the immediate vicinity of human activities associated with gravel placements, and will result in minor displacement of breeding birds with no expected population-level impacts.

There is concern that petroleum development had indirectly caused increases in Glaucous Gull, Arctic fox, and Common Raven abundance, due primarily to supplemental food, and that this may result in increased predation on tundra nesting shorebirds and waterfowl.

Effects of offshore oil development on marine and coastal birds are described in Hansen (1981) and summarized in FEIS for Lease Sale 144 (MMS 1996a), and include oil pollution of the marine environment, noise, and disturbance of bird populations. Sources of noise and disturbance to marine and coastal birds are primarily air and marine traffic. Routine shift changes during breakup (helicopter) and the early open water period (boats) have the greatest potential of disturbance to nesting and early brood-rearing waterfowl. Low altitude overflights of Howe Island and other offshore islands with nesting waterfowl could lead to increased predation by Glaucous Gulls and Common Ravens on eggs and young as adult birds are flushed from nests and distracted from protecting their young. Frequent boat-traffic disturbance of nesting ducks has resulted in 200 to 300 percent increases in gull predation on duck eggs and young in areas within 200 meters of gull colonies (Åhlund and Götmark 1989 *in* MMS 1996a). Other studies (Johnson et al. 1987) have shown that petroleum development activities on offshore barrier islands have negligible effects if mitigation programs are implemented and enforced. BPXA will restrict helicopter overflights of Howe Island during spring nesting periods (mid-May through mid-July); to avoid the airspace over or around the island, aircraft will maintain a minimum 1,500 feet altitude or lateral separation from Howe Island, and travel to the project site over land to the greatest extent practicable.

5.4.8.1 Threatened and Endangered Species

Spectacled Eiders are subject to the same types of concerns generally afforded other species of birds on the North Slope. These concerns include the potential for decreased populations (or impediment to recovery) due to habitat loss, disturbance of birds, and decreased productivity. Decreased productivity is generally a secondary effect arising from increased predator populations reducing nest success, including such factors as nest abandonment and predation on eggs or chicks. Protection measures can be expected to be applied more conservatively in areas supporting Spectacled Eiders versus other tundra-breeding birds in general, because these birds are currently listed as threatened under the Endangered Species Act. The U.S. Fish and Wildlife Service has developed preliminary protection guidelines for new developments within the breeding range of the Spectacled Eider. These measures include:

- Prohibiting high-noise facilities, such as gathering centers and airports, within 0.6 mile of nest sites;
- Prohibiting facilities within 0.1 mile of nest sites; and
- Maintaining adequate access for birds to move from nest sites to brood-rearing areas.

Some disturbance of Spectacled Eiders may result from regular inspection flights required to monitor pipeline integrity. However, aerial surveys of Spectacled Eiders indicate that they are tolerant of low altitude helicopter flybys (i.e., they exhibit low incidence of flushing) during regular census surveys.

Steller's Eiders are not expected to occur within the Liberty Development Project area, so Liberty operations are not expected to have any adverse effects on this species.

5.4.9 Mammals

The proposed onshore gravel placement will not affect movements of large mammals (e.g., bears, caribou, muskoxen, and moose). However, some species may be attracted to gravel pads to seek relief from insect harassment (caribou) or because of availability of attractants such as food (bears, foxes). Additional detail on potential impacts to large mammals is presented below.

The subsistence use of terrestrial mammals from the project area is minimal, primarily due to its distance from Nuiqsut and Kaktovik. Existing Prudhoe Bay oil and gas development already somewhat restricts access to the area from Nuiqsut. In any event, the proposed project will have little effect on the present pattern of use of terrestrial mammals for subsistence by local Inupiat hunters.

5.4.9.1 Caribou

No significant impacts on caribou are expected as a result of operating the Liberty Development Project. The potential impact of the project on Central Arctic Herd (CAH) caribou is displacement of maternal caribou from a portion of their calving grounds and blockage of caribou movement during the insect season. While use of calving areas varies greatly among years, the northern portion of the traditional calving grounds can extend toward the proposed development area. The coastal location for the pipeline routes (i.e., proposed project and eastern route) has little potential for interference with caribou during the calving period, because it intersects only the northern-most portion of the traditional calving grounds. Pipelines elevated $\geq$ 1.5 meters (5 feet) without associated gravel roads allow free passage of caribou (Cronin et al. 1994), and are not expected to block caribou movements during the insect season. Disturbance from routine travel to and inspection of pipelines may cause short-term local displacement of a few caribou, but will not affect the CAH.

5.4.9.2 Muskoxen

Muskoxen calve and overwinter in areas south of the Liberty Development Project area. Therefore, no effects on this species are expected.

5.4.9.3 Moose

Because relatively few moose are found in the project area, no effects on this species are expected.

5.4.9.4 Grizzly Bear

Once onshore pipeline construction is completed, no adverse effects on grizzly bears are expected due to oil field operations.

5.4.9.5 Arctic Fox

Arctic foxes have been shown to be extremely tolerant of human activities associated with oil development at Prudhoe Bay (Garrott et al. 1983). They have been able to occupy the Prudhoe Bay area and successfully reproduce there, concurrent with extensive development (Eberhardt et al. 1982; Garrott et al. 1983; Burgess and Banyas 1993). Day-to-day operations of the Liberty Development Project are expected to have no impact on Arctic foxes.

5.4.10 Cultural Resources

No effects on cultural resources are expected as a result of Liberty Development Project operations.

5.5 FATE AND EFFECTS OF OIL SPILLS

5.5.1 Risk of an Oil Spill

BPXA is required by both state and federal law to implement approved spill contingency plans for this project. Implementation of these plans (an Oil Spill Contingency Plan approved by MMS, and an Oil Discharge Prevention and Contingency Plan approved by the Alaska Department of Environmental Conservation) is the primary means of minimizing the risk of a spill, and assuring that BPXA is capable of responding in the event a spill does occur. The project spill plan identifies MMS and ADEC-required spill prevention measures, as well as demonstrates the capability to respond to worst-case spill events.

5.5.2 Behavior of Spilled Oil

5.5.2.1 Marine Environment

5.5.2.1.1 Open Water Conditions

Once released to open water, a large array of mechanical, physical, chemical, and biological processes begin to act upon the spilled oil. The processes work together to determine the ultimate fate of the spilled oil and, in the Beaufort Sea, are complicated by the seasonal effects of cold temperatures and the presence of ice (Dames and Moore 1988). The processes alter the chemical and physical characteristics and toxicity of spilled oil. Collectively these processes are referred to as weathering and, along with the physical oceanography and meteorology, determine the oil's fate. The major oil-weathering processes have been identified as: spreading, evaporation, dispersion, dissolution, emulsification, microbial degradation, photo-oxidation and sedimentation to the seafloor or stranding on the shoreline (Payne and McNabb 1985; Payne et al. 1987; Boehm 1987). Figure 5-8 provides the basic processes and their time frames for acting upon the spilled oil. Colder arctic temperatures could act to increase these times. Oil spills spread less and remain thicker than in temperate waters because of differences in the viscosity of oil (MMS 1996a).

During or immediately after an oil spill occurs in open water, the processes of spreading and advection determine the distribution and character of the spilled oil. The oil slick will spread horizontally in an elongated pattern oriented in the direction of wind and currents, with areas of thin sheen interspersed by thicker patches. Advection tends to dominate all other transport mechanisms and acts throughout the entire time the spill is on the water surface.

5.5.2.1.2 Floating Solid Ice Conditions

Oil released into the water column under a floating solid ice cover will rise and gather in pools or lenses at the bottom of the ice sheet. Oil may become trapped in brine channels or become entrained as new ice grows beneath the oil (Industry Task Group 1983). Currents approaching 26 cm/s (0.5 knot) would be needed to remove and transport exposed oil in subsurface depressions prior to entrainment (Cox and Schultz 1981). Typical under-ice currents along the Liberty pipeline are unlikely to exceed an average of 2 cm/s (see Section 4.4.1); however, currents ≥ 10 cm/s do occur. These winter under-ice currents are unlikely to spread spilled oil beyond the initial point of contact with the ice under surface.

Two physical factors that act to naturally limit the area contaminated by oil under solid ice are natural depressions related to variability in snow depth, and rapid incorporation of the oil by new ice growth around and beneath the oil layer. Ice naturally develops an undulating bottom surface in response to snow drift patterns on the surface. Researchers have investigated the holding capacity of ice covers by mapping the under-ice topography and calculating the potential for oil containment (e.g., Kovacs et al. 1981). More information is provided in the spill plan.

Natural variations in ice thickness comprise the most important physical characteristic limiting the spreading of oil from an instantaneous (batch) release characteristic of a pipe rupture. In the case of a small leak in the order of hundreds of barrels per day, a second natural limit on oil spreading will include the continuing growth of new ice around the periphery of the contaminated area.

With a chronic leak, new ice is prevented from immediately growing directly as a hard layer beneath the oil pocket due to the continuing arrival of fresh oil. Ice crystals present in the water at the oil/ice interface will probably be incorporated to provide a slush/oil mixture that gradually thickens the longer the leak remains undetected. At the same time, new ice growing around the perimeter of the contaminated area will progressively contain the oil. The end result for most of the winter will be a cylinder of liquid oil and slush deepening as the surrounding ice grows. Once the leak is detected and the flow stopped, new ice will begin to form beneath the oil within several days during the primary growth period (December to April).

In the case of a chronic leak spanning the April to June period, the contaminated area will increase as the ice growth rate slows down. The final trapped oil geometry in this late winter situation would be similar to chronic leaks in midwinter, except that the oil pocket will assume the shape of an inverted truncated cone, with the largest diameter at the deepest depth and the angle of the cone increasing as new ice growth diminishes.

The rate of vertical migration depends on the degree of brine drainage within the ice (a function of internal temperature), oil pool thickness, and oil viscosity. During the period from November to February, when the sheet is cooling and growing rapidly, there are very few passages for the oil to penetrate. Vertical migration of the oil in this period is limited to several inches of initial penetration through the porous skeletal layer of individual ice crystals at the ice/water interface.

The internal ice temperature reaches a minimum in late February. As ice temperatures gradually increase in March and April, brine trapped between the columnar ice crystals begins to drain out of the ice, leaving vertical channels for the oil to eventually rise to the surface. The rate of oil migration increases rapidly once daily air temperatures remain consistently above freezing. Natural melt of the ice from the surface down acts as a competing process to expose encapsulated oil. When this melt reaches the level where the ice was growing at the time of the spill, the oil is exposed. In most situations of a concentrated thick oil layer in the ice, natural migration will bring most of the oil to the surface before the surface melts down to meet it.

Once the oil reaches the ice surface, it lies in melt pools or remains in patches on the melting ice surface after the surface waters have drained. Winds act to herd the oil into thicker layers against the edges of individual pools. Any oil remaining on the ice at final breakup and disintegration of the ice cover will be released into the water as slicks and sheens.

5.5.2.1.3 Broken Ice Conditions

In broken ice conditions, oil would rise to the surface and either collect in the interstices or openings between individual floes or be trapped underneath the floes themselves. During the early period of broken ice in the spring, that portion of the oil rising beneath the floes will naturally migrate through the rotting ice and appear on the ice surface within a matter of hours. For the case of oil trapped under newly forming pancakes or sheet ice in the fall, the likely fate will be rapid entrapment, with new ice quickly growing beneath the oil as already discussed. The fate of oil trapped between floes will depend largely on the ice concentration and time of year.

During freezeup, the oil will most likely be entrained in the solidifying grease ice and slush present on the water surface prior to forming sheet ice. Storm winds at this time often break up and disperse the newly forming ice, leaving the oil to spread temporarily in an open water condition until it becomes incorporated in the next freezing cycle.

Spills from the pipeline may take the form of either a chronic leak below detectable limits or an accidental spill from a rupture or more severe leak. The possible result in each case during freezeup and early winter is discussed below.

- A chronic leak below detectable limits would result in a narrow (tens of feet wide) ribbon of oiled ice with long dimensions corresponding to the actual ice drift track and drift rate during the time the leak continues undetected. In practice, much of the oil may be contained in a tighter area encompassing various reversals and loops taken by the ice in response to winds at the time. During periods of strong storm winds, the oiled track will become more consistent and follow the prevailing wind direction for several days (within 20 degrees).

- An accidental spill from a rupture or leak would result in a circular (ice stationary) or slightly elliptical (ice moving) area with maximum lateral dimensions on either side of the movement track of less than 500 feet.

At breakup, ice concentrations are highly variable from hour to hour and over short distances. In high ice concentrations, oil spreading is reduced, and the oil is partially contained by the ice. As the ice cover loosens and the floes move apart, more oil is able to escape into larger openings. Eventually, as the ice concentration decreases, the oil on the water surface behaves essentially as an open water spill, with localized oil patches being temporarily trapped by wind against individual floes. Any oil present on the surface of individual floes will move with the ice as it responds to winds and nearshore currents.

"Pumping" of oil from the water onto the surface of new ice forming as "pancakes" in a high sea state is a physical process that has been widely discussed in scientific papers (e.g., Stringer and Weller 1980). There is limited field experience to support the theory that this process would be important in redistributing a large volume of oil in a Beaufort Sea spill. Given the limited wave fetch occurring at breakup or freezeup in the Beaufort Sea, violent floe interactions necessary to generate a pumping action are unlikely to occur.

5.5.2.1.4 Oil Spilled on Top of the Ice

In a blowout scenario (the only expected scenario that could present significant oil on the ice surface at the island location), approximately 50 percent of the oil remaining after evaporation (equivalent to 18 percent of the total volume) could land within 1.6 miles of the island, with the remainder being carried as far as 4 miles in the form of a fine mist. Ice and snow combine to provide a natural holding capacity of several thousand barrels of oil per acre (Nelson and Allen 1982). Over time, shifts in wind direction and speed could lead to a variable pattern of oil accumulating in the snow cover on top of the sea ice around the production facility. A general pattern of oiling from a winter blowout can be depicted as a "bow tie" shape centered on the island, with the axis oriented from west-southwest to east-northeast, corresponding to the proportion of time the winds are blowing either from the east to northeast or from the west to southwest. The overall area of contamination will change very little with time, and oil thickness in the most heavily contaminated areas could gradually build up.

A number of process equations are available to predict the spreading behavior of oil in snow (Belore and Buist 1988). Key behavioral factors associated with oil spilled on snow can be summarized as follows (after Wotherspoon 1992):

- Oil evaporation rates in snow are substantially reduced compared with oil slicks on open water.
- Oil mixed with snow does not readily form emulsions.
- Once ignited, there are no appreciable differences between burning oil in snow or oil in water.

5.5.2.2 Tundra

A large oil spill during the winter on the frozen tundra will not be likely to penetrate the frozen soil. A snow layer will serve to protect the frozen tundra from the oil, and the oiled snow could be carefully removed for melting and proper disposal.

If a spill were to occur during breakup or in the summer, the oil might penetrate downward through the tundra layer to the permafrost layer. However, most tundra will be wet or inundated with water so that oil will be blocked from entering the root systems of the plants (USACE 1984). The tundra is highly sensitive to disturbance and can be damaged if exposed to heavy traffic, so containment strategies will be carefully planned.

5.5.3 Oil Spill Trajectory Analysis

Movement of oil released into the open waters of Foggy Island Bay is primarily in response to wind, currents, and spreading mechanisms (as described in Section 5.3.2). Freshwater discharge into the bay also can affect the movement of surface oil. Since currents in Foggy Island Bay are generally wind-driven, a qualitative estimate of the likely trajectory of spilled oil under open water conditions can be determined by inspecting the wind roses for nearby Seal Island (Figure 5-9). These data show that wind blows from the east to northeast for about 60 percent of the time. Easterly winds cause a westward movement of water, creating upwelling conditions in the bay, a depressed shoreline water surface, and subsequent surface water movement to the north. For about 28 percent of the time, winds blow from the west and southwest. Winds from this direction cause the water to move eastward, creating downwelling conditions, elevated water levels (+1 m) nearshore, and subsequent surface water movement to the south (shoreward).

A spill on the island under prevailing easterly winds will be transported to the west. Using an Alaska Clean Seas (ACS) spill trajectory model, it was found that 10-knot winds from the northeast could put oil spilled at Tern Island on the western shores of Foggy Island Bay within the first 12 to 15 hours of the spill. Oil could also move westward past Point Brower and reach Heald Point within 36 to 45 hours. This trajectory analysis was completed prior to construction of the Endicott Causeway. It is likely that the presence of the causeway could block a significant percentage of the westward moving oil along with spill response at Endicott that would limit the spread of a spill at Liberty. The ACS model completed for a spill at Tern Island does not consider freshwater input from the Sagavanirktok distributaries, along with upwelling conditions caused by the easterly winds. These factors could work to keep oil offshore of Tern Island. Any floating oil not stranded on the beaches, gravel islands or the Endicott Causeway or not cleaned up could move past Point Brower and become entrained in the westward flowing coastal current.

Under westerly wind conditions, oil released, and not contained, at the proposed island site will tend to move to the east. If westerly winds are sustained, downwelling conditions will be initiated in the bay and the oil will follow surface flows to the south, or onshore, and towards Tigvariak Island and the Shaviovik River delta. Freshwater input from the Shaviovik may cause localized changes in the movement of oil and may act to reduce a portion of the onshore component. In this case, oil could move past Tigvariak Island and reach Mikkelsen Bay.

Catastrophic spills along either of the pipeline routes will move towards the west and offshore with eventual entrainment in the westward flowing coastal current. Large amounts of oil spilled or leaked along the pipeline east of Point Brower and closer to the island will behave as described above for an oil release from the island. During westerly wind conditions, oil not immediately contained will move to the east and onshore. Therefore for the pipeline route, a spill close to land under easterly winds will move towards the eastern distributary of the Sagavanirktok River and Point Brower. The likelihood of a spill from the pipelines impacting the Sagavanirktok delta depends on the location of spilled oil along the pipe, the strength of the easterly winds, and the input of freshwater flow from the river acting to keep the oil off of the delta.

Under westerly winds, oil will move onshore towards the Kadleroshilik and Shaviovik rivers. Again, freshwater flows may help to counteract the onshore component and keep the oil from moving onto the river deltas. Depending on where along either pipeline route the oil is spilled, the potential for contact with the western shore of Tigvariak Island also exists; oil spilled closer to the drilling island could move towards Tigvariak Island or past the island into Mikkelsen Bay.

5.5.4 Effects of Oil Spills

Effects to organisms in a spill situation vary depending on a number of factors including:

- Time of year (ice conditions)
- Oil type (viscosity and molecular composition)
- Nature of the spill (amount and time frame)
- Oil transport, deposition and persistence
- Local weathering conditions

- Sensitivity of species and life history stage present
- Exposure time of organisms
- Success of containment or cleanup
- Time to detection

The following sections describe the potential effects of an oil spill on organisms expected in the development area. Effects upon subsistence are discussed in Section 5.6.4.3.

5.5.4.1 Fish

The shallow nearshore zone is used extensively by anadromous fish. An oil spill contacting the nearshore environment of Foggy Island Bay could affect several species of anadromous fishes as they move along shore to feeding, overwintering, or spawning grounds. Foggy Island Bay is within the range of Arctic cisco, Dolly Varden, broad whitefish, and adult least cisco (see Section 4.7.6.2). Adult fish are likely to avoid an oil spill and, therefore, not suffer great mortality. However, juveniles are more vulnerable to floating oil because they are more sensitive to toxic effects and are less or not at all able to avoid the spill (MMS 1996a). Since there is potential for an oil spill to contact the river deltas in Foggy Island Bay (see Section 5.5.3.1), and anadromous fish are known to use the bay (see Section 4.6.5.2), many anadromous fish could be affected by lethal concentrations of oil if a river delta were contacted by a spill (MMS 1996a). The greatest risk to the nearshore foraging habitat overall is that a spill can indirectly affect an area far larger than the extent of its direct influence. For example, a large spill or blowout could affect the nearshore corridors, thereby rendering segments of the coastline inaccessible to anadromous fishes or preventing fish from returning to their overwintering grounds. However, most anadromous fishes make spawning runs and outmigrations from the rivers over a period of time, so it is unlikely that an entire population will experience mortality or sublethal effects (MMS 1996a, p IV-B-17).

Arctic cod are numerous in Foggy Island Bay (see Section 4.7.2.2); this species has floating eggs which are particularly sensitive to oil and, depending on the size, time and location of the spill, could suffer extensive mortality. Arctic cod spawn under ice in winter (Lewbel 1983) and would only be affected if oil from a winter spill would be deposited under the ice. Also, these fish are broadly distributed so regional population effects are likely to be minimal. Effects of a spill on marine fish species likely will be the death of only a small portion of the population, due to local extent and limited duration of toxic conditions produced by an oil spill. Larvae, eggs, and juvenile fishes are more susceptible due to increased sensitivity and decreased mobility. Species with floating eggs (e.g., Arctic cod) could suffer extensive mortality (MMS 1996a), but only if the timing of the spill is consistent with spawning times.

5.5.4.2 Plankton

Large-scale effects on plankton due to petroleum-based hydrocarbons have not been reported to date (MMS 1996a). Effects of oil spills on planktonic communities are expected to be very local and of limited duration. Severity of lethal and sublethal effects depend on the extent and duration and timing of the spill. Adverse effects of oil on phytoplankton include inhibition of photosynthetic activity and growth, lowered feeding and reproductive activity, community changes, and death. Given the rapid regeneration time of phytoplankton (9 to 12 hours), recovery will be expected within 1 or 2 days (MMS 1996a). Adverse effects of oil on zooplankton communities include external contamination, tissue contamination, inhibition of feeding, altered metabolic rates and direct mortality (MMS 1996a). Zooplankton communities appear to rapidly recover from oil contamination because of their wide distribution, large numbers, rapid rate of regeneration, and high fecundity (MMS 1996a).

5.5.4.3 Birds

The effects on birds of an oil spill from Liberty Development will vary with the season. Spills that occur during the winter will not have an immediate effect on birds because at that time they are absent from the area. However, any oil remaining in the ice until the following spring breakup period could subsequently affect birds directly through contact, indirectly by reducing food source availability, and/or by contamination of food sources.

The direct loss of birds due to one or more spills could affect 10,000 or more waterfowl and shorebirds (MMS 1996a). Direct oil contact usually is fatal, resulting in death from hypothermia, shock or drowning. Ingestion of oil through preening leads to endocrine dysfunction, liver dysfunction, weight loss and reduced growth in young birds (MMS 1996a). Local reduction or contamination of available food sources due to an oil spill could temporarily reduce survival and reproductive rates.

From mid-July to early September, Oldsquaw, eiders, phalaropes and other marine birds congregate inside the barrier islands and along the south shores of the McClure Islands. A spill moving offshore towards these islands could affect the marine bird populations. The duration of impact on Oldsquaw, other sea ducks, or other abundant species would likely be one or two generations. Natural recruitment within abundant species' populations, such as Oldsquaw, probably will replace such losses fairly quickly (MMS 1996a). Potential oil spill impacts on Spectacled Eiders and Steller's Eiders is presented in Section 5.5.4.5.

Although the western Alaska breeding population of Oldsquaws and some Canadian Arctic breeding populations (that overwinter in the Great Lakes) have shown recent declines, there is no similar evidence for a decline in the Oldsquaw population that nests on the Arctic Coastal Plain of Alaska. Based on aerial surveys conducted from 1986 to 1997 (Conant et al. 1997) and 1957 to 1994 (Hodges et al. 1996), Oldsquaw populations have remained relatively stable in this area.

5.5.4.4 Marine Mammals

Pinnipeds, cetaceans and polar bears are not likely to avoid oil spills intentionally, although they may limit or avoid further contact with oil if they experience discomfort as result of contact (MMS 1996a). In some cases, they may be attracted to the spill if concentrations of food organisms are nearby, or they may have no choice but to migrate through the spill area. Polar bears may be attracted to a spill site due to curiosity or due to the presence of dead birds or other carrion.

Pinnipeds such as the ringed, bearded and spotted seals are present in open water areas during summer and early autumn (see Section 4.8). Seal densities are generally low within the barrier islands in winter but may sometimes be higher in summer and fall. Ringed seal densities recorded in the Liberty area during spring aerial surveys indicate that maximum densities south of the barrier islands (0.43 seals/km^2) were slightly lower than those north of the barrier islands (0.51 seals/km^2) (G.W. Miller, LGL Ltd., unpubl. data.) (Figure 4-4). Therefore, impacts could occur to local populations of seals if oil is spilled in Foggy Island Bay during the summer/fall months. Also, any oil spilled under the ice has the potential to directly contact seals. Depending on the extent of oiling and characteristics of the oil, externally oiled seals often survive and become clean, but heavily oiled seal pups and adults may die. Adult seals are likely to suffer some temporary adverse effects, such as eye and skin irritation, with possible infection (MMS 1996a). Such effects may increase stress and contribute to the death of some individuals. Ringed seals may ingest oil contaminated foods, but there is little evidence that oiled seals will ingest enough oil to cause lethal internal effects. Newborn seal pups will be likely to suffer direct mortality from oiling through loss of insulation and resulting hypothermia.

Bowhead and beluga whales migrate through the Alaskan Beaufort Sea; however, the project area is inside the barrier islands and, therefore, south of the migration corridor used by these cetaceans. Any effects of an oil spill would occur only if oil were forced offshore and entrained in the coastal current, as described previously. The specific effects of an oil spill on bowhead, gray or beluga whales are not well known. Direct mortality is unlikely. However, exposure to spilled oil potentially leads to skin irritation, baleen fouling which reduces feeding efficiency, respiratory distress from inhalation of hydrocarbon vapors, localized reduction in food resources, consumption of some contaminated prey items, and temporary displacement from contaminated feeding areas. Gerachi and St. Aubin (1990) summarize effects of oil on marine mammals, and Bratton et al. (1993) provide a synthesis of knowledge of oil effects on bowhead whales. The number of whales contacted by a spill will depend on the size, timing, and duration of the spill. Whales may not avoid oil spills, and have been observed feeding within oil slicks. In the case of an oil spill occurring during migration periods, disturbance of the migrating cetaceans from cleanup activities may have more of an impact than the oil itself. Human activity associated with cleanup efforts could deflect whales away from the path of the oil. However, noise created from cleanup activities likely will be short term and localized with no long-term consequences for individuals or populations. In fact, whale avoidance of cleanup activities may benefit whales by displacing them from the oil spill area.

Polar bears occasionally den onshore, and some feed on whale carcasses on offshore barrier islands. However, they are normally associated with pack ice, located well offshore of the development area (see Section 4.8.3), and will primarily be directly affected by oil forced offshore into that region. Depending on the time and size of the spill, denning females, young males, and females with young cubs that hunt in fast ice areas may encounter oil. Polar bears could suffer direct mortality from the effects of oiling (Øritsland et al. 1981). Polar bears may not avoid oiled areas and may consume oiled prey. Oiling reduces insulation quality of polar bear fur, and will cause significant thermoregulatory problems. Oil can be ingested during grooming, and toxic internal effects including anemia and renal impairment, which may not be evident until two to four weeks after oiling. Mortality for heavily oiled bears is probable (Øritsland et al. 1981; Richardson et al. 1989). Indirect effects include the loss or tainting of food sources, or toxic effects from feeding on tainted food items. Impacts from cleanup activities (e.g., displacement of some bears due to disturbance) also may occur.

5.5.4.5 Threatened and Endangered Species

Spectacled Eiders are known to nest in the Sagavanirktok River delta and between the Kadleroshilik and Shaviovik rivers where they are restricted to within 8 miles of the coast (see Section 4.9.3.1). They nest along shore above the high tide line during June; therefore, any effects of marine oil spills are expected to be indirect (e.g., disturbance from cleanup, food source impacts). In the unlikely event of an onshore pipeline spill, nests or breeding birds could be directly affected.

Steller's Eiders are not expected to occur within the proposed development area, which is east of their primary nesting area south of Barrow. A proportion of the population could be exposed to an oil spill along the Beaufort Sea coast during staging/migration in spring (late May to early June) and summer/autumn (males leave in June to July, females and young leave in August to September). Some spring and autumn migrant Steller's Eiders use overland routes and will not be exposed to a coastal spill.

The Western Arctic stock of bowhead whales is currently listed as endangered and is classified as a strategic stock by NMFS (see Section 4.8.2.1). Very few bowheads occur near the project area until early to mid-September, with migration ending by late

October. Only a very small proportion are likely to travel close enough to shore to come within 10 km (6 miles) of the Liberty Development. These animals will only be directly affected by oil in the unlikely event of a very large spill forced offshore by easterly winds and eventually entrained in the westward-flowing coastal current (see Section 5.5.3). Potential effects of an oil spill on bowhead whales have been described previously (see Section 5.5.4.4).

5.5.4.6 Boulder Patch

The subtidal marine plants and animals associated with the Boulder Patch community of Stefansson Sound are not likely to be directly affected by an oil spill from the Liberty Island pipeline. The only type of oil that can reach the subtidal organisms of the community (located in 5 to 10 meters of water) will be highly dispersed oil having no measurable toxicity, occurring as a result of heavy wave action and vertical mixing (MMS 1996a). Hence, the amount and toxicity of oil reaching the subtidal marine community is expected to be so low as to have no measurable effect. However, oil spilled under the ice during winter could act to reduce the amount of light available to the Boulder Patch. This could be an indirect effect of a spill.

Depending on the timing of a spill, planktonic larval forms of Boulder Patch organisms such as annelids, mollusks, and crustaceans may be affected by floating oil. The contact may occur anywhere near the surface of the water column (MMS 1996a). Due to their wide distribution, large numbers, and rapid rate of regeneration, the recovery of marine invertebrate populations is expected to occur soon after the surface oil passes.

5.5.4.7 Terrestrial Mammals

As discussed in Section 4.10, caribou, musk ox, grizzly bear, Arctic fox, moose, and Arctic ground squirrels may occur in the vicinity of the onshore pipeline. In the unlikely event of an onshore oil spill that contaminates tundra habitat, caribou, moose, and muskoxen probably will not ingest oiled vegetation because they are selective grazers. Oil spill cleanup activities also will tend to displace these animals from contaminated habitats. Grizzly bear and foxes may be indirectly affected by feeding on oiled prey items or carrion. Any of these terrestrial mammals that become oiled by direct contact with spilled oil could die from the inhalation of toxic hydrocarbons and/or absorption through the skin (MMS 1996a). Terrestrial mammals could be directly or indirectly affected by spill cleanup activities. Staging and support for either an offshore spill or a large onshore spill likely would be onshore.

5.5.4.8 Wetlands and Vegetation

Tundra vegetation may be exposed to oil in the event of a pipeline leak. In addition, coastal wetlands or salt marsh habitats could be affected by an offshore spill that reaches the shoreline. For pipelines, small spills will be expected to occur either at the pipeline tie-in or the landing. These most likely will be contained on the gravel pads. Leaks in the elevated portion of the pipeline could expose the tundra to oil. During winter these will be on top of the snow, and will be cleaned with minimal impact to tundra vegetation. Spills occurring during summer will penetrate the tundra mat, killing the vegetation; but oil will not penetrate beyond the permafrost. In the event of a summer spill, the contaminated area will be cleaned and revegetated. Few oil spills have occurred on tundra during the development and operation of the Prudhoe, Kuparuk and Milne Point oil fields. Operating within guidelines established for North Slope oil fields, these events are expected to be rare, limited to small areas, quickly contained, and restored.

5.6 GENERAL IMPACTS

The following sections address impacts that are common to all phases of the proposed project and its alternatives. These impacts include solid waste, contaminated sites, hazardous waste, and socioeconomic issues.

5.6.1 Solid Waste

Solid wastes generated during construction and operation of the Liberty Development Project will be disposed of on site and/or backhauled to the Prudhoe Bay oil field for disposal. Drilling wastes (spent muds and cuttings) will be ground and injected on site or, if necessary, backhauled to another facility for disposal. Other construction waste, such as wood debris, insulation, and scrap metal, will be taken to Prudhoe Bay for recycling or disposal at NSB-operated facilities. Food wastes will be stored in appropriate containers prior to disposal on-site or prior to transport to Prudhoe Bay. As a result, this project will produce a small incremental impact since disposal of solid waste will utilize capacity at pre-existing facilities.

5.6.2 Contaminated Sites

The proposed pipeline routes and wellsite are offshore and do not contain any previously-identified contaminated sites (Montgomery Watson 1997). The onshore portions of the proposed project and eastern pipeline routes also do not have any identified contaminated sites.

5.6.3 Hazardous Wastes

Minimal volumes of hazardous waste are likely to be generated during construction and operation of the Liberty Development Project. Substitution of non-hazardous materials, as well as waste minimization practices, will be utilized to further reduce the generation of hazardous wastes. All hazardous wastes will be properly identified, labeled, packaged, and shipped to approved disposal facilities in accordance with all federal and state regulations. Measures will be implemented to minimize spills of all substances including those which are hazardous.

5.6.4 Socioeconomic Effects

Socioeconomic effects associated with the Liberty Development Project can be categorized into: (1) "economic" effects and (2) "subsistence" effects. Economic effects are defined in terms of jobs generated by the proposed action, likely income and tax scenarios, and similar indices which can be quantified. Subsistence effects require a more qualitative discussion. These two categories of effects are aspects of an integrated socioeconomic system (Galginaitis et al. 1984; IAI 1990a; Pedersen 1995).

Subsistence effects are of two main types: those resulting from effects upon animals important for subsistence (reduction in their numbers or displacement to areas not usually hunted), and those resulting from effects upon the subsistence users themselves (the need to increase hunting effort or reduced harvest due to the displacement of animals and/or loss of access to areas usually hunted and/or increased competition, and the reduction of harvest related to concerns over potential contamination).

For purposes of this Environmental Report, the discussion which follows separates economic and subsistence effects only to facilitate description of the likely effects of the Liberty Development Project.

5.6.4.1 Traditional Knowledge/Local Concerns

There have been over 20 years of public hearings and meetings on state and federal oil development on the North Slope. Residents of the North Slope have been remarkably consistent in their primary concerns during that time. This document cannot adequately reproduce or discuss this voluminous testimony, but other recent documents have summarized many of these concerns (MMS 1996a, 1996c, 1997a). The main categories of Inupiat concern are summarized as follows:

1) Oil development will result in an influx of population and other influences which will disrupt and degrade Inupiat community life. In addition, oil development and its effects will impose additional demands upon Inupiat communities and individuals.

2) Marine mammals, and especially whales, are sensitive to noise. Hunters stalking marine mammals avoid making any sort of extraneous noise, and the loud and relatively constant noises associated with seismic testing, drilling, and boat and air transport will cause whales (and other marine mammals) to avoid areas where such noise is audible to them. The range of whale sensitivity to noise is quite large.

3) Any given oil spill may be a relatively low probability event; but, over the long run, the probability of at least one such spill occurring is quite high. Oil spills are likely to have the largest and longest lasting effects upon the Inupiat people, primarily in terms of subsistence activities.

4) Many NSB residents believe that the technology to clean up oil spills in Arctic waters, and especially in broken ice conditions, is poorly developed and has not been adequately demonstrated to be effective.

5) Many NSB residents believe that public comments at public hearings and other public forums may be noted, but have little or no effect on project decisions or the overall direction and philosophy of the leasing program. Traditional and local knowledge is given less weight than "hard, scientific" information.

Comments reflecting all of these views and the MMS's response are represented in Volume II of the Final EIS for Lease Sale 144 (MMS 1996a), as well as most public hearings conducted for prior lease sales. This Environmental Report for the Liberty Development has attempted to be responsive to these concerns, both in previous sections of this document and in those that follow. Issues in the draft EIS for Lease Sale 170 (MMS 1997a) also have been evaluated and addressed in this document.

5.6.4.2 Economic Effects

Direct economic effects from any of the development alternatives (e.g., job creation, increased revenue flow) will take place mostly on the North Slope and in southcentral Alaska. BPXA has made a commitment to hire local workers on the North Slope and within Alaska. However, few village residents are currently employed by the oil industry, even though recruitment efforts are made and training programs are available. Many local residents prefer subsistence activities to oil development employment. The Liberty Development Project is not expected to change this pattern. It is a small project, and relatively few long-term jobs will be created. Much of the employment in North Slope villages is indirectly related to oil development, as most is funded through the NSB which, in turn, depends on tax revenue derived from taxing oil production facilities. This project will increase the NSB tax base through construction of additional oil transportation facilities. In addition, many of the contractors hired by BPXA (design, construction, drilling, operations) are either Native Corporations, subsidiaries of such corporations, or otherwise affiliated with such corporations through joint ventures or other relationships. This will provide significant local economic benefit.

The proposed project (western pipeline route) is projected to generate approximately 300 construction jobs, 100 drilling jobs, and 50 maintenance/operational jobs. The numbers for the eastern pipeline alternative are essentially the same. Island construction, pipeline construction, final fabrication of facilities, and drilling and processing will take place on-site on the North Slope. BPXA has a policy of preferring to hire Alaskan workers and contracting with Alaskan firms, so most of this work will be expected to generate economic multiplier effects within Alaska. Anchorage will be the site of most engineering, module and other material fabrication, and the mobilization of the sea lift to the North Slope work site. Construction of the Permanent Living Quarters (PLQ) module may take place in Wasilla. Pipe fabrication and insulation may take place in Fairbanks. Only equipment not manufactured or available in Alaska will be procured from the Lower-48 (generators, separators, pumps, compressors, process heaters, etc.).

Drilling is scheduled to be a continuous operation lasting for about 18 months. It is expected that two crews will be on the island at any time, working 12-hour shifts, and crews will be rotated in and out on a 14-day basis. Thus, 25 workers will be drilling at any given time, and each drilling position will employ four full-time workers. Once production starts, a single operation crew will be on the island at any time, with one out on break. Construction will generally be conducted with one shift present at the work site and one out on break. The total construction period is scheduled to be 14 to 18 months (from module fabrication to pipeline construction).

The State of Alaska will benefit directly by infusion of capital expenditures into the economy, leading to the creation of jobs. Over the estimated life of the project, additional benefits will accrue to the State through the State's share of the Federal royalty, income tax, and *ad valorem* tax, some of which will accrue to the NSB (Table 5-10). This benefit will occur at a time when State revenue, heavily dependent on production from the large North Slope oil fields, will be declining. The Liberty project by itself will not offset these declines, but it will help mitigate the severity of the decline. Such benefits will be lost with adoption of the "no action" alternative.

As the *Exxon Valdez* spill cleanup effort demonstrated, the economic effects of spill incidents can produce significant economic impacts (both positive and negative) (IAI 1990d, 1990e, 1990f, 1990g). The large influx of cleanup funds and workers into Prince William Sound communities increased the demand for community services, as well as greatly increasing local economic opportunities. Given the differences between the North Slope and Prince William Sound, it is likely that any required non-resident cleanup workforce will be kept separate from local communities (other than perhaps Barrow). To the extent that NSB residents are employed in cleanup efforts, either through reinstituted local oil spill response teams or as part of more general cleanup activities, cleanup funds will be retained on the North Slope. This may also impose some temporary

TABLE 5-10

FEDERAL, STATE, AND NORTH SLOPE BOROUGH REVENUE SHARE FROM THE LIBERTY DEVELOPMENT

Source: BP Exploration (Alaska) Inc.

ASSUMPTIONS		PROJECTIONS (in $000's)	
Oil Price ($/bbl)	$16.00	Gross Revenue	$ 1,440
Transportation Costs ($/bbl)	4.00	Revenue Net of Royalty	1,260
Wellhead Price ($/bbl)	12.00	Capex	480
Reserves (mmbbls)	120	Opex	240
Capital Expenditures ($/bbl)	4.00	Taxable Income	540
Operating Expenditures ($/bbl)	2.00		
Royalty Rate	12.5%	Fed Royalty	131
State Share of Royalty	27%	Fed Income Tax	181
Fed Income Tax Rate	35%	Total Fed Revenue	313
State Income Tax Rate	4%		
State Spill and Conservation Tax	$ 0.034	State Royalty	49
Ad Valorem Tax Rate	2%	State Income Tax	22
		State Spill and Conservation Tax	4
		Total State Revenue	74
		Ad Valorem Tax	5
		NSB Revenue	5

labor shortages within local communities. The Final EIS for Lease Sale 144 (MMS 1996a) discusses the "windfall" economic opportunities of such events, but not the problems that they may create for local communities. While local participation in cleanup efforts will allow local residents to feel they have more control and oversight of what is being done to protect and restore their local resources, and ultimately foster more confidence in the security and safety of these resources, such participation also imposes costs on the local participants (economical, social, psychological) over and above the potential detrimental subsistence effects discussed below. Cleanup workers hired from local communities may forego subsistence activities for a period of time. The overall effects on these subsistence activities, and the consequent change in lifestyle from not participating in subsistence activities, will depend on the length of time workers are employed away from their communities and whether opportunities remain during the season to resume some level of subsistence activity. Oil spill cleanup efforts will clearly provide short, temporary economic opportunities for Anchorage and the State as a whole.

5.6.4.3 Subsistence Effects

The most salient socioeconomic effects for local residents are those related to subsistence, which can be produced by direct actions upon the biological resources or result from changes in human behavior. The following discussion addresses a variety of possible concerns. Direct biological effects upon subsistence resources are evaluated in terms of the subsistence use of those resources. Less direct impacts (displacement of resources) also are evaluated in terms of past patterns of use of such resources. Potential displacement of subsistence activities because of effects upon the subsistence users (perception that areas are closed to them, or that the subsistence experience has been affected, or that the resource has been tainted) also are discussed.

5.6.4.3.1 Offshore Island Construction

Direct effects upon marine mammals (ringed seals) will be minimal (Section 5.1.7), and winter use of this area by subsistence hunters is little or none (Section 4.13.1). Thus, offshore island construction will be expected to have minimal or no effect upon subsistence activities. It is assumed that gravel placement will occur during the winter, and the only open-water construction will be for island slope protection (concrete block, gravel bags) and foundation construction. The open water period is the main period of use for sealing, and displacement effects will be localized enough so as to be minimal. Whales will not be present in the proposed project area during island construction, so whales and whaling will not be affected.

Similarly, potential biological effects on fish are judged to be minimal, and subsistence use of the area is infrequent and limited to summer. Similarly, effects upon terrestrial subsistence resources and their use will be minimal. The effects of gravel extraction for construction purposes is assumed to be minimal because the mine site is not in an area of biological significance and subsistence use.

5.6.4.3.2 Subsea Pipeline Construction

The effects of subsea pipeline construction on subsistence will be minimal. Construction will take place during February through May, when subsistence use of the area is low to non-existent. Ringed seals and polar bears are the only marine mammals expected to be within the proposed project area at that time, and direct effects upon them are expected to be limited to displacement (Section 5.2.7). Given the current pattern of relatively low or non-existent subsistence use of the area at that time, subsistence effects will be minimal.

Effects upon the subsistence use of fish and terrestrial mammals will be minimal, for the same reasons as for island construction. The effects of gravel extraction for construction also will be minimal, for the same reasons as discussed above.

5.6.4.3.3 Onshore Pipeline Construction

Polar bear denning habitat may be encroached upon by onshore pipeline construction and associated ice roads (Section 5.3.7). Given the infrequency of polar bear harvest by Nuiqsut hunters and the distance of the project area from the community, this effect upon subsistence use will be minimal.

While fish resources in this area have been historically used in the past, they are currently not used because of the area's distance from Nuiqsut. Areas closer to Nuiqsut are the primary harvest locations for fish, but the area may be used opportunistically by people who are in the area for other reasons. Such use will be infrequent, however. The pipeline will avoid fish habitat.

Effects upon terrestrial subsistence resources and their use will also be low. Direct effects upon the resources will be low or non-existent (Section 5.1.9). Use of the area by subsistence hunters is very low (distance from present communities, already existing development) (M. Galginaitis, Applied Sociocultural Research, pers. comm.), so that subsistence effects will also be low. Gravel extraction effects on subsistence will also be minimal.

5.6.4.3.4 Oil Production Operations

The most significant potential subsistence effects occur in this phase of the project. Noise effects are shared to some extent with prior developmental phases, although the source of the noise differs.

Noise will arise primarily from drilling and support traffic (boat, air, ice road vehicle). Production equipment also will be a source of noise but will not be as loud and will be much more regular. The main direct effects will be the localized displacement of seals—both from the area of the gravel island (drilling noise and traffic), as well as from the proximity of vessels and aircraft in transit. Whales are not expected to be directly affected by noise, as their normal migration route (seaward of the barrier islands) is beyond the transmission range of the noise expected to be generated. Vessel and aircraft traffic can cause a significant displacement of whales if close to the animals (Section 5.4.8).

Seals may be directly affected by spill incidents. Whales are less likely to be affected by oil spills because of their more seasonal use of the area and their greater distance from the production area and pipeline. Such effects are nonetheless possible. Potential effects upon subsistence uses for seals will still be relatively low, as the area most likely to be affected is not one of high use for subsistence sealing. The potential effects upon subsistence whaling, however, are quite large and could extend to Nuiqsut's principal whaling area. This effect could be limited to the displacement of Nuiqsut whaling to alternate areas, or could in fact eliminate an entire whaling season if a spill incident occurred during the relatively short fall whaling season. Drilling will be continuous for a two-year period, and probably carries the greatest risk for a relatively large scale spill. Pipeline spills are possible for the total production period of the project. Either type of spill could occur at any time of the year.

As mentioned previously, fish resources in this area were historically used in the past, but currently are not used due to the area's distance from Nuiqsut. Therefore, overall subsistence effects of oil production operations will be non-existent.

Direct effects of an oil spill upon terrestrial subsistence resources and their use will be minimal (Section 5.1.9). Use of the area by subsistence hunters is very low due to the distance from present communities and other already existing developments.

Oil-spill cleanup activities could increase disturbance effects on subsistence resources from vessel and aircraft traffic, causing temporary disruption and possible displacement effects (Final EIS for Lease Sale 144, MMS 1996a). In the event of a large spill contacting and extensively oiling coastal habitats, the presence of several thousand humans, hundreds of boats, and the many aircraft involved in the cleanup will (depending on the time of the spill and the cleanup) potentially displace seals, polar bears, and other marine mammals, and increase stress and reduce pup survival of ringed seals if operations occurred in the spring. Such effects will persist for one or more years within one mile of the cleanup. Birds within about one mile will be affected for one or two seasons. Caribou will be displaced and experience seasonal stress for one or two seasons in areas near cleanup activities. Oil spill and cleanup activities in river delta areas during fish migrations will have adverse effects on these fish, and will displace nesting, molting, and feeding birds and contribute to their reduced reproductive success. Oil-spill cleanup activity will exacerbate and increase disturbance effects to subsistence species, increase the displacement of subsistence species, and alter or reduce access to subsistence species.

One of the most persistent effects of the *Exxon Valdez* oil spill was the reduced harvest and consumption of subsistence resources due to the local perception that they had been tainted by oil (Fall and Utermohle 1995). Even though extensive testing programs were instituted, and no such contamination of fish or marine mammals was established (some shellfish were contaminated), this pattern of reduced consumption persisted for at least a year, but most affected communities had returned to documented pre-spill levels by the third year after the spill. A significant number of households in these communities still reported that subsistence resources had not recovered to pre-spill levels, however, and harvest levels of subsistence resources for the three communities most affected by the spill still were below pre-spill averages even after three years. While expressed concerns or causal reasons had shifted more to lowered resource populations rather than the fear of contamination of the resource, contamination still remained an important concern for at least some households (Fall and Utermohle 1995). As an example, an Elder gave up eating local salmon after the spill, even though salmon is the most important subsistence resource and he had eaten it every day of his life up to that point (M. Galginaitis, field notes). These same effects could be expected after a spill on the North Slope, with the extent of the decline in harvest and use and the temporal duration of the effect dependent upon the size and location of the spill. This analysis reflects the local perception that oil spill events pose the greatest potential danger from offshore oil development.

5.7 CUMULATIVE IMPACTS

NEPA regulations require that, in determining whether the effect of a project will be significant, an agency must consider "whether the action is related to other actions with individually insignificant but cumulatively significant impacts" [40 CFR 1508.28(b)(7)]. Cumulative impacts are defined by NEPA [40 CFR 1580.7] (emphasis added) as

> ...the impact on the environment which results from the incremental impact of the action when added to other past, present, and <u>reasonably foreseeable</u> future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

5.7.1 Approach

An analytical approach was adopted for comprehensive consideration of cumulative impacts in assessing the Liberty Development Project, similar to that used for assessing the Alpine Development Project (ARCO et al. 1997). This approach is structured in six sequential steps:

Step 1. Identify past and present actions (i.e., projects) associated with the Liberty Development.

Step 2. Identify other projects that are "reasonably foreseeable."

Step 3. Of the past, present, and "reasonable foreseeable" projects, determine which might contribute to cumulative impacts of the Liberty Development.

Step 4. Of the projects which might contribute to cumulative impacts of the Liberty Development, determine what types of impact could be associated with their development.

Step 5. Describe additional NEPA review involved with present and future development.

Step 6. Summarize projects for cumulative impacts analysis.

Results of the cumulative impacts analysis are described below, by step.

5.7.1.1 Past and Present Projects in the Context of the Liberty Development

Present projects (i.e., existing development) in the industrialized portion of the North Slope include: exploration, the Trans-Alaska Pipeline System, Prudhoe Bay Unit (PBU), Endicott (Duck Island Unit), Badami Unit (currently completing development), Kuparuk River Unit (KRU), and Milne Point Unit (MPU). One past project, Tern Island, an abandoned artificial gravel island approximately 1.5 miles east of the proposed development, could also be associated with the Liberty Development.

5.7.1.2 Projects that are "Reasonably Foreseeable"

For complete assessment of cumulative impacts, agencies must reasonably forecast and predict effects of other projects before they are developed. The level of consideration given to a project depends on the stage of decision-making for that project. Generally, a project will be considered "reasonably foreseeable" if it is likely to be constructed (i.e., if there is an identified intent to develop the project).

Projects considered in this cumulative case are all related to the oil and gas industry. This is due to the nature of the action under consideration and to the fact that oil and gas development is the principal agent of industrial change on the North Slope (BLM and MMS 1997). In the oil and gas industry, the likelihood of development is directly related to the stage of decision-making that proceeds from leasing through exploration, discovery, delineation and development of a prospect, as warranted by findings at each stage. More specifically, for an oil and gas project to be developed, a well-defined series of tasks must be completed, including:

- determine availability of acreage/tracts
- analyze geology
- complete environmental permitting for geological/geophysical exploration activity
- acquire and analyze geophysical data
- identify prospects
- complete economic analyses
- obtain leases in prospective area(s)
- resolve other constraints
- locate area and site for exploration well(s)
- complete environmental permitting for exploration
- drill the well(s)
- interpret drilling results
- acquire additional seismic data (additional permitting may be required)
- drill more exploratory wells or delineation wells (additional permitting may be required)
- conduct production tests
- perform further economic evaluations
- evaluate development potential
- evaluate options
- collect additional site data
- define development
- design development
- obtain project funding
- complete environmental permitting
- construct facilities
- drill pre-development wells
- complete development wells and commence commercial production

The fewer tasks that have been completed, the more speculative the project. On the North Slope, with seasonal restrictions and cold weather limitations on completing many of these tasks, the time frame from beginning of the initial leasing process through development can take 10 or 15 years, particularly for offshore projects. The oil and gas industry is driven by economics and demand; but, even with favorable economics and demand, the chances of finding a marketable prospect are small. Even when discoveries are made, they may not prove commercially viable. Consider the following example.

Over the last 30 years, for every 10 exploration wells drilled, only one resulted in a discovery, and for every five discoveries, only one was delineated as commercial. Two recent examples of successful exploratory and discovery drilling (Kuvlum and Sunfish) failed to result in production. In Alaska, only 4.2 percent of exploratory wells drilled have resulted in oil and gas development – less than one in 20 (ARCO et al. 1997).

Based on this, it is not reasonable to consider an oil and gas development of an exploratory prospect as "foreseeable," at least until commercial quantities of oil and gas have been confirmed and an economic development concept has been identified. Accordingly, in this analysis, a distinction is drawn between exploration/discovery/delineation of a prospect and commercial development of a project. Based on this premise, an undeveloped project can be classified either as a "reasonably foreseeable" project, or with less certainty, a "potential future" project. In defining "potential future" projects, BPXA set temporal limits of 15 years. Beyond this time frame, future development is so speculative and subject to change that potential impacts are impossible to evaluate in a meaningful, defensible way.

Reasonably foreseeable projects on the North Slope include Northstar, PBU satellite expansion (e.g., NW Eileen), KRU satellite expansion (e.g., West Sak), MPU expansion (e.g., Shrader Bluff), Alpine Development Project, and Tarn; as well as general seismic exploration and exploratory drilling in the region not specifically associated with now-identified prospects. Potential future projects (i.e., not reasonably foreseeable) could result from exploration or delineation of prospects at Sourdough, Pt. Thomson, Kuvlum, Hammerhead, Warthog, Fiord, discoveries in the Sandpiper Unit and Kuukpik Unit, a major gas transportation system (e.g., TAGS), and more remotely, from leasing in the National Petroleum Reserve-Alaska (NPRA), OCS Lease Sale 170, and State Lease Sale 86/87.

5.7.1.3 Past, Present and Reasonably Foreseeable Projects Which Might Contribute to Cumulative Impacts of the Liberty Development

In completing this analysis, a geographic scope of 30 miles from the proposed development was set as the primary affected area. Outside the boundaries of this area, projects have some general relationship to the proposed action, but are unlikely to contribute to cumulative impacts in more than a very general way. General environmental impacts of oil and gas development across the North Slope have been recently evaluated in numerous documents, including the OCS Lease Sale 170 EIS and the NPR-A DEIS.

Past and present projects within the primary affected area (30-mile radius) include Badami, Endicott (Duck Island Unit), the Prudhoe Bay Unit, the TAPS pipeline, Tern Island (Figure 5-10), exploratory drilling and ongoing seismic exploration and support activities (e.g., sealift) within that radius. The only identified reasonably foreseeable projects to be considered are Northstar and possibly PBU satellite expansion. Other projects that could contribute to cumulative impacts in a very general way are addressed in Section 5.7.2.

5.7.1.4 Potential Impacts Associated with Related Past, Present and Future Projects

Existing projects comprise an element of the environment in which the direct and indirect environmental impacts of a proposed action are assessed. In this respect, cumulative impacts associated with Endicott, Badami, Prudhoe Bay, and TAPS are *de facto* considered in Sections 5.1 to 5.6 of this document. Likewise, impacts associated with Tern Island, which was constructed in 1981 and abandoned in 1991, are considered in Sections 5.1 to 5.6, as well as in Section 2.0 (Development Alternatives).

Reasonably foreseeable projects that potentially could contribute to cumulative impacts include Northstar and possibly PBU satellite expansion, depending on the type and location of the expansion. These projects are briefly described below, to assess the cumulative impacts of the Liberty Project.

Northstar: The Northstar Unit lies approximately 25 miles northwest of Liberty, between 2 and 8 miles offshore in the Gwydyr Bay area. Because of the distance from shore, the Northstar Unit cannot be developed from land using current drilling technology. As a result, the Northstar Development will be the first remote oil production project in the Alaskan Beaufort Sea without a causeway. Required offshore development will include construction of a gravel island (over the remnants of the Seal Exploration Island), installation of drilling and production facilities, production wells, injection wells, camp facilities, utilities, fuel storage, dock, heliport, and subsea pipelines between the shore and offshore facilities and associated vessel and helicopter traffic. BPXA estimates Northstar will produce 145 MM bbl of oil over a 15-year period (ARCO et al. 1997).

PBU satellite expansion: Prudhoe Bay, the first producing area on the North Slope, is located onshore, approximately 10 miles west of Liberty. The PBU is jointly operated by ARCO and BPXA. The field has been producing since 1977, and production has been declining since 1988. Recent developments within the PBU include Lisburne, Point McIntyre, West Beach, North Prudhoe Bay State, and Niakuk. With two exceptions, all PBU production facilities are located onshore. Point McIntyre and the Seawater Treatment Plant are technically offshore, but are connected to the shoreline by a gravel causeway extending into the Beaufort Sea. According to exploration and development strategies recently announced by ARCO and BPXA, satellite facilities associated with the PBU (e.g., NW Eileen) will be developed from existing pads to the extent possible, with new roads and pads developed only in isolated locations. NW Eileen development is outside the area of consideration for cumulative impacts, and no other PBU satellite expansion is identified at this time.

5.7.1.5 Additional NEPA Review Involved with Present and Future Development

Projects already existing on the North Slope remain subject to several levels of environmental review when significant changes are proposed. Most proposed actions are subject to Alaska Coastal Management Plan Consistency and review by the Alaska Departments of Natural Resources, Environmental Conservation, and Fish and Game. Since most projects involve activity in wetlands, the USACE, EPA and/or the USFWS may also be involved in review. Offshore projects are typically evaluated by these and other federal agencies, including MMS, NMFS, and the USCG. The North Slope Borough reviews all major projects on state lands and waters. Depending on specific location, other agencies also may be involved in reviews.

Under NEPA, federal agencies are mandated to consider environmental issues associated with an action under their jurisdiction. NEPA was enacted in 1970, and the trend in implementation indicates that it will continue to impose a high level of environmental assessment in agency decision-making. Evaluation of future projects will be based on the knowledge and technology of their time. All projects identified as "reasonably foreseeable" will be subject to analysis of potential environmental impacts prior to authorization for development. The USACE is currently preparing a Draft EIS on the Northstar project, and satellite expansions in the PBU also will be subject to NEPA review by the USACE.

Regardless of specific NEPA requirements, a high level of scrutiny is likely from all agencies – federal, state, and local – for all major development on the North Slope. Recent trends in public interest and public involvement in agency decision-making also indicate that projects will be evaluated by all affected parties. It is reasonable to assume that all future projects noted in this assessment will be subject to environmental review, and any cumulative impacts resulting from future development will continue to be examined incrementally, with proposed development of individual projects, changes in regulations, or major changes in operations of existing programs.

5.7.1.6 Projects for Cumulative Impact Assessment

Impacts associated with existing projects have been considered in Sections 5.1 to 5.6 because these projects comprise an element of the existing environment in which the direct and indirect impacts of the Liberty Development are assessed. In the analysis of cumulative impacts, the focus is on future projects, and a distinction is made between exploration, discovery or delineation of a prospect versus commercial development of a project. For reasonably foreseeable projects, cumulative impacts will be evaluated because a "critical decision" has been made to act on the project (e.g., Northstar). Potential future projects in the project area, including possible exploration or development stemming from OCS Lease Sale 170 or State Lease Sale 86/87, are considered, but with much less detailed attention.

5.7.2 Cumulative Impacts

This discussion considers the impact of the Liberty Development Project combined with those projected from reasonably foreseeable projects located where they could potentially have a common influence over the local environment. Based on the approach adopted for this assessment, the only reasonably foreseeable discrete project identified is Northstar. Other potential future projects are very uncertain, and it is not possible to synthesize defensible potential impacts except in a most general way. Interaction of the proposed project and other reasonably foreseeable projects is described below, based on major environmental issues identified with offshore development in the Beaufort Sea.

5.7.2.1 General Impacts on Oil and Gas Development Potential in the Area

The proposed Liberty Development will be located approximately 25 miles east of the TAPS pipeline, 10 miles east of (the eastern boundary of) PBU, 7 miles east of the Endicott facility, and approximately 13 miles west of the Badami Unit. Endicott (Duck Island Unit), in production since late 1987, was previously the easternmost oil production project on Alaska's North Slope. When Badami Development is completed in 1998, it will be the easternmost production facility, and the first production facility east of the Sagavanirktok River. Development of Badami extends oil field infrastructure approximately 30 miles east of the original North Slope fields. Badami facilities include an oil and products pipeline that Liberty will tie-in to for onshore transport to the TAPS pipeline. Once in the TAPS via the Endicott Pipeline, the oil produced at Liberty will follow the same path as North Slope oil from all other sources.

One of the reasonably foreseeable projects identified in this cumulative impact scenario, PBU satellite expansion, involves onshore development. This likely would involve one or two new pads, with access roads from existing pads in PBU. Considering the type of development, the location, and the experience and stated development strategies of the operators, cumulative impacts of PBU satellite expansion would be minor and would be re-evaluated when the projects are proposed for development.

It is likely that these satellite expansions may affect caribou, foxes, and some bird species. These effects will be localized and small, but will be additive to the existing affected landscape. The construction stipulations for this additional infrastructure will include measures proven to mitigate serious adverse effects, particularly on larger mammals such as caribou and grizzly bear, such as pipeline and road spacing. These developments also will be required to locate gravel pads and roads to avoid sensitive vegetation types or bird nesting areas, and limit pad size to minimize terrestrial habitat change.

The Liberty Development will result in a small additional terrestrial impact, including covering terrestrial vegetation with gravel for the pipeline landfall and Badami tie-in. The short segment of pipeline from the landfall to the Badami Sales Line is not expected to affect caribou nor other terrestrial wildlife. When considered with other current or future developments, these very small effects will be additive to similar effects already observed in the Prudhoe Bay region generally, but will not measurably increase adverse effects on these resources, nor will these effects have any population level consequences to terrestrial wildlife. Other effects, such as those from gravel mine development, ice road construction, and periodic overflights of helicopters to the Liberty facilities, will be minor but additive to similar activities already occurring in the region.

Some potential exists that development of the Liberty field could increase the economic feasibility of other regional oil and gas prospects due to construction of offshore infrastructure in a previously undisturbed area. BPXA and other companies have mounted a considerable effort to find new oil and gas reserves in the general area of Prudhoe Bay to compensate for the decline of existing reserves. To minimize impacts of development in the offshore environment, BPXA has incorporated numerous planning, design, construction, and future operation mitigation features. The use of a relatively small offshore island, compact facility design, and siting between existing units will all help to reduce the potential for cumulative impacts of future development. Additional cumulative impacts from construction and operation of the project are expected to be minor.

In addition, BPXA's proposed development plan includes provisions for evaluating additional productivity of the reservoir as new well information is obtained. If economically-recoverable prospects were defined by drilling from this island, the plan would be to use existing island infrastructure for production of those hydrocarbons. In effect, this could extend the life of the project facilities by continuing production over a longer time period than envisioned for the Liberty prospect alone.

The principal issues associated with development of the Liberty project are its potential effects on the marine environment. These include potential effects on the Boulder Patch and potential effects on marine mammals and subsistence harvest of marine mammals.

The Boulder Patch occurs only in a small area of Steffanson Sound, according to available information. In the 1980s, expressed concerns over potential effects on the Boulder Patch from the Endicott Development led to a monitoring program to measure these effects. None were observed during a seven year program (Gallaway and Martin 1992). No Boulder Patch communities have been found at the Liberty island and pipeline sites, nor are any such communities known to exist at the Northstar Development site. Thus, no cumulative effects on the Boulder Patch are expected from these two new developments.

Marine mammal issues, however, are of potential concern. These include effects on seals, bowhead whales, and polar bears. The ringed seal is the principal pinniped species present in the region. Effects from the Northstar and Liberty projects may involve localized disturbance from noises and presence of machinery and facilities during construction and operation. The one type of disturbance that might affect a few individuals significantly would occur during spring pupping in maternal lairs on the nearshore sea ice. Birth lairs are constructed on sea ice in the lee of ridges and other surface structure where snow can accumulate (more common north of barrier islands than in lagoons). The radius of influence for seals is small, perhaps a kilometer or two at most. Available data indicate that habitat suitable for ringed seal pupping is present throughout the region. Effects from both the Northstar and, especially, the Liberty projects are expected to be minimal. These effects would be disturbance from noise or human encounter of seals and pups in maternal dens. Because the zones of potential disturbance to seals from either project do not overlap, the effects from both will be additive. These localized effects could continue throughout the life of both projects, but these effects are not likely to have any significant consequences to the population as a whole.

Bowhead whales may be disturbed if sounds reach the animals during migration; if the sounds are of sufficient intensity and duration, they may cause whales to deviate from their migratory route. The radius of influence around an industrial site is larger for bowhead whales than for seals (i.e., whales can be disturbed by sound at a greater distance). Liberty is close to shore and within the barrier islands in shallow water. Data show that the great majority of whales migrate beyond the barrier islands. Sounds from Liberty construction or operation are not expected to be efficiently transmitted into the water, since these sounds will be almost entirely from island surface activities. And for the sounds that do emanate from the island under water, the shallow lagoon and its soft benthic sediments will limit sound propagation to a few kilometers, far short of the main migration route of the whales. Northstar is in deeper water and beyond the barrier islands, and sounds from its construction or operation are more likely to affect migrating whales, depending on sound intensity and frequency of occurrence.

Two studies of sound propagation and ambient noise around the Liberty site were completed during the winter and summer of 1997. Results of the late winter under ice study are given in Greene (1997). Data from the summer study will be available in spring 1998, and will give additional evidence of the low likelihood of sounds traveling from the Liberty site to the whale migration corridor.

The sealifts for both the Liberty and Northstar developments, needed to transport production modules and other equipment to the islands, will occur during summer, probably during the August open water period. Tug boats and barges will travel slowly, which will avoid the potential for collisions with whales and will greatly reduce the potential for disturbance. Other vessel traffic in the region during summer, including potential seismic boat operations, could add to these sounds and together have some effects on whales. The nature of these cumulative effects will depend on the extent, timing, and duration of the barge, seismic, and other marine transportation activities planned for the summers of 2000 or 2001.

Polar bear concerns involve disturbance during denning and human encounters. Denning may occur on offshore pack ice and onshore near the coast. Denning locations in this region are widely scattered. Effects from Northstar and Liberty will be in different geographic areas, and any disturbance will be additive since different bears would be involved. Specific den sites are not used by bears each year, so any disturbance from either development to a denning bear and/or cub likely will be isolated and temporary. Long-term disturbance effects could accumulate if seasonal supply flight operations disturb den sites.

Humans are likely to encounter polar bears at Liberty and Northstar because of the offshore locations of these developments. These encounters will be with bears that are foraging on sea ice, particularly during fall and winter months, or when bears may investigate the island facilities. This type of encounter has occurred occasionally at the Endicott facilities. There probably is a linear relationship between additional developments in this region and human encounters with polar bears - more offshore developments, more potential human contact with polar bears. These are not likely to be serious (except to humans if a protective enclosure is not nearby), but potential lethal encounters to bears could rarely occur (although no lethal encounters have occurred in the Prudhoe Bay region). Mitigation measures, such as proper food waste disposal practices and appropriate wildlife interaction training, will minimize or even alleviate these potential effects. No long- term cumulative effects on polar bears are expected from these offshore developments given adherence to standard avoidance practices.

Northstar and Liberty islands likely will be constructed in different years (currently Northstar is scheduled for winter 1999 and Liberty for winter 2000), and thus the potential disturbance effects of the two offshore developments will occur more than once. While island placement and offshore pipeline construction for the two projects will occur over two winter seasons, the sealift activities to install modules on both islands could occur in a single summer season, limiting potential noise disturbance to bowhead whales to a single several-week period, but over a larger geographic area. Whether a single episode like this, as compared to less intensive operations spread over a larger period, has more or less of an effect on whales or other marine organisms is speculative. But the effects will be additive in space and time. Nonetheless, even when considered together, the Northstar and Liberty construction activities likely will have very localized and temporary effects. Requirements to limit activities to time periods when whales are not present will reduce potential disturbance effects. No long-term consequences to the marine resources in this region are expected.

Some offshore seismic activity may continue in this region in future years. This activity, which is not associated with a particular development, will add an increment of potential disturbance to whales and seals. These effects likely will be minimized by stipulations in government authorizations and/or conflict avoid agreements with local subsistence hunters.

Operation of both developments will include periodic barge or other vessel support, helicopter traffic, and seasonal ice road construction and vehicle use. Periodic seasonal vessel and helicopter activities will occur throughout the life of both fields. These activities may disturb birds and mammals, and cause a small but localized reduction in use of ice habitat by seals, but will not have significant or long-term effects on animal populations, even when considered together, because of the distance between the two developments and the sporadic nature of these operational activities.

Permanent changes to the marine environment will result from island placement. Northstar and Liberty islands are approximately 25 and 23 acres in size, respectively (base of footprint). The islands will cover a cumulative 48 acres of benthic habitat. No sensitive areas will be covered, and the island slopes may colonize with organisms that require hard substrates, providing no net loss of biological productivity and conceivably a net gain. Regardless, the extremely small cumulative effects of both developments on the marine benthic community in the region will be negligible.

5.7.2.2 Subsistence

A major issue associated with development anywhere in Alaska is the potential effects on subsistence resources and subsistence use practices of Alaska Natives. In the project area, major subsistence resources include marine mammals, polar bears, anadromous fish, and to some extent, caribou. The primary subsistence practice of concern is whaling, which will receive the most attention.

In discussions regarding offshore development along the North Slope, concern was expressed in several local communities that, while noise and other effects may be insignificant or can be mitigated for the Liberty Development project, the potential cumulative effects of several projects in the region, developed over time, may be significant and the mitigation insufficient. One Nuiqsut resident offered the hypothetical scenario where whaling could be relatively unaffected by the modest development of one or two projects (e.g., Northstar and/or Liberty); however, as more projects were developed along the coast, oil development would pose greater cumulative impacts (M. Galginatis, 1997 field notes).

The threshold at which this concern becomes reality, and poses significant impacts that outweigh the benefits of development, is difficult to assess. However, based on this analysis of reasonably foreseeable projects likely to pose cumulative impacts, only Northstar was identified as being reasonably foreseeable. Other offshore projects in this vicinity are possible, such as exploratory drilling or continued seismic exploration not specifically associated with Northstar. The location, resource levels, economic potential and infrastructure requirements of yet un-announced specific development plans is only conjecture at this time. With strong agency and community involvement in the NEPA process (as well as third-party oversight of all environmental activity in Alaska), future project review on a case-by-case basis should be able to effectively identify when potential cumulative impacts become significant.

The construction and/or operational activity most likely to affect subsistence resources or activities in this region is noise disturbance to bowhead whales. Whaling occurs each fall (September) from Cross Island by Nuiqsut-based whalers. Theoretically, sounds emanating from either the Liberty or, more likely, the Northstar island (during barge movements, module placement, oil well drilling, and long-term operation of island facilities) may travel through air or water, be sensed by migrating whales, and possibly deflect bowheads from their usual migratory route. However, data collected show that the sounds from drilling are not expected to propagate beyond a few kilometers (see Section 5.4.7). Thus, the potential disturbance zones around Liberty and Northstar will not overlap, and will be additive in time and space (i.e., sounds will emanate from each location, but will be encountered by whales at different places and at different times, if encountered at all). Liberty will be "upstream" from Cross Island, while Northstar will be "downstream". Because Liberty is in a lagoon, it is unlikely that its effects will extend north of the barrier islands. The Liberty Development is not expected to contribute appreciably to any cumulative effects on the main migration corridor seaward of the islands, but may affect those few whales that enter the lagoon or the entrances to the lagoon.

However, Eskimo whalers are concerned that noise from both Northstar and Liberty may move whales beyond range during the fall hunting season. North Slope whaling captains believe whale movements can be affected considerable distance from sound sources (MMS 1997b). Through Incidental Harassment Authorizations or Letters of Authorization governing incidental takes (by harassment) of whales during construction and operation of Liberty and Northstar, plans of cooperation with whalers from Nuiqsut will be negotiated. These agreements not to interfere with traditional fall whaling activities in the Cross Island region will address reasonable means to limit effects from construction, sealift, drilling, and production operations on subsistence activities.

5.7.2.3 Threatened and Endangered Species

Potential impacts of the proposed Liberty Development on Threatened and Endangered Species (TES) are discussed in Sections 5.1, 5.2, and 5.3. Species under consideration include bowhead whales, Spectacled Eiders and Steller's Eiders.

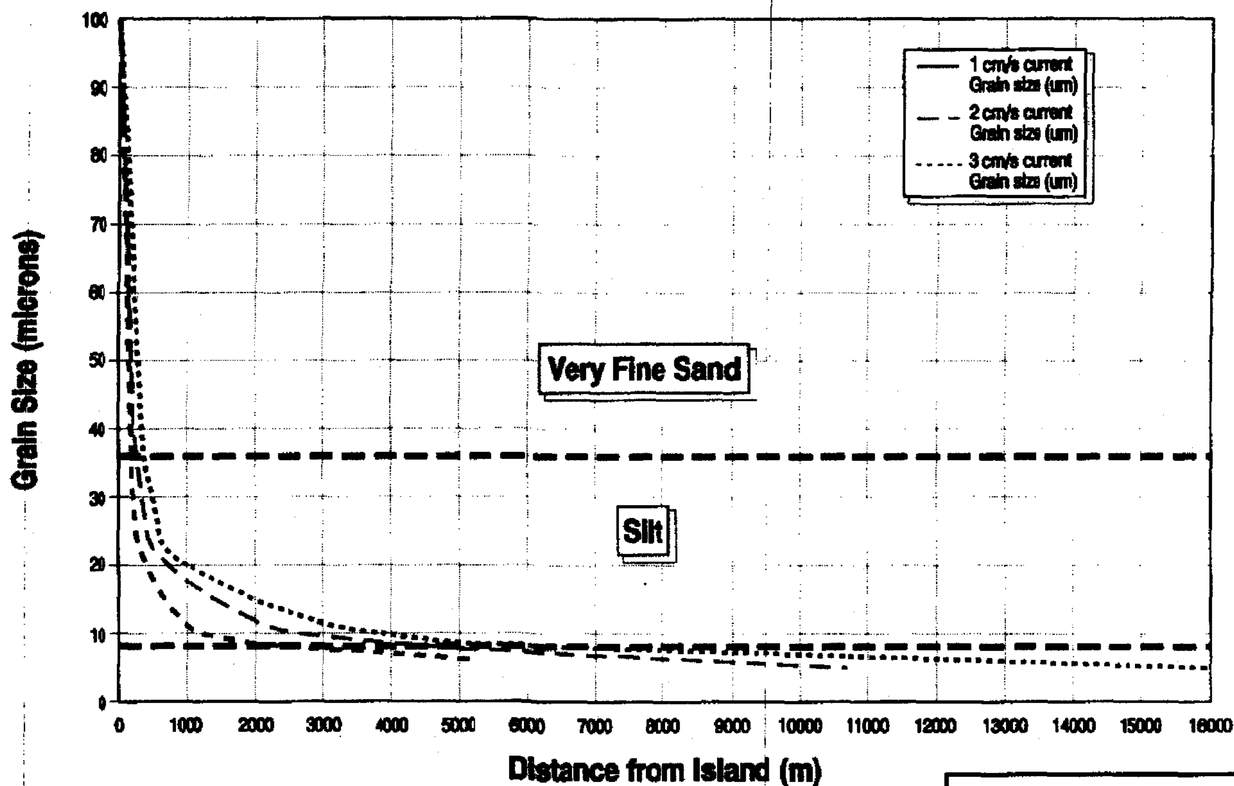
Bowhead whales were discussed previously. Steller's Eiders are not likely to be found in the Liberty Development area, and thus no cumulative effects on this species are expected. Most Spectacled Eiders use habitats west of the Sagavanirktok River, although some nest near the Kadleroshilik River. Spectacled Eiders prefer habitats in drained lake basins and wet coastal tundra for nesting and brood rearing; these habitat types have been avoided in the proposed design. Construction of Liberty is not likely to affect these habitats, since Spectacled Eiders are not likely to use the Liberty area. Periodic overflights and inspections of the onshore pads and pipeline during operation could occasionally disturb birds that may use nearby habitats in the future. The incremental additional effect of the Liberty Development on Spectacled Eiders is expected to be minimal. BPXA specifically incorporated design and construction criteria and operational stipulations to effect this result.

Some recent environmental assessments (e.g., NPR-A DEIS) have considered all aspects of potential cumulative impact of oil and gas leasing and development in the central Alaskan Arctic region, including transportation of oil produced as a result of proposed development. For the Liberty project, consideration should be given to TES along the transportation corridor from the North Slope to Valdez and from Valdez to ports on the U.S. west coast or the Far East. However, as noted in Section 5.7.2.1, production from the Liberty Development will have essentially no effect on TAPS or the marine vessel traffic from Valdez to these ports. The existing transportation systems (pipeline and marine) will continue to operate without discernible change due to Liberty, and little potential impact to TES along the corridor would be attributable to the Liberty Project. This small effect would be from extending the life of this transportation system by adding oil to the stream that would otherwise not be marketed due to the decline in production from the Prudhoe Bay and other North Slope oil fields. Together with satellite field development near the Prudhoe Bay and Kuparuk River fields and the Northstar Development, Liberty will extend the time petroleum products travel this transportation route from Pump Station 1 to United States and other world markets.

TES of concern along the marine petroleum transportation routes from Port Valdez to U.S. west coast ports are listed below. These include species that have been listed or have been proposed for listing under requirements of the Endangered Species Act. Potential risks to species such as the southern sea otter and the Marbled Murrelet are discussed in the Cook Inlet Lease Sale 149 EIS (MMS 1996d) and are incorporated here by reference. Potential risks of oil shipment to ports in the Far East may involve other species of endangered coastal and marine birds, pinnipeds, and whales, and are discussed in the Beaufort Sea Lease Sale 144 EIS (MMS 1996a) and are incorporated here by reference. Other species of animals that have been listed occur along the tanker shipping routes, but interagency consultations will likely determine that the transport of petroleum from the Liberty Development along the west coast or Far East routes poses little or no concern to these species.

- Snake River sockeye salmon (ocean and Columbia River)
- Snake River spring/summer chinook salmon (ocean and Columbia River)
- Snake River fall chinook salmon (ocean and Columbia River)
- Southern Oregon/Northern California coast coho salmon
- Central California coast coho salmon
- Sacramento River winter-run chinook salmon
- Umpqua River cutthroat trout
- Ten evolutionarily significant units of steelhead (Washington, Oregon, California)
- Tidewater goby (fish, coastal California)
- Sacramento splittail (fish, Sacramento and San Joaquin river estuaries)
- Suisum thistle (plant, tidal marshes in San Francisco Bay)

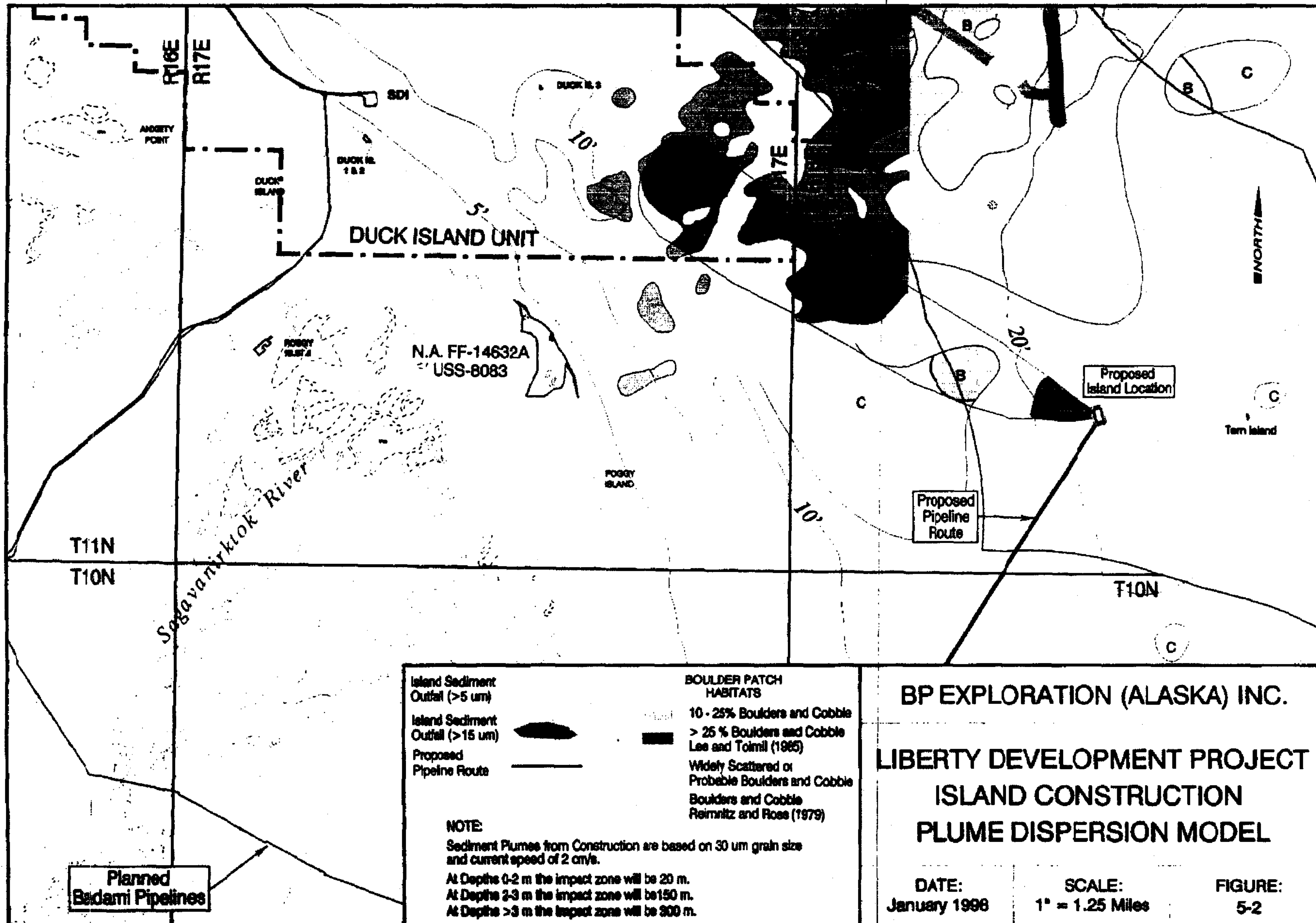
An extensive discussion of the above-listed species is provided in the NPR-A DEIS (BLM and MMS 1997), and is incorporated here by reference. The NPR-A DEIS discusses current knowledge of each species or evolutionarily significant unit, and provides an assessment of potential effects of oil spills along the marine transportation route to west coast ports.

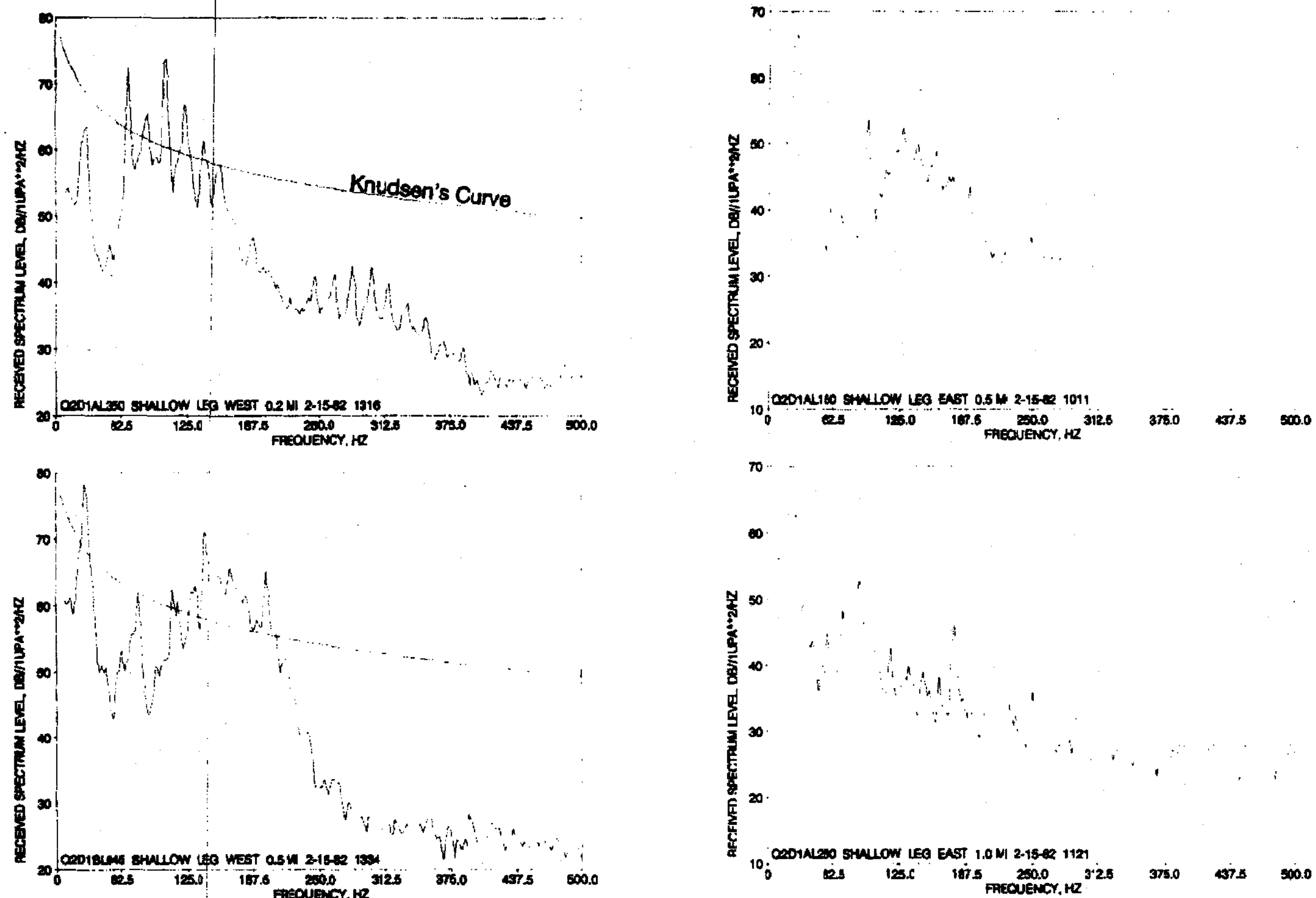


BP EXPLORATION (ALASKA) INC.

SETTLING DISTANCE
BASED ON GRAIN SIZE

DATE:	SCALE:	FIGURE:
January 1998	N/A	5-1


R16E
R17E
SDI
DUCK IS. 3
ANGERY POINT
DUCK IS. 1 & 2
DUCK ISLAND
10'
5'
DUCK ISLAND UNIT
R17E
B
C
NORTH
20'
Proposed Island Location
C
Tern Island
N.A. FF-14632A
USS-8083
C
B
FOGGY ISLAND
Sagavanirktok River
10'
Proposed Pipeline Route
T11N
T10N
T10N
C
Planned Badami Pipelines
Island Sediment Outfall (>5 um)
Island Sediment Outfall (>15 um)
Proposed Pipeline Route
BOULDER PATCH HABITATS
10 - 25% Boulders and Cobble
> 25 % Boulders and Cobble Lee and Toimil (1985)
Widely Scattered or Probable Boulders and Cobble
Boulders and Cobble Reimnitz and Ross (1979)
NOTE:
Sediment Plumes from Construction are based on 30 um grain size and current speed of 2 cm/s.
At Depths 0-2 m the impact zone will be 20 m.
At Depths 2-3 m the impact zone will be 150 m.
At Depths >3 m the impact zone will be 300 m.
BP EXPLORATION (ALASKA) INC.
LIBERTY DEVELOPMENT PROJECT
ISLAND CONSTRUCTION
PLUME DISPERSION MODEL
DATE: January 1998
SCALE: 1" = 1.25 Miles
FIGURE: 5-2



NOTE:
SOUND PRESSURE SPECTRA FOR ICE ROAD CONSTRUCTION NEAR THE MID POINT OF THE ROAD FOR SEAL IS.AND COMPARED TO KNUDSEN'S SOUND PRESSURE SPECTRUM (SMOOTH LINE CURVES) FOR SEA STATE ZERO (GREENE 1983).

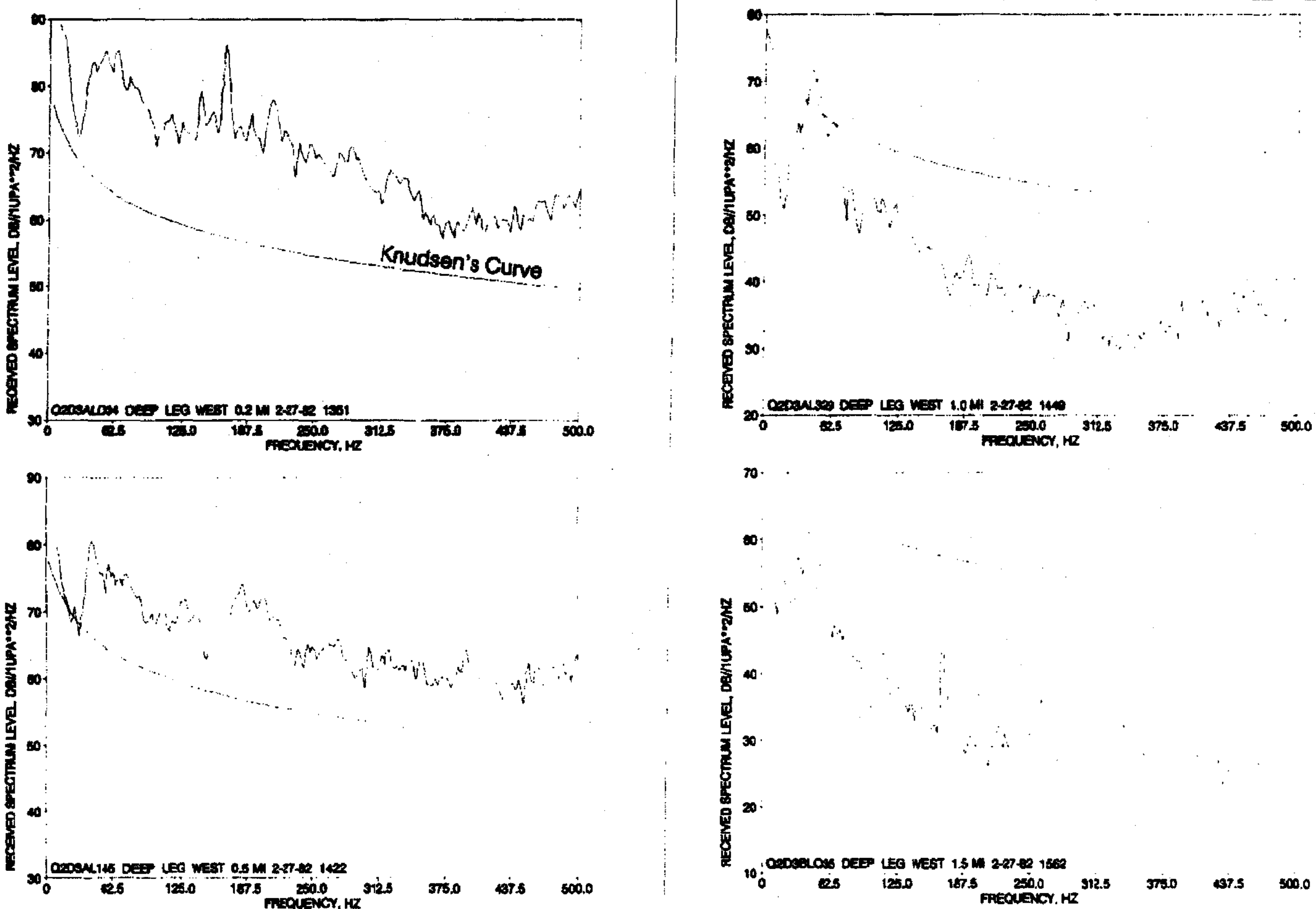
EQUIPMENTIN OPERATION INCLUDES ROLLIGONS, AUGERS AND PUMPS.

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
SOUND PRESSURE SPECTRA
LIBERTY #1 WELL
ICE ROAD CONSTRUCTION

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	5-3

fb109.dgn



NOTE:
SOUND PRESSURE SPECTRA FOR EARLY ISLAND CONSTRUCTION 0.3, 0.4, 1.6 AND 2.4 KM FROM SEAL ISLAND, COMPARED TO KNUDSEN'S SOUND PRESSURE SPECTRUM (SMOOTH LINE CURVES) FOR SEA STATE ZERO (GREENE 1983).

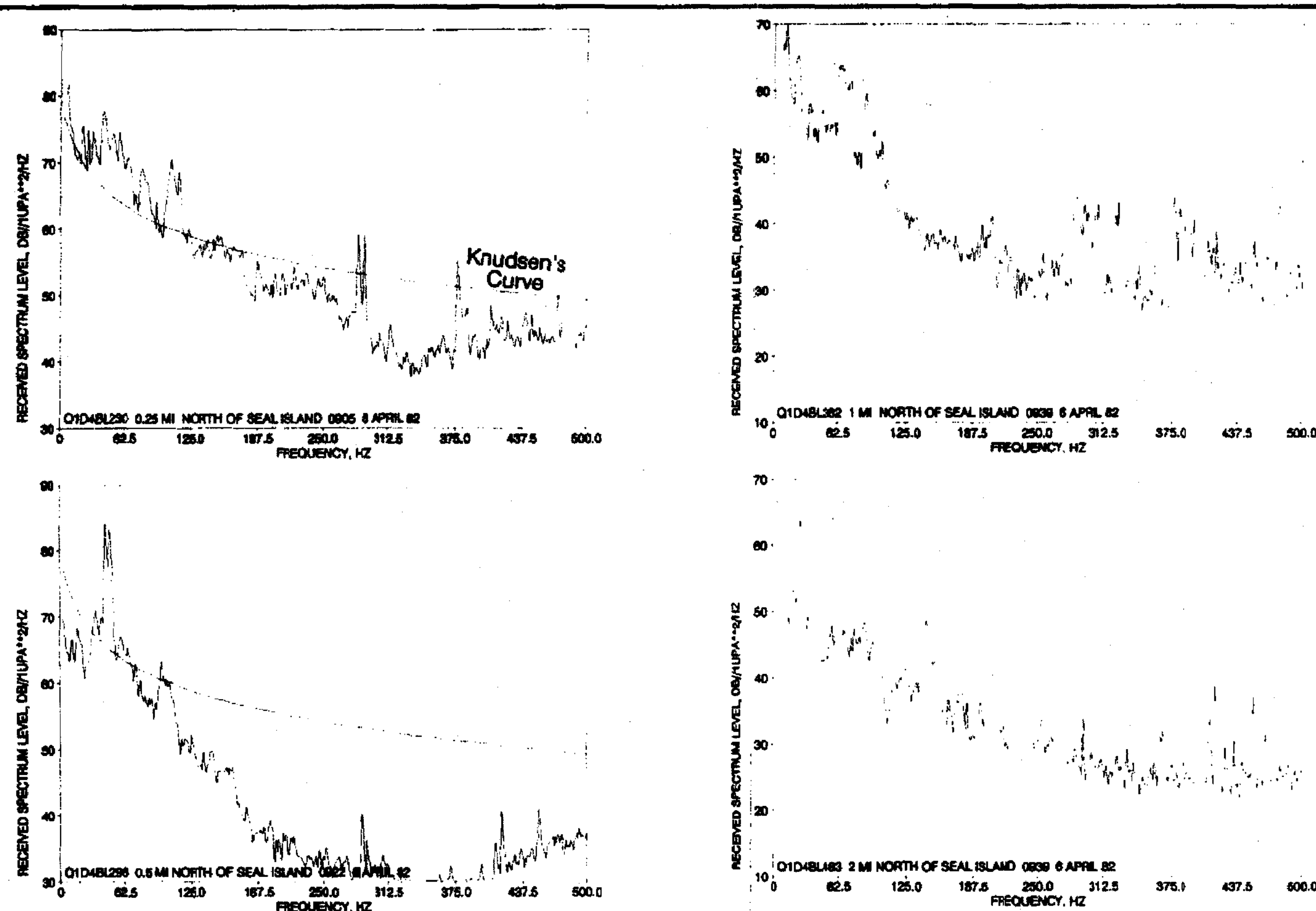
EQUIPMENT IN OPERATION INCLUDES D-7 AND D-8 CATERPILLAR, DITCHWITCH FOR CUTTING ICE AND BACKHOES HAULING ICE CUBES.

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
SOUND PRESSURE SPECTRA
LIBERTY #1 WELL
EARLY ICE ISLAND CONSTRUCTION

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	5-4

lib108.dgn



NOTE:
SOUND PRESSURE SPECTRA FOR FINAL ISLAND CONSTRUCTION FROM MIDPOINT OF SEAL ISLAND COMPARED TO KNUDSEN'S SOUND PRESSURE SPECTRUM (SMOOTH LINE CURVES) FOR SEA STATE ZERO (GREENE 1983).

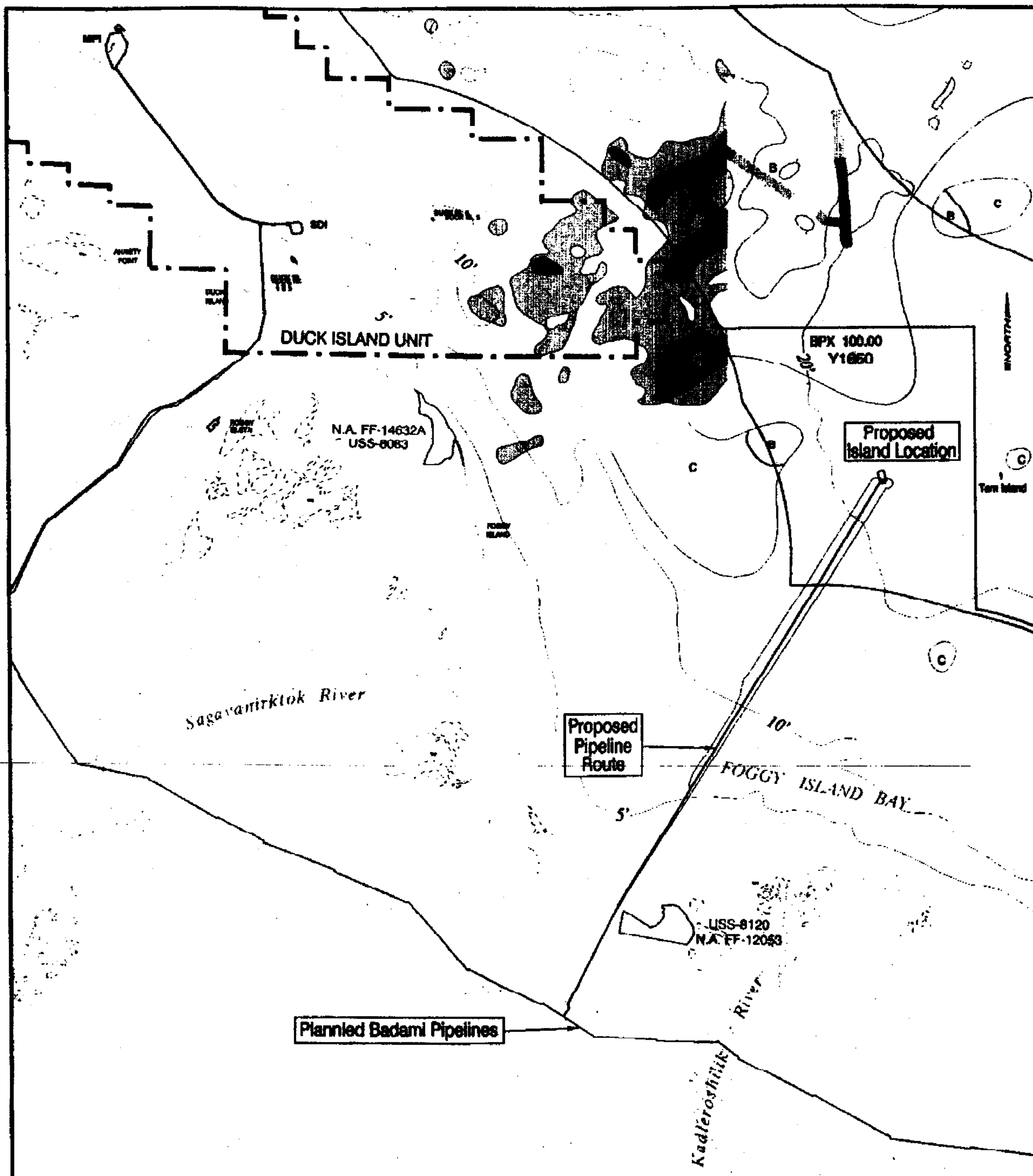
EQUIPMENT IN OPERATION INCLUDES PORTABLE LIGHTING PLANTS, LARGE GRAVEL TRUCKS, AND MISCELLANEOUS OTHER VEHICLES AND AUGERS.

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
SOUND PRESSURE SPECTRA
LIBERTY #1 WELL
FINAL ICE ISLAND CONSTRUCTION

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	5-5

lib108.dgn



Pipeline Sediment Outfall

Proposed Pipeline Route

BOULDER PATCH HABITATS

10 - 25% Boulders and Cobble

> 25 % Boulders and Cobble
Lee and Toimil (1985)

Widely Scattered or Probable Boulders and Cobble

Boulders and Cobble
Reimnitz and Ross (1979)

NOTE:

Sediment Plumes from Construction are based on 30 um grain size and current speed of 2 cm/s.

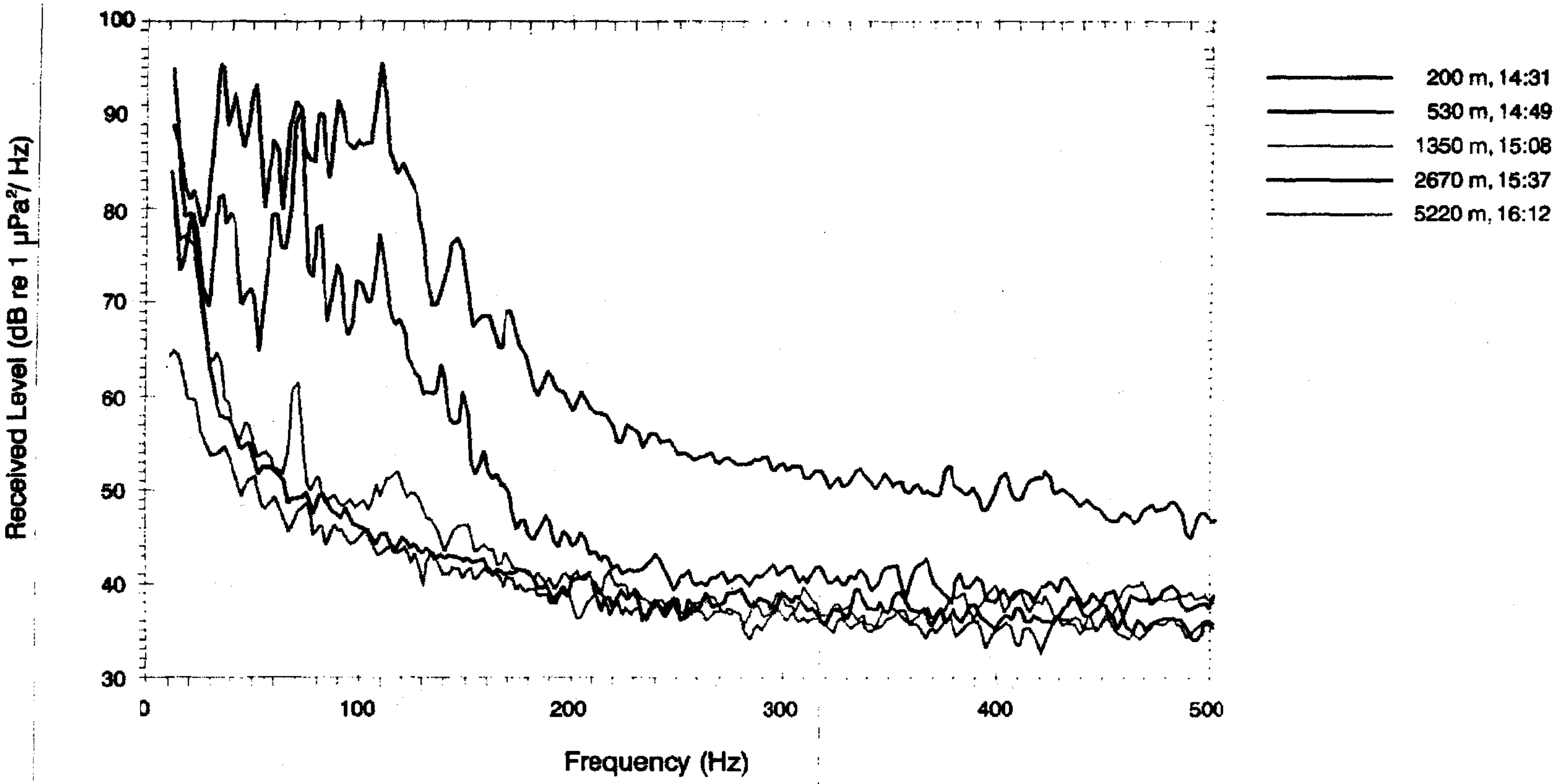
At Depths 0-2 m the impact zone will be 20 m.
At Depths 2-3 m the impact zone will be 150 m.
At Depths >3 m the impact zone will be 300 m.

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT PIPELINE CONSTRUCTION PLUME DISPERSION MODEL

DATE:	SCALE:	FIGURE:
January 1998	1" = 1.75 Miles	5-6

bs13491a.dgn



Measured received sound spectral densities recorded at five distances North of the Tern Island drilling on 18 February 1997.
The 9.8-Hz harmonic family of tones is present, as on the East leg, but the pattern of peaks differs.

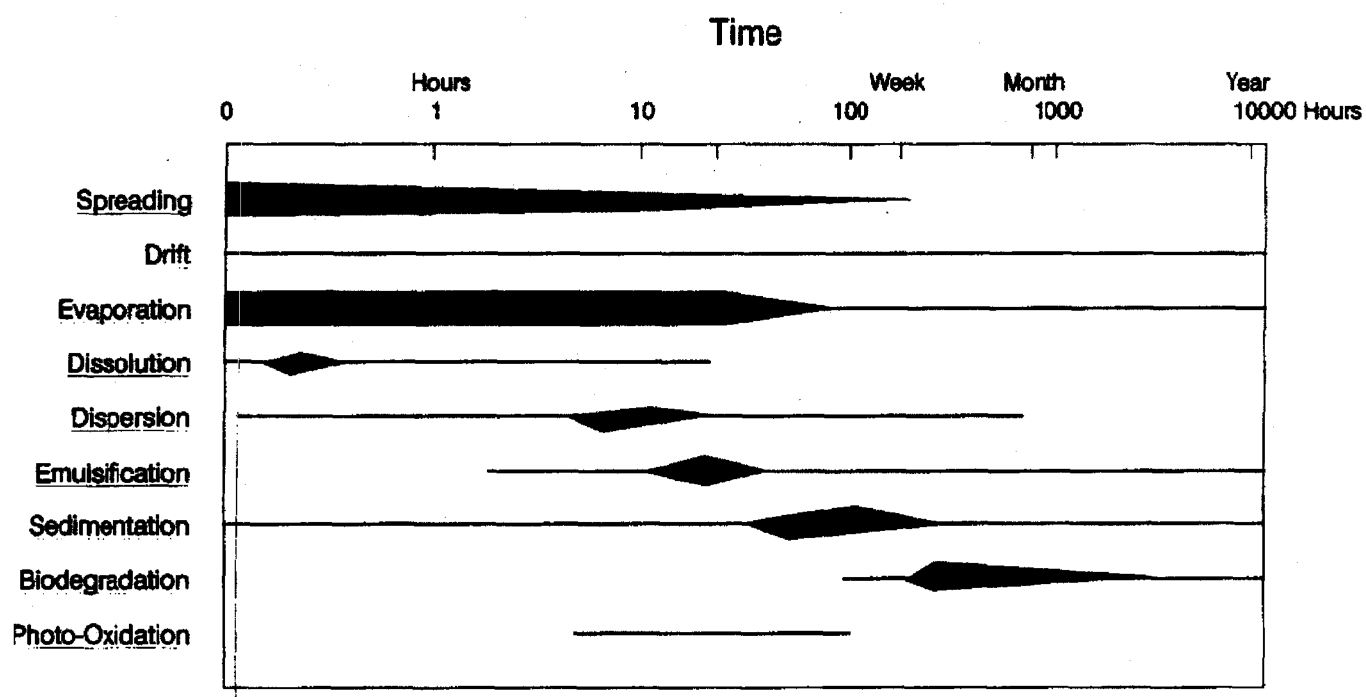
Source: Greene 1997

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
RECORDED SOUND SPECTRUM LEVELS
AT VARIOUS DISTANCES FROM A
DRILLING OPERATION ON
TERN ISLAND FEBRUARY 1997

DATE:	SCALE:	FIGURE:
January 1998	N/A	5-7

lib198.dgn

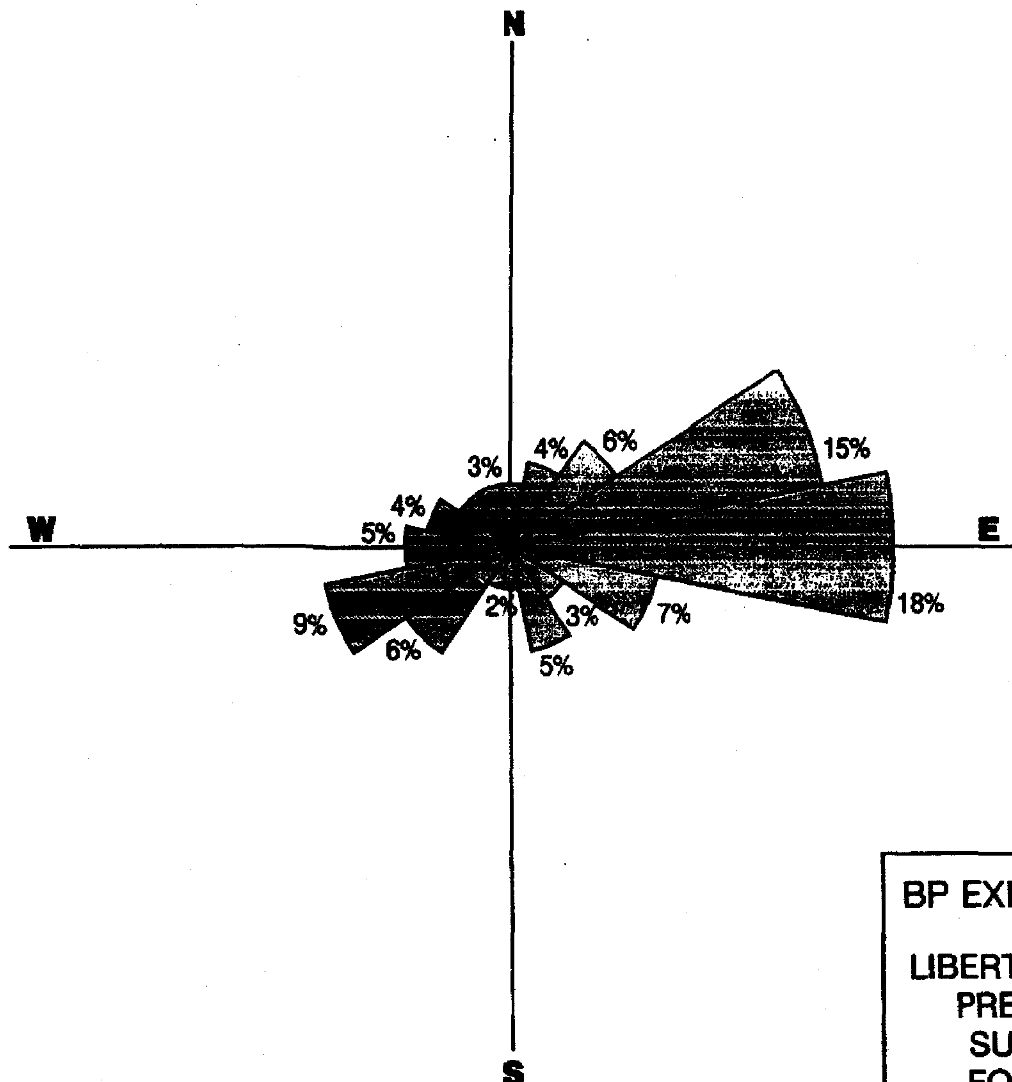


Source: Exxon Oil Spill Response Field Manual, 1992

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
SPILL SCENARIO PROCESS
VS. ELAPSED TIME

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	5-8

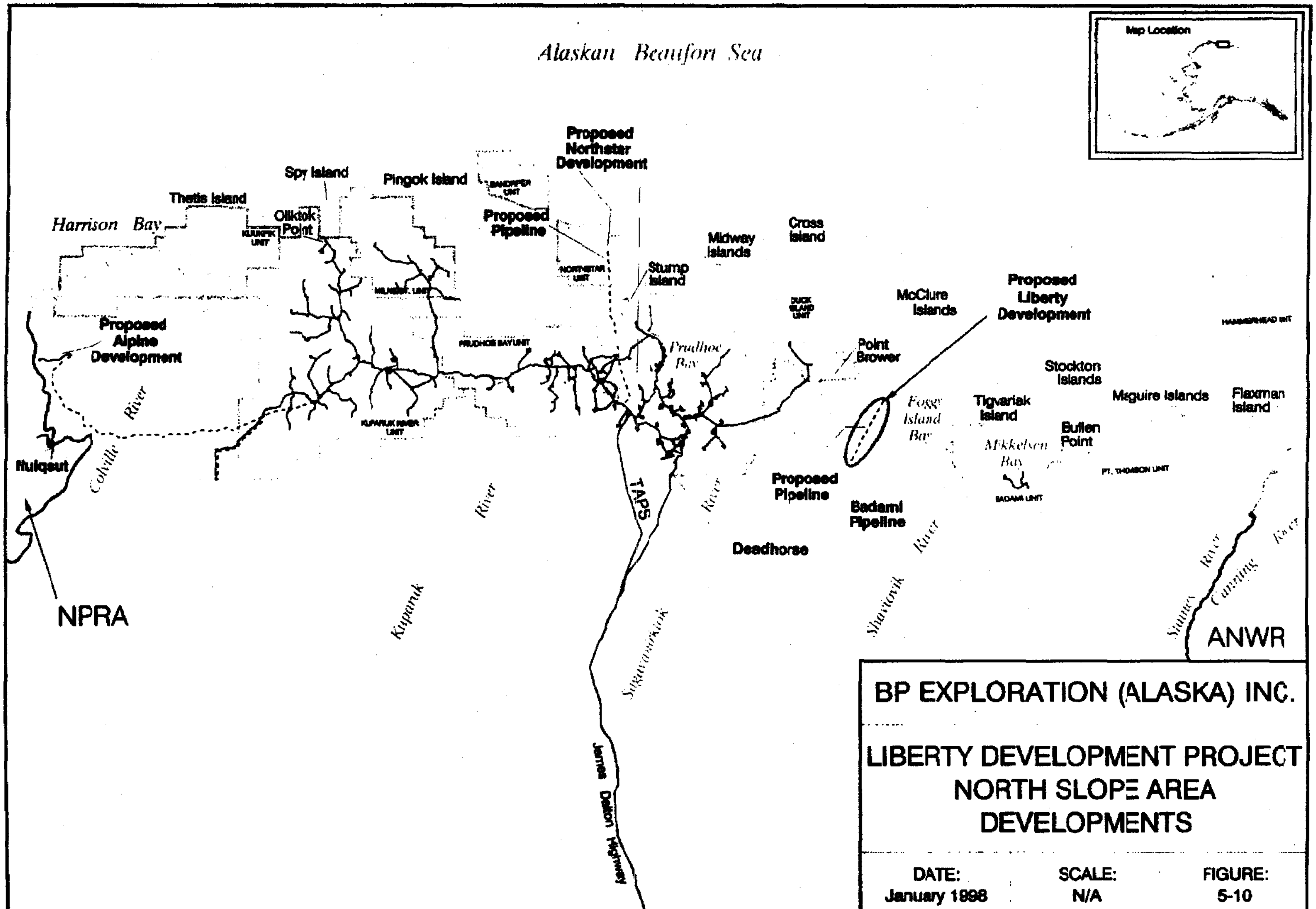


Source: ACS, Alaska Beaufort Sea Coastal Region Manual, 1986

BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
PRECENT DISTRIBUTION OF
SUMMER WIND DIRECTION
FOR SEAL IS. AND VICINITY

DATE:	SCALE:	FIGURE:
January 1998	NOT TO SCALE	5-9



BP EXPLORATION (ALASKA) INC.

LIBERTY DEVELOPMENT PROJECT
NORTH SLOPE AREA
DEVELOPMENTS

DATE:	SCALE:	FIGURE:
January 1998	N/A	5-10

6. MITIGATION MEASURES

This section describes the mitigation measures considered in the design of the proposed Liberty Development Project. A consistent goal of BPXA has been to minimize overall project impacts through careful design and planning of the project. Findings and analysis of this Environmental Report have been iteratively shared with the design team in the project decision-making process. Tables 6-1 and 6-2 summarize mitigation actions and expected benefits at the design, construction, and operation levels.

6.1 MITIGATION OF CONSTRUCTION IMPACTS

To minimize environmental impacts, all major construction involving offshore and on-tundra activities will take place during winter, including pipeline construction from ice roads and ice pads, potential development of the gravel source in the Kadleroshilik River drainage during winter, and construction of the gravel island and placement of the buried subsea pipeline from the sea ice.

By conducting all major construction activities in winter, disturbance of wildlife will be negligible, and impacts to tundra, other than those specifically authorized by permit, will be minimized or eliminated. Turbidity increases due to offshore gravel placement and pipeline corridor excavation will also be reduced by winter construction.

6.1.1 Gravel Mining

Gravel for the project will be obtained from a new site in the Kadleroshilik River floodplain. BPXA intends to follow the Alaska Department of Fish and Game's North Slope gravel pit performance guidelines (McLean 1993), where practicable, for locating and restoring the new gravel mine site. Areas that will not be excavated include wetland sites supporting *Arctophila fulva*, drained lake basins, and known fish overwintering pools. Disturbances in vegetated areas of river floodplains, which provide nesting habitat for birds and food and cover for moose and muskoxen, will be avoided. Where possible, the new mine will be located so that fish overwintering and rearing habitat can be created. Organic overburden will be removed and stockpiled for reuse or placed in the pit as a nutrient source. Disturbed areas will be cleaned up and restored, if necessary.

TABLE 6-1

LIBERTY DEVELOPMENT PROJECT
AVOIDANCE AND MINIMIZATION OF ENVIRONMENTAL IMPACT

DESIGN

ACTION	BENEFIT
Developed the oil and gas reservoir from an island with subsea pipeline to the shore.	Avoid use of causeway. Minimize benthic disturbance from gravel placement. Avoid potential effects on fish or nearshore oceanography. Minimize volume of gravel needed for development.
Minimized facility size; reduced wellhead spacing to 9 feet, directional drilling.	Minimize impacts associated with size of the offshore island.
Designed facility for zero discharge of drilling wastes; no reserve pits.	Reduce island size and impacts to benthos; eliminate potential for contaminant release from reserve pits.
Propose to locate new mine site in the Kadleroshilik floodplain.	Minimize impacts to tundra wetlands; facilitate immediate rehabilitation of gravel source to wildlife habitat consistent with Alaska Department of Fish and Game guidelines.
Optimized location of island site to avoid known Boulder Patch locations. Locate island as close to shore as possible.	Minimize impacts of island footprint on known Boulder Patch areas. Reduce length of pipeline necessary to reach shore, thereby minimizing disturbance to the marine environment.
Use filter fabric to reduce leaching of fine sediments from the gravel island following construction.	Minimize redistribution of fine particulates downstream onto sensitive marine habitat.
Fully considered all viable pipeline route alternatives based on potential impacts on Boulder Patch, marine, aquatic, and terrestrial habitats.	Proposed project was selected to avoid the Boulder Patch and reduce the potential impacts on other marine and terrestrial habitats (lakes, salt marsh) and cultural resources.
Eliminated Liberty to Endicott pipeline alternative.	Avoid known Boulder Patch habitats.
Surveyed multiple western pipeline routes to determine optimum placement.	Proposed western route environmentally same or better than other western route alternatives.
Met with federal, state, and local agencies early and frequently in project development to reaffirm critical issues and develop familiarity with project.	Verify critical issues early in project design; establish agency involvement early in process.

TABLE 6-1 (cont.)

LIBERTY DEVELOPMENT PROJECT
AVOIDANCE AND MINIMIZATION OF ENVIRONMENTAL IMPACT

DESIGN

ACTION	BENEFIT
Reviewed and summarized existing data on oceanographic conditions and potential alterations due to construction of an island in Foggy Island Bay.	Identify potential project and cumulative impacts; minimize impacts within project design and operational constraints.
Reviewed and summarized existing data on use of Foggy Island Bay by anadromous and freshwater fish, marine mammals and birds.	Identify potential project and cumulative impacts; minimize impacts within project design and operational constraints.
Coordinated with U.S. Fish and Wildlife Service on Spectacled Eider surveys since 1991.	Ensure protection of a threatened species.
Process design incorporated measures to minimize CO_2 emissions.	Reduce emissions of "greenhouse" gases.
Conducted baseline studies (acoustical data, seal survey, Boulder Patch survey, and archaeological survey).	Gather information for optimal project siting and design

TABLE 6-2

LIBERTY DEVELOPMENT PROJECT
AVOIDANCE AND MINIMIZATION OF ENVIRONMENTAL IMPACTS

CONSTRUCTION AND OPERATION

ACTION	BENEFIT
Use ice roads to access Liberty project and temporary water sources.	Eliminate impacts to tundra wetlands.
Use sea ice to support construction for island construction and pipeline placement. Install pipeline during winter when water currents are low.	Avoid barge traffic in summer for gravel transport, reducing air emissions. Reduce sedimentation of disturbed materials from the pipeline trench on adjacent benthic environments. Reduce noise disturbance to marine mammals.
Construct island and pipeline during winter from ice roads.	Eliminate impacts to wildlife; reduce sediment input effects, eliminate dust effects, eliminate impacts to tundra wetlands from a permanent access road; minimize subsistence displacement.
Minimize Island size.	Reduce footprint of island and impacts on benthic environment.
House pipeline construction workers in existing facilities.	Reduce temporary facilities on site; reduce potential for wildlife disturbance or attraction.
Strictly enforce speed limits within project construction areas.	Reduce potential for impacts to wildlife; reduce accidents and spill potential both on road surface and onto tundra and sea ice.
Coordinate with Alaska Department of Fish and Game on studies of fish, and brown bears within project area. Identify and avoid den locations.	Minimize interactions with bears; identify important fish resources in project area.
Coordinate with U.S. Fish and Wildlife Service on historic and recent locations of polar bear den sites.	Avoid actions that would disturb denning polar bears.
Mine gravel during winter according to approved mining plan.	Minimize impacts to fish overwintering areas; facilitate abandonment and reclamation of mine site (if new site is chosen), reduce or eliminate impacts due to increased dust.
Dispose of solid wastes onshore.	Minimize waste storage on the island. Reduce fox and polar bear encounters.
No discharge of drilling wastes (disposed of in injection well).	Avoid water quality impact
Electrical power for drilling.	Reduce air emissions and risks of fuel spills.

TABLE 6-2 (cont.)

LIBERTY DEVELOPMENT PROJECT
AVOIDANCE AND MINIMIZATION OF ENVIRONMENTAL IMPACTS

CONSTRUCTION AND OPERATION

ACTION	BENEFIT
Impose spring helicopter Howe Island overflight restrictions.	Avoid disturbance to breeding and nesting snow geese and brant.
Route helicopter routes to minimize other wildlife disturbance. Route vessel traffic inside the barrier islands.	Minimize disturbance to seals, bowhead whales, polar bear dens, and subsistence whaling activities.
Maintain continual on-site environmental presence during construction and operation to ensure compliance with permit requirements.	Minimize variances from permitted activities.
Follow U.S. Fish and Wildlife Service protection guidelines for Spectacled Eiders.	Minimize disturbance to these threatened birds.
Consult with Alaska Eskimo Whaling Commission if bowhead whales are observed inside the Midway Islands barrier island group.	Minimize disturbance to migrating bowhead whales or subsistence whaling activities.
Prohibit hunting by project personnel and restrict public access.	Protect wildlife and cultural resources.
Train personnel in interactions with wildlife. Establish an environmental awareness program.	Reduce potential for disturbance to wildlife. Increase awareness of risks and means to reduce impacts on wildlife.
Train personnel to recognize and avoid cultural resources.	Ensure that cultural resources are preserved.
Develop Conflict and Avoidance Agreement with local subsistence users.	Avoid unreasonable conflicts to subsistence activities.

6.1.2 Ice Roads

Ice roads will be used for temporary access during island and pipeline construction and for access to the Liberty Island during winter operation. Ice roads will be located within the nearshore areas and offshore to the island. An ice road likely will connect the Endicott Causeway with Liberty Island and the pipeline (as needed). Onshore ice roads for pipeline construction can be breached at river and stream crossings if necessary prior to breakup, and all ice roads will melt during breakup.

6.1.3 Wetlands

BPXA is using the following approach to reduce or eliminate impacts to wetlands in the Liberty Development Project area:

1) Identify wetlands of known or potential high value during project design.
2) Avoid, to the extent practicable, specific wetlands habitats, including drained lake basins and salt marshes and other areas identified by resource and regulatory agencies as having high value.
3) Place major facilities (island) offshore to reduce impact on wetlands.
4) Conduct all on-tundra operations during winter from ice roads or ice pads.
5) Minimize the total acres of all types of wetlands directly covered by gravel.
6) Use maps to identify small lakes and ponds, drained lake basins, pingoes, and other important habitats to aid in avoiding these habitats where practical and to minimize construction-related disturbances in riparian and estuarine areas.
7) Minimize trench width as much as possible, and soil from the top of the excavation will be replaced. Revegetation by seeding with appropriate species may be considered, as necessary.

6.1.4 Benthic and Boulder Patch Communities

Construction impacts on benthic communities, especially Boulder Patch resources, have been minimized by surveying the island placement area and alternative pipeline routes, and by optimizing the island placement and aligning the pipeline route to avoid areas with Boulder Patch communities or potential Boulder Patch substrates. The gravel island will be covered with a fabric liner, which will prevent subsequent fines in the gravel from increasing turbidity after construction.

No major effects to the Boulder Patch community are expected. Boulder Patch biota have regenerative capabilities that suggest mitigation could have been achieved had there been major effects. Martin and Gallaway (1994) demonstrated that bare rock placed on the bottom was colonized by biota typical of the Boulder Patch. Although colonization was slow, occurring over the course of six years, it did, nevertheless, demonstrate the ability for communities to repopulate and expand. The placement of substrate in appropriate areas could enable expansion of the Boulder Patch community. Submerged sideslopes of the Liberty Island likely will colonize with algae and various associated sessile organisms. Localized but temporary disruptions to the Boulder Patch would be negated over the long term, without any mitigation, due to the community's ability to recolonize.

6.1.5 Waterfowl and Marine Birds

Gravel hauling and construction activity will take place during winter to avoid direct effects on birds and to reduce effects on their habitat.

6.1.5.1 Spectacled Eiders

While included in the biological range of this species, few Spectacled Eiders are expected to be present in the Liberty Development Project area. BPXA has been conducting Spectacled Eider surveys in the North Slope oil fields since 1991. In 1993, radio transmitters were placed on some eiders to track their movements during migration to wintering grounds; this effort continued in 1994 when the survey was extended from Milne Point in the west to Bullen Point in the east. As in the past, BPXA will continue to share survey data with the U.S. Fish and Wildlife Service and will coordinate with them throughout the planning, construction, and operation phases of the proposed development.

6.1.6 Terrestrial Mammals

Measures for reducing disturbance to caribou and muskoxen are summarized in Tables 6-1 and 6-2. There is a low potential for grizzly bears to be attracted to artificial food sources (i.e., dumpsters, handouts) during construction, since major work will be conducted offshore during winter, and all construction workers will be housed in Deadhorse and transported to the construction site daily. Other measures to reduce potential conflicts with polar bears include site layout and facility design to increase visibility and reduce potential bear hiding places, physical barriers to prevent bear access under elevated buildings, protection of cable systems that supply remote power and monitoring of the wellsite, awareness training for employees, storage of all food and food wastes inside facilities, good housekeeping, and emphasis on good lighting to eliminate hiding places for bears.

Studies conducted in the Prudhoe Bay oil field have suggested that availability of artificial food sources (refuse and feeding by oil field personnel) in developed areas results in increased Arctic fox productivity, increased density, and dampened population fluctuations (Eberhardt et al. 1982, 1983). Artificially high fox populations increase the potential risk of exposure of oil field workers to rabies and may lead to abnormally high predation of tundra bird populations. Proper handling and disposal of garbage in appropriate dumpsters, coupled with enforceable restrictions on feeding wildlife, will minimize the likelihood of detrimental animal/human interactions during construction of the proposed development. All food wastes will be stored inside buildings or in animal-proof containers.

6.1.7 Marine Mammals

The number of individual animals expected to be directly encountered during the course of the proposed construction will be small. Densities of the most abundant resident marine mammal, ringed seals, are relatively low (one seal/km^2). Winter construction operations will not affect seasonally-occurring pinnipeds (bearded seals, spotted seals and walrus) or whales (bowhead, gray, and beluga whales).

To minimize the likelihood that impacts will occur to the species, stocks, and subsistence users of the species or stocks, BPXA will operate at all times in compliance with all applicable regulations. During the summer, BPXA will conduct all of its helicopter operations over land, to the extent practicable, and vessel traffic inside the barrier islands. If any spotted seal haulout sites are identified, air traffic will be instructed to avoid these sites. As appropriate, BPXA will coordinate activities with the relevant federal and state agencies (particularly the National Marine Fisheries Service, U.S. Fish and Wildlife Service, National Biological Service, and Alaska Department of Fish and Game), local authorities (North Slope Borough), communities (Barrow, Nuiqsut, and Kaktovik), and whaling captains and their representatives (Alaska Eskimo Whaling Commission; Barrow, Nuiqsut, and Kaktovik Whaling Captains Associations). A Cooperation and Avoidance Agreement with local subsistence users will be developed, if necessary. Communications with local subsistence users concerning construction plans will be ongoing.

6.1.8 Personnel Training

All BPXA and contract personnel will receive environmental training which identifies physical, biological, and human resource concerns of the project area and explains BPXA's policies for addressing these concerns. This training program will include, but not be limited to, BPXA's Achieving Environmental Excellence training and polar bear, grizzly bear, and fox awareness training, as well as specific training materials being developed to address offshore construction and operations. Construction personnel will be strictly forbidden to feed wildlife. Selected personnel will receive training for polar bear deterrence to meet the requirements of Section 112(c) of the Marine Mammal

Protection Act. This training will be under the supervision of the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game. This training program is intended to fulfill Lease Sale Stipulation No. 2.

6.1.9 Cultural Resources and Subsistence

Most potential effects of construction associated with the project (island, subsea pipeline, onshore pipeline) will be mitigated by winter construction. This is also the period of lowest human (subsistence) use of the area.

For cultural resources, the primary mitigation measure for construction is avoidance. Reconnaissance of alternative pipeline routes has verified that significant cultural resource sites can be avoided. BPXA conducted archeological surveys during the summer of 1997 and found that no cultural resources would be affected by the onshore construction. In addition, cultural resource recognition and sensitivity will be part of the instruction/orientation program for all personnel, and a strict policy of non-contact with such resources will be enforced. The oil spill plan for this project will identify cultural sites for special protection.

If cultural resources not identified during archeological surveys are discovered during construction, work will be halted and the State Historic Preservation Officer will be contacted. In addition, the North Slope Borough Inupiaq History, Language, and Culture Commission will be consulted. A decision will be made, following these discussions, to avoid, protect, or remove the resource, using appropriate scientific and culturally-sensitive techniques.

6.1.10 Water Quality

The occurrence of small spills of gasoline, diesel fuel, and hydraulic fluids from construction equipment will be mitigated through personnel training and by following Best Management Practices (BMPs). Fueling operations will only occur at designated locations and will follow accepted BMPs.

6.2 MITIGATION OF OPERATION IMPACTS

Measures for protecting air and water quality, and for managing wastes during construction, also will be used as appropriate during project operation. Specific operations features and mitigation measures are summarized in Table 6-2 and are provided in the following sections.

6.2.1 Wildlife Protection

Project personnel will not be allowed to hunt in the project area, and access, by virtue of a roadless and offshore project design, will be restricted to essential personnel only. All project personnel will receive environmental training, and they will be strictly forbidden from feeding wildlife. Firearms kept on location for protection from polar bears and grizzly bears will be stored in locked cabinets and access to them restricted to trained personnel.

Helicopter travel to the island during spring and fall will be restricted to an inland route to avoid nesting snow geese and brant on Howe Island.

Summer vessel transit to the island will be restricted to a route inside the barrier islands to minimize disturbance to migrating bowhead whales and subsistence whaling activities.

6.2.1.1 Marine Mammals

Some disturbance to marine mammals may occur during project operation. Operations will be conducted under small take provisions, including either (1) Incidental Harassment Authorizations or (2) regulations and Letters of Authorization, or both, which will allow the take by harassment of small numbers of whales, pinnipeds and polar bears. It is anticipated that regulations governing takes of marine mammals by project activities will be in place when production operations begin. Existing regulations for polar bears and walruses expire on 15 December 1998 and will need to be renewed by the USFWS. New rules for cetaceans and seals will need to be developed by NMFS. Petitions seeking these actions will be submitted by BPXA. The petitions for rulemaking will deal not only with harassment, but also with the (unlikely) possibility of injury or mortality of small numbers of marine mammals by oil spills or other unforeseen events. Cooperation and Avoidance Agreements with local subsistence users will be developed, and communications with local subsistence users will be ongoing.

Effects of proposed development and associated transportation on seals are expected to be limited to short-term and localized behavioral reactions by a very small number of seals. Aircraft will avoid flying within two miles of any identified spotted seal haul-out sites in or near the proposed development to mitigate against the known high sensitivity of this species to aircraft. Overall, there will be no significant effects on individual seals or their populations by operation of the proposed development.

Polar bears are extremely curious and opportunistic hunters, and they have been known to approach facilities in search of food. All operations in the project area will be conducted to minimize the attractiveness of the construction sites to polar bears and to prevent their access to garbage, food, or other potentially-edible or harmful materials. BPXA has implemented its own polar bear interaction plan using the MMS guidelines for operation within polar bear habitats (Truett 1993; BPXA 1993). BPXA will coordinate all activities associated with polar bears in the region with the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game. Trained personnel have authority under Section 112(c) of the Marine Mammal Protection Act to haze polar bears under certain circumstances involving the protection of life.

Effects of the proposed development and associated transportation on bowhead whales are expected to be minimal. Vessel movements during the construction phase, especially in waters north of the barrier islands, will be completed before 1 September insofar as ice and other conditions allow. Aircraft overflights of waters north of Liberty will be avoided after 31 August, except in emergency conditions. Island and pipeline construction will be conducted in winter, avoiding disturbance to whales. The details of these mitigation measures will be negotiated with the Alaska Eskimo Whaling Commission and NMFS during the IHA and rulemaking processes and during the establishment of a Communication and Avoidance Agreement with the whalers.

6.2.2 Cultural Resources and Subsistence

Negotiation towards a Cooperation and Avoidance Agreement between BPXA and subsistence whaling representatives may initially be restricted to the open water season and subsistence whaling, but may be broadened to include additional species and seasons (year-round). Discussed in Section 6.3 in terms of Lease Sale Stipulation No. 5, this may be expanded to include many or most of the other "subsistence mitigation measures."

Operations will be conducted under IHAs and/or small take regulations and Letters of Authorization, which will allow the take of small numbers of marine mammals. Cooperation and Avoidance Agreements with local subsistence users will be developed, and communications with local subsistence users will be ongoing. IHAs and small take regulations require that there be no unmitigable adverse effects on the availability of bowhead whales or other marine mammals to meet subsistence needs (by displacing mammals, displacing hunters, or preventing hunters access to certain areas).

6.2.3 Air and Water Quality

Potential impacts of operations activities to air and water issues will be mitigated through the following measures:

- Reduction of greenhouse gas emissions.
- Using high-line power instead of diesel to power the drill rig, resulting in reduced emissions.

- Injecting all drilling muds and cuttings and produced water into a permitted, onsite injection well, thereby removing the need to discharge these wastes into water of Foggy Island Bay.
- Developing and following BMPs for all fuel handling, storing, and dispensing activities associated with production.
- Process design to minimize carbon dioxide omissions.

6.2.4 Major Oil Spills

The North Slope Borough has requested a seasonal drilling restriction for all offshore leases due to concerns over oil spills (NSB 1987, 1990; ASNA 1995). While no seasonal drilling restriction is currently required by MMS for this lease, this issue is of ongoing concern. Through its Oil Spill Contingency Plan (submitted in parallel with this Environmental Report), BPXA will identify measures to control and mitigate spills and work safely during periods of whale migration.

6.3 COMPLIANCE WITH LEASE SALE STIPULATIONS

The proposed development area encompasses waters in lease tract OCS-Y1650, which was leased under Sale 144. In accordance with 30 CFR Part 250.34(b)(4), this section describes how BPXA will comply with the stipulations of this Lease Sale.

6.3.1 Stipulation No. 1, Protection of Biological Resources

Stipulation Summary: The Regional Supervisor, Field Operations (RS/FO) may require the lessee to conduct biological surveys needed to determine the extent and composition of biological populations and habitats requiring additional protection. As a result of these surveys, the RS/FO may require the lessee to relocate the site of operations, modify the operation and/or establish that operations will not have adverse effects, or ensure that special biological resources do not exist. In addition, the lessee is required to report any area of biological significance discovered during the conduct of any operations on the lease, and make every effort to preserve and protect the biological resource from damage until the RS/FO provides direction with respect to resource protection.

Planned BPXA Compliance: The proposed project is located near the Stefansson Sound Boulder Patch, a special biological resource. The proposed island location and pipeline routing have been selected to avoid impacts to Boulder Patch habitats. In summer of 1997, surveys were conducted to delineate Boulder Patch habitats in areas that might be directly or indirectly affected by project construction and operation. The scope of this summer field program included side-scan and multibeam sonar surveys, supplemented with limited Remotely Operated Vehicle (ROV) visual observations. The work program scope and approach was developed in consultation with the Arctic Biological Task Force.

These studies showed Boulder Patch habitat likely was absent from the seafloor at the island site and along the proposed pipeline route. Some areas of sonar return were interpreted to suggest scattered rocks might be present, but these had densities well below 10 percent. These areas will be ground-truthed in winter 1998 using an ROV to confirm that rock cover is lower than 10 percent and that no Boulder Patch communities are present.

6.3.2 Stipulation No. 2, Orientation Program

Stipulation Summary: The lessee must develop a proposed orientation program for all personnel involved in the exploration program. The program must address environmental, social, and cultural concerns that relate to the area, including the importance of not disturbing archaeological and biological resources and habitats. The program will include distribution of information cards on endangered and/or threatened species in the sale area. The program shall be designed to increase the sensitivity and understanding of the personnel to community values, customs, and lifestyles in areas in which such personnel will be operating. The orientation program also shall include information concerning avoidance of conflicts with subsistence, commercial fishing activities, and pertinent mitigation. The program shall be attended at least once a year by all personnel involved in onsite exploration or development and production activities. The lessee shall maintain a record of all personnel who attend the program onsite for so long as the site is active, not to exceed five years.

Planned BPXA Compliance: BPXA's standard North Slope Environmental and Cultural Awareness training in the form of BPXA's "Achieving Environmental Excellence" program will form the foundation for environmental orientation for all personnel and contractors involved in Liberty offshore development. This program will be expanded to address specific issues of concern related to offshore locations, including protection of known onshore archaeological resources, wildlife interaction, protection of marine mammals, best management practices to minimize the potential for spills, awareness of local sociocultural issues and concerns, and awareness of subsistence resources and activities. BPXA is currently developing a video to be used in the training process; development of this video will be coordinated with MMS. The overall training program will be submitted to the RS/FO for review and approval.

Personnel will receive appropriate training on at least an annual basis, and full training records will be maintained for at least five years.

6.3.3 Stipulation No. 3, Transportation of Hydrocarbons

Stipulation Summary: Pipelines are the preferred transportation mode for production.

Planned BPXA Compliance: BPXA is proposing to construct a pipeline system from the gravel island to an onshore connection with the Badami pipeline system.

6.3.4 Stipulation No. 4, Industry Site-Specific Bowhead Whale Monitoring Program

Stipulation Summary: A monitoring program is required for exploratory operations conducted during the bowhead whale migration.

Planned BPXA Compliance: Not applicable to this proposed development and production program.

6.3.5 Stipulation No. 5, Subsistence Whaling and Other Subsistence Activities

Stipulation Summary: The lessee must conduct operations in a manner that prevents unreasonable conflicts between industry activities and subsistence activities. Prior to submitting a DPP, the lessee shall consult with the potentially-affected communities and the Alaska Eskimo Whaling Commission to discuss potential conflicts with the siting, timing, and methods of proposed operations and safeguards or mitigation measures which could be implemented to prevent unreasonable conflicts. The lessee shall make every reasonable effort to assure that development and production activities are compatible with whaling and other subsistence hunting activities and will not result in unreasonable interference with subsistence harvests.

A discussion of resolutions reached during this consultation process and any unresolved conflicts shall be included in the DPP. In particular, the lessee shall show in the plan how mobilization of the drilling unit and crew and supply boat routes will be scheduled and located to minimize conflict with subsistence activities. Those involved in the consultation shall be identified in the plan. The lessee shall notify the RS/FO of all concerns expressed by subsistence hunters during the operations and of steps taken to address such concerns.

Planned BPXA Compliance: BPXA is proposing to incorporate several measures into design, construction, and operations to minimize any potential conflicts with subsistence users. These measures include ongoing community liaison as described in Section 7, development of a Cooperation and Avoidance Agreement with the Alaska Eskimo Whaling Commission, major construction activities occurring in the winter season, and generally limiting vessel transit to the island to routes inside the barrier islands. An ongoing consultation process will be used to identify any concerns not addressed by BPXA proposed mitigation, as well as potential additional measures to be considered.

6.3.6 Stipulation No. 6, Agreement Between the United States of America and the State of Alaska

Stipulation Summary: An advisory regarding the terms of the subject agreement.

Planned BPXA Compliance: No compliance activity required.

6.3.7 Stipulation No. 7, Agreement Regarding Unitization

Stipulation Summary: An advisory regarding the terms of an agreement between the United States of America and the State of Alaska.

Planned BPXA Compliance: No compliance activity required.

7. CONSULTATION AND COORDINATION

7.1 AGENCY LIAISON

As an integral part of project planning, BPXA has worked with various federal and state agencies and the North Slope Borough in development of the proposed project. Meetings with individual agencies were held to informally discuss proposed project plans, project alternatives, design concepts, and environmental, geotechnical, hydrological, and engineering data collection programs. Comments from agency personnel on project scope, project alternatives, environmental concerns, permitting requirements, and data gaps were actively sought during these meetings. Table 7-1 lists each of these meetings.

7.2 LOCAL LIAISON

7.2.1 Background

BPXA is planning a local liaison program that is intended to identify issues of concern to local communities. BPXA commits to deal with each of the issues raised by those communities, particularly the issues of greatest concern, such as potential marine mammal disturbance and oil spill prevention and cleanup capability. Three communities are near the Liberty Development Project: Nuiqsut, the closest community, is 84 miles to the west of the project area; Kaktovik is 92 miles to the east; and Barrow is 224 miles to the west.

BPXA has held preliminary meetings with those North Slope communities, and proposes a continuing information and consultation program during the planning, development and production phases of the project. As listed in Table 7-2, BPXA representatives have discussed the project in several meetings with these communities since late 1996, and in meetings with the North Slope Borough, the Alaska Eskimo Whaling Commission, and the Whaling Captains Associations of Nuiqsut and Kaktovik.

In meetings held in the three communities in late January, just prior to submission of this application, the following concerns were voiced:

- noise and effects on subsistence whaling
- oil spill prevention and leak detection
- jobs and training
- pipeline integrity (leak detection and ice keel)

TABLE 7-1

AGENCY COORDINATION MEETINGS

DATE	PURPOSE	ATTENDEES
10/30/96	Project Concept Introduction	MMS, BPXA
12/16/97	Project Status Update	MMS, BPXA
12/18/96	Project Concept Introduction	SPCO, BPXA
1/7/97	Part 55 Air Permit Requirements	Region X EPA (Air Division), BPXA
2/3/97	Project Status Update	MMS, BPXA
2/6/97	Part 55 Air Permit Requirements	Region X EPA, BPXA
2/11/97	Project Concept Introduction	Corps of Engineers, BPXA
2/21/97	ACMP Process	ADGC, MMS, BPXA
2/21/97	Biological Task Force	BTF, MMS, BPXA
2/21/97	CVA process	MMS, BPXA
2/24/97	Pipeline Permitting Process	SPCO, BPXA
2/24/97	Project Concept Introduction	Region X EPA (Water Division), BPXA
2/27/97	Project Concept Introduction	NSB, BPXA
3/4/97	Project Status Update	MMS, BPXA
3/10/97	Project Status Update	MMS, BPXA
3/24/97	ACMP Process	ADGC, MMS, BPXA
4/10/97	Project Status Update	MMS, BPXA
4/25/97	Pipeline Permitting Process	SPCO, BPXA
5/1/97	Pipeline Permitting Process	SPCO, BPXA
5/13/97	Project Status Update	MMS, BPXA
5/19/97	Biological Task Force	BTF, MMS, BPXA
6/20/97	Preliminary Activities	MMS, BPXA
6/23/97	Pipeline Permitting Process	MMS, SPCO, BPXA
7/3/97	Preliminary Activities	MMS, BPXA
7/3/97	Permitting Issues	MMS, BPXA
7/10/97	Pipeline Permitting Process	SPCO, BPXA
7/11/97	Project Concept Introduction/Mine Site	DNR, ADFG, USFWS, BPXA
7/16/97	Project Status Update, ACMP Process	MMS, DGC, BPXA

TABLE 7-1 (cont.)

AGENCY COORDINATION MEETINGS

DATE	PURPOSE	ATTENDEES
7/17/97	Permitting Issues	MMS, BPXA
7/21/97	Project Status Update, Permitting Process	Corps of Engineers, BPXA
8/14/97	Pipeline Permitting Process	SPCO, BPXA
8/14/97	Project Status Update	MMS, BPXA
8/21/97	Project Status Update, Air Permitting Issues	Region X EPA (Air Section), BPXA
8/22/97	Project Concept Introduction, Permitting Process	EPA, BPXA
8/26/97	Permitting Issues	MMS, BPXA
8/28/97	Pipeline Permitting Process	MMS, SPCO, BPXA
9/9/97	Project Status Update, NPDES Permitting Issues	Region X EPA (Water Section), BPXA
9/12/97	Permitting Issues	MMS, BPXA
9/18/97	Project Concept Introduction	DOG, BPXA
10/2/97	Permitting Issues	MMS, SPCO, BPXA
10/2/97	Permitting Issues (Spill Planning)	MMS, BPXA
10/14/97	Permitting Issues	SPCO, BPXA
10/15/97	Project Concept Introduction/Mine Site	DNR, ADFG, ADEC, BPXA
10/22/97	Project Status Update	MMS, BPXA
10/22/97	Permitting Issues	MMS, BPXA
10/24/97	Part 55 Air Permit Requirements	Region X EPA, BPXA
11/5/97	Injection Well Permit Issues	MMS, BPXA
11/10/97	Biological Task Force	BTF, MMS, BPXA
11/18/97	Permitting Issues	MMS, BPXA
12/1/97	Permitting Issues	MMS, BPXA
12/9/97	NPDES Permitting Issues	EPA, BPXA
12/10/97	Permitting Issues	MMS, BPXA

TABLE 7-1 (cont.)

AGENCY COORDINATION MEETINGS

DATE	PURPOSE	ATTENDEES
12/30/97	Permitting Issues	MMS, BPXA
1/6/98	Permitting Issues	MMS, BPXA
1/7/98	NEPA Coordination - MMS/EPA	MMS, EPA, BPXA
1/12/98	Permitting Issues	MMS, BPXA
1/13/98	NEPA coordination - MMS/Corps of Engineers	MMS, Corps of Engineers, BPXA
1/21/98	EIS Kickoff Workshop	MMS, BPXA
1/26/98	Pipeline Permitting Process	SPCO, BPXA
1/27/98	Permitting Issues	MMS, BPXA

TABLE 7-2

LOCAL LIAISON

DATE	EVENT
10/96	Discussion on plan for winter Liberty Exploration Well. Meeting with a representative of each organization: Kaktovik Whaling Captains Association, Joe Kaleak; Nuiqsut Whaling Captains Association, Thomas Napageak.
3/3/97	Presentation on Liberty Exploration to Nuiqsut City Council and residents (council members on 3/3/97 included Leonard Lampe, Alice Woods, Ruth Nukapigak, Rosemary Ahtuangaruak, George Seilak) and community members in audience.
3/4/97	Individual and informal meetings with available Nuiqsut residents (Isaac Nukapigak, Frederick Tukle)
5/1/97	Liberty Confirmation Press Release
5/28/97	Liberty Alliance Contractor Selection Press Release
6/26/97	North Slope Borough Planning Commission, project update
7/28/97	BP Technology Fair, Nuiqsut (community at-large)
7/29/97	BP Technology Fair, Kaktovik (community at-large)
7/31/97	BP Technology Fair, Barrow (community at-large)
11/6/97	Job Fair, Nuiqsut (with Kuukpik Corporation for community at-large, and Kuukpik officials: Joe Nukapigak, Thomas Napageak, other key community officials present included Leonard Lampe, Isaac Nukapigak)
1/10/98	Liberty introduction at post-season ocean bottom cable seismic monitoring meeting with AEWC (Nuiqsut and Kaktovik Whaling Captains, NSB staff and AEWC staff)
1/27/98	Liberty introduction to Nuiqsut community (Kuukpik Corporation, Thomas Napageak, Dale Stotts, Mayor Leonard Lampe, Nuiqsut community members)
1/28/98	Liberty introduction to North Slope Borough Mayor, Arctic Slope Regional Corporation, senior staff, and other community groups (NSB Mayor Ben Nageak, Marie Adams Carroll; Mike Pedersen, ASNA; Anna Jack, UAA; Jake Adams, Oliver Leavitt, ASRC; Dave Heier, NSB)
1/29/98	Liberty introduction to North Slope Borough Planning Commission meeting in Kaktovik (NSB Planning Commission members; Kaktovik Mayor, Lon Sonsalla; Joe Kaleak, Kaktovik Whaling Captains Association; and other community members in attendance)

- access to facilities
- respect of local knowledge and incorporation of it into project plans
- how to consider knowledge gained from Northstar construction and operations into Liberty construction and operations

BPXA senior project managers attended these community meetings and committed to deal with issues of local concern. BPXA also committed to involve representatives of the three communities in the ongoing planning of the Liberty Development Project, particularly in the company's efforts to assure the project incorporates the most advanced environmental safeguards. This effort will facilitate the exchange of information between the communities and the company, so that local concerns are understood by the Liberty Project Management team, and so that the communities have the greatest access to information about the project. BPXA will also seek the advice of village elders who have traditional knowledge of local weather and ice conditions, wildlife, subsistence use, archeological and grave sites; and to provide employment and business opportunities, to the greatest extent possible, to residents of the coastal communities.

BPXA proposes that its community program be divided into three phases, as follows:

- **Planning phase:** In 1998 and 1999, BPXA will carry out an extensive information and consultation program.
- **Construction phase:** During project construction in 2000, BPXA will involve community representatives in a program to monitor development activity, particularly potential impacts of construction on marine mammals.
- **Production phase:** In the long-term production phase of Liberty, BPXA will involve representatives of the communities in periodic review and monitoring of potential marine mammal effects; oil spill prevention, containment and cleanup planning; and employment/business opportunities for community residents.

7.2.2 Detailed Plans

- BPXA will involve representatives of the communities in the planning phase of the Liberty Development Project. BPXA managers will meet with community representatives at least quarterly: in workshops on project specifics such as project design and engineering, and oil spill response planning.
- BPXA also proposes meetings in the local communities, held at least quarterly, for interested residents. The purpose of these meetings will be to

provide updated information on the project and to discuss, in greater detail, specific issues.

  - the issue to be discussed in depth in the first meetings planned for July, 1998, is potential marine mammal disturbance. Disturbance to bowhead whales during the September migration is of particular concern to local residents. BPXA has identified potential sound sources and their effects on marine mammals in this Environmental Report (see Sections 5.1.7, 5.2.7, 5.3.4, 5.4.7, 5.5.4.4, and 5.6.4.3), and has examined potential cumulative effects of this project (see Section 5.7). BPXA will be prepared to answer questions and discuss marine mammal disturbance issues at these meetings.
  - the issue tentatively selected for the fall meeting, planned for October, 1998, is oil spill contingency planning.
  - the issue planned for the winter meeting, tentatively set for January, 1999, is employment and business opportunities.

- Following each of the quarterly community meetings, BPXA will publish an informational newsletter on the meeting in English and Inupiat, and prepare an audio version of the newsletter appropriate for radio broadcast and a video version appropriate for regional television broadcast.
- BPXA will organize a program to incorporate the traditional knowledge of village elders into project planning. The program will primarily involve elders in Nuiqsut, the closest community to the Liberty project, but may include, if necessary, traditional knowledge of elders, whaling captains and subsistence hunters in Kaktovik and Barrow.
- During construction, BPXA will involve community residents and organizations, through the Alaska Eskimo Whaling Commission, in any required monitoring of development activities for potential marine mammal and wildlife impacts. Conflict avoidance agreements (extensions of existing agreements) will be negotiated with the Alaska Eskimo Whaling Commission and the Whaling Captains Associations of Nuiqsut and Kaktovik, consistent with those achieved in the past.
- BPXA will involve community residents and organizations in oil spill prevention and response, through Alaska Clean Seas, the industry North Slope spill cooperative. This will include involving village representatives in shoreline sensitivity assessments and the organization of village response teams to assist in the event of a spill. This commitment will require training and assistance by the village teams in annual spill drills held in the Prudhoe Bay vicinity.
- BPXA will involve community residents and local institutions and organizations in development and implementation of a training program in

cultural and environmental awareness for BPXA and contractor employees involved in Liberty development and subsequent production.

8. LIST OF PREPARERS

BPXA contracted with LGL Alaska Research Associates, Inc. who, together with Woodward-Clyde Consultants and Applied Sociocultural Research, independently prepared this Environmental Report. Personnel responsible for this analyses and document preparation were:

LGL Alaska Research Associates, Inc.

Steven K. Davis, Project Manager (February–May 1997), LGL Alaska Research Associates, Inc.
William J. Wilson, Project Manager (June 1997–present), LGL Alaska Research Associates, Inc.
Lynn E. Noel, Wildlife Biologist, LGL Alaska Research Associates, Inc.
Audrey J. Bishop, Document Production, LGL Alaska Research Associates, Inc.
Margaret J. Kircher, Document Production, LGL Alaska Research Associates, Inc.
Benny J. Gallaway, Ph.D., Marine Biologist, LGL Ecological Research Associates, Inc.
Robert G. Fechhelm, Ph.D., Fishery Biologist, LGL Ecological Research Associates, Inc.
W. John Richardson, Ph.D., Marine Mammal Biologist, LGL Limited environmental research associates
Gary W. Miller, Wildlife Biologist, LGL Limited environmental research associates
Stephen R. Johnson, Ph.D., Wildlife Ecologist, LGL Limited environmental research associates

Woodward-Clyde Consultants

Joseph M. Colonell, Ph.D., Coastal Engineer, Woodward-Clyde Consultants
Sue Ban, Oceanographer, Woodward-Clyde Consultants
Bryan Trimm, Oceanographer, Woodward-Clyde Consultants

Applied Sociocultural Research

Michael Galginaitis, Sociocultural Scientist, Applied Sociocultural Research

The following personnel were responsible for review of the document, contributions related to project description and alternatives analyses, and for graphics preparation.

Karen S. Wuestenfeld, Liberty Project Permitting/Environmental Representative, BP Exploration (Alaska) Inc.
Christopher J. Herlugson, Ph.D., Supervisor, Environmental Assessment, BP Exploration (Alaska) Inc.
Christopher J. Ruthven, Liberty Project Development Engineer, BP Exploration (Alaska) Inc.
Ken J. Ambrosius, Supervisor, Cartography, Aeromap US

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ADF&G. See Alaska Dept. of Fish and Game.

ADNR. See Alaska Dept. of Natural Resources.

AEIDC. See Arctic Environmental Information and Data Center.

ASNA. See Arctic Slope Native Association, Ltd.

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Note to Reader:

Exhibit A of the Environmental Report dated February 17, 1998 has been superseded by Exhibit A of Revision 1 of the Development and Production Plan dated November 9, 1998

LIBERTY DEVELOPMENT PROJECT

ENVIRONMENTAL REPORT SUPPLEMENT

November 9, 1998

SUBMITTED TO:
U.S. MINERALS MANAGEMENT SERVICE
ALASKA OCS REGION
949 E. 36TH AVENUE, ROOM 603
ANCHORAGE, ALASKA 99508-4392

SUBMITTED BY:
BP EXPLORATION (ALASKA) INC.
P.O. BOX 196612
ANCHORAGE, ALASKA 99519-6612

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NOTE TO READER

On February 17, 1998, BP Exploration (Alaska) Inc. submitted a Development and Production Plan to the U.S. Minerals Management Service (MMS) for review and approval of the proposed Liberty Development. Since submittal of the DPP, BPXA has continued final design and project optimization studies. As a result of this ongoing work, BPXA identified several modifications to the Liberty project, as described in the original DPP.

Accordingly, BPXA has issued Revision 1 of the DPP to describe these project modifications; the February 17, 1998 version of the DPP has been entirely replaced with Revision 1. Scope changes include:

- *a two year construction schedule*
- *more likelihood of use of a camp barge*
- *refined traffic forecasts*
- *more likelihood of use of hydraulic (suction pump) dredge*
- *additional ice road and ice pad segments*
- *an automated valve at the shore crossing*
- *identification of disposal areas for excess material excavated from the pipeline trench*
- *two season gravel mining*
- *burying gravel-filled bags over the pipeline to assure vertical pipeline stability*
- *increased requirements for temporary diesel storage during construction*
- *identification of an increased production option*
- *elimination of the planned deck drainage discharge*
- *minor refinements in island slope protection and footprint dimensions (all within original planned "footprint")*

In addition, this supplement to the February 17, 1998 Environmental Report has been prepared. ***This Supplement is not a stand-alone document, and must be used with the February 17, 1998 Environmental Report.*** *The Supplement briefly describes impacts of the project modifications, and incorporates additional information provided to MMS by BPXA since February 1998. Supplemental information about effects of project construction on water quality is also provided in this document.*

This Supplement is to be used in conjunction with the original February 17, 1998 Environmental Report as follows:

Environmental Report (2/17/98 version)	Effect of Rev. 1 of DPP and of Supplement)
Section 1	Supplement updates Subsections 1.3 and 1.4
Section 2	Supplement does not change February 17, 1998 version
Section 3	February 17, 1998 version superseded by Rev. 1 of the DPP
Section 4	Supplement describes additional data forwarded to MMS subsequent to February 17, 1998
Section 5	Supplement briefly assesses any impacts of scope changes and provides an updated analysis of the effects of project construction on water quality
Section 6	Supplement updates
Section 7	Supplement updates
Section 8	Supplement updates
Section 9	Supplement updates

1. INTRODUCTION

This Environmental Report (ER) Supplement has been prepared in conjunction with issuance of Revision 1 of the BP Exploration (Alaska) Inc. (BPXA) Liberty Development and Production Plan (DPP). The DPP and supporting ER were originally submitted to MMS on February 17, 1998. This ER Supplement meets three major objectives:

1. Identifying and describing additional data concerning the Liberty project available since submission of the February 17, 1998 DPP and ER. This additional data includes reports of 1997 and 1998 field studies and/or analyses.
2. Briefly summarizing any change in project impacts expected as a result of project scope changes (as identified in the Note to Reader and in Revision 1 of the DPP).
3. Providing supplemental water quality analysis based on additional information and project scope refinements.

1.1 UPDATE TO SECTION 1

The basic content of Section 1 of the February 17, 1998 ER, which described the overall purpose and need of the project and the scope of the ER is still valid. However, text relating to project milestones and permits and approvals requires minor updates.

1.1.1 Project Milestones

The major milestones of the Liberty Development Project are described in Table 1; graphic schedules are provided in Revision 1 of the DPP. BPXA's goal is to have the Liberty Development Project in production by the end of 2001.

1.1.2 Permits and Approvals

Table 1-1 of Revision 1 of the DPP lists new permits and approvals needed for the Liberty project.

2. DEVELOPMENT ALTERNATIVES

Development alternatives for Liberty were identified as part of the conceptual engineering process, and have not changed. However, BPXA has prepared a more detailed discussion of these alternatives as described in a report submitted to MMS titled; "Liberty Field Development Alternatives, 4/24/98".

TABLE 1

MAJOR MILESTONES - LIBERTY DEVELOPMENT PROJECT

MILESTONE	TIME FRAME	DESCRIPTION
Exploration Well, Conceptual Engineering	Winter 1996-97	BPXA drilled an exploration well (Liberty #1) at the Tern Island site in Foggy Island Bay to further assess the reservoir and determine whether the field was economically viable. Conceptual engineering proceeded based on assumed well results to develop a "test case."
Well Results	May 1997	BPXA announced estimated recoverable reserves of 120 million barrels at Liberty.
Geotechnical Studies and Route Survey	1997	A geotechnical (soils) drilling program, which included sediment and water sampling, was conducted during the winter of 1997. Shallow hazards and sidescan and multibeam sonar work was completed in the summer of 1997.
Additional Environmental Studies	Summer 1997	The results of environmental studies conducted in this region are summarized in Section 4 of this document. An additional survey of the Boulder Patch was conducted during the summer of 1997 to confirm the feasibility of constructing an island and routing a subsea pipeline through the area with minimal environmental impact. An archaeological survey of the onshore pipeline corridor was completed. Seal surveys were conducted during May and June of 1997, and underwater acoustic studies were conducted July-September 1997.
Geotechnical Studies	Winter 1998	Geotechnical soils drilling program.
ROV surveys	Winter 1998	Visual "ground-truthing" of sea floor conditions at island site and along pipeline route to confirm results of summer 1997 side-scan sonar surveys.
Detailed Engineering	Mid 1999	Detailed engineering commenced in mid-1997. This will provide the necessary information for the major operational permits (see Section 1.6).
Gravel Construction	Winter 1999-2000	Gravel construction will commence in winter 1999-2000 utilizing equipment mobilized over ice roads. Most gravel work at the Liberty field development will be done in a single winter season, with gravel obtained from one of several existing sites or a new mine site.
Pipeline Construction	Winter 2000-2001	Pipeline construction will commence in winter 2000-2001 and is expected to be complete by May 2000.
Sealift	Summer 2000 and Summer 2001	Infrastructure modules will be brought into Liberty by sealift in the summer of 2000 and offloaded on the island; process modules will be brought to Liberty by sealift in the summer of 2001 and offloaded on the island.
Development Well Drilling	Winter 2001	Development drilling will commence using a single rig in winter of 2001, after mobilizing the rig to the site by ice road.
Production	Late 2001	Production from Liberty will commence at the end of 2001 and build to rates of up to 65,000 barrels per day.

3. PROJECT DESCRIPTION

The Project Description contained in the February 17, 1998 ER has been superseded by Revision 1 of the DPP.

4. AFFECTED ENVIRONMENT

At the time the February 17, 1998 ER was issued, BPXA and its contractors were in the process of preparing reports on field research conducted in 1997, and planning for field work to be conducted in 1998. Additional information that has been provided to MMS subsequent to issuance of the original ER is listed in Table 2. None of the additional background data collected in 1998 revealed a need to alter project siting or design.

5. ENVIRONMENTAL CONSEQUENCES

This section describes the general environmental effects of engineering design and schedule changes to the Liberty Development Project, and also provides supplemental information about effects of project construction on water quality.

5.1 EFFECTS OF SCOPE CHANGES

5.1.1 Two Year Construction Schedule

BPXA intends to construct the Liberty Project over two years, with gravel island construction occurring in year one (winter of 1999-2000) and pipeline construction in year two (winter of 2000-2001).

Project effects will be essentially the same as described in the Environmental Report (LGL et al. 1998); these effects will occur over two years rather than one. No new impacts on the environment will occur; the timing of some of the disturbances will occur in one or the other, or in both, construction years, as opposed to occurring only in one year.

Construction ice roads will be built over two winter seasons. In the first season, roads supporting island construction will be built, and in the second season, roads supporting pipeline construction will be built. With a two year construction schedule, marine mammal disturbance from heavy equipment usage during the construction and use of the ice road complexes will occur over two winters. With a two- rather than a one-season winter construction program, some

TABLE 2

ADDITIONAL INFORMATION SUBMITTED TO MMS IN SUPPORT OF LIBERTY DEVELOPMENT AND PRODUCTION PLAN AND ENVIRONMENTAL REPORT (AFTER FEBRUARY 17, 1998)

DATE SUBMITTED	DESCRIPTION
April 14, 1998	Chemical characterization of Liberty crude oil
April 14, 1998	BPXA estimates of Liberty production data and estimated revenues from the Liberty project by year
April 22, 1998	Field acoustical data collected while drilling the Liberty #1 Exploration Well, in a report:
	"Under Ice Drill Rig Sound, Sound Transmission Loss, and Ambient Noise Near Tern Island, Foggy Island Bay, Alaska, February 1997", prepared by Greeneridge Sciences and LGL Alaska Research Associates
April 22, 1998	BPXA estimates of Alaskan employment from the Liberty Project
April 22, 1998	A summary and overview of the contents of BPXA's February 13, 1998 Part 55 Air Quality Application for Liberty Project
April 27, 1998	Additional analytic information characterizing the risk and nature of a spill from the products pipeline
April 30, 1998	Field data and engineering analysis of the proposed shore crossing location, in a report:
	"Coastal Stability Analysis - liberty Pipeline Shore Crossing, December 1997", prepared by Coastal Frontiers Corporation
May 29, 1998	Additional public geologic information in response to scoping comments
June 4, 1998	Video tapes of 1998 ROV survey in Foggy Island Bay
June 4, 1998	Background socioeconomic data and revenue forecasts in a report:
	"Liberty Development Project", May 1998, prepared by Northern Economics
July 13, 1998	Data report:
	"Laboratory Testing to Determine Spill Related Properties of Liberty Crude Oil", prepared by SL Ross Environmental Research Ltd. June, 1998
July 20, 1998	Geotechnical data regarding pipeline route and island location, in report:
	"Geotechnical Exploration Liberty Development, North Slope, Alaska", prepared by Duane Miller & Associates on July 6, 1998.

TABLE 2 (CONT'D)

ADDITIONAL INFORMATION SUBMITTED TO MMS IN SUPPORT OF LIBERTY DEVELOPMENT AND PRODUCTION PLAN AND ENVIRONMENTAL REPORT (AFTER FEBRUARY 17, 1998)

July 27, 1998	Results of Summer 1997 and Winter 1998 Boulder Patch Survey, in report: "Liberty Development 1997-1998 Boulder Patch Survey", prepared by Coastal Frontiers Corporation and LGL Ecological Research Associates, July, 1998.
August 26, 1998	Field acoustical data collected in Summer 1997, in a report: "Underwater Acoustic Noise and Transmission Loss During Summer at BP's Liberty Prospect in Foggy Island Bay, Alaska Beaufort Sea", prepared by Greeneridge Sciences and LGL Alaska Research Associates
September 11, 1998	Results of field vegetation site inspections at proposed mine site, shorecrossing pad, and pipeline tie-in September 11, 1998 Trip Report summarizing Wetland and Vegetation Information for Liberty EIS, prepared by LGL
September 30, 1998	Background water and sediment sample data collected in winter 1998, in report: "Liberty Island Route Water/Sediment Sampling, March 28-29, 1998", prepared by Montgomery Watson

additional disturbance of ringed seals and polar bears may result from the use of heavy equipment and the presence of human activities on nearshore and offshore ice over two winters instead of one winter. If polar bear den sites, seal breathing holes, or seal birthing lairs are identified in the project area during either year, BPXA will avoid these sites. Regardless of whether the Liberty Development is built over one or two years, ice road complexes will be constructed annually throughout the production life of the development; thus the incremental effects from an additional year's construction season will be negligible.

BPXA intends to transport the drill rig to the island over an ice road in winter, not a barge during late summer as previously planned. Since the rig movement will occur in winter, this will eliminate the potential for disturbance to bowhead whales and to subsistence whaling.

As previously described in LGL et al. (1998), marine water turbidity levels will increase slightly due to the island and pipeline construction activities, potentially affecting the nearby Boulder Patch benthic communities. With the island construction occurring in year one and the pipeline construction in year two, these turbidity effects will extend over two years. However, these effects will not, in the aggregate, be different or increased from the one-season construction scenario; no new areas will be disturbed.

With a two-year construction scenario, gravel removal at the Kadleroshilik River mine site will occur in two winter seasons, not one. Since gravel excavation and transport from the mine site will be limited to the winter season, no additional effects on birds or mammals that may use habitat at the mine site will occur. No additional acreage will be disturbed. Reclamation of the mine site will be conducted after all gravel removal activities have been completed.

With movement of construction vehicles and supplies extended over two seasons, there will be some additional potential for small fuel spills. However, spills are very unlikely given the fuel handling and transport procedures practiced by industry on the North Slope. Fuel and other contaminant safe handling practices will be followed throughout the two-year construction season and throughout the operational life of the Liberty Development.

The overall effects of a two-year construction schedule will be of little additional consequence to the environment or biological resources in this region, since during each year a different area will be affected (island site versus pipeline corridor). There will be cumulative effects over two successive seasons rather than one, but the net increase in impact on the environment will be negligible.

5.1.2 Detailed Mining Plan

A detailed gravel mining and rehabilitiation plan was developed subsequent to submittal of the February 1998 Environmental Report. The final plan was based on project gravel needs and site investigation. The surface acreage in the mine site area is approximately 53 acres, which represents a "planning footprint". Within the 53± acres, it is estimated that approximately 31 acres will be directly affected by mining to support project development. The remaining 22± acres is available to support temporary mining activities, contingency mining if needed during project development, future emergency gravel supply, and possible future regional gravel needs.

Phased development of the mine is currently planned, with the proposed 31± excavation area developed as two cells, to match the two year project construction schedule. One cell of the mine would be developed each winter construction season, with gravel extracted and site rehabilitation initiated by breakup of that year. Other portions of the planning area would be reserved for possible development in the future. Mining plans for the primary excavation area, as well as for the reserve area, are similar.

The mine site is in a region of riverine barrens and flood plain alluvium. From aerial photo interpretation and a site visit, it is estimated that the 53 acre mine site area is about 40 percent dry dwarf shrub/lichen tundra, 10 percent dry barren/dwarf shrub, forb grass complex, and 50 percent river gravels. The site investigation showed evidence of grazing by caribou and muskoxen

5.1.3 Camp Barge During Construction

BPXA is considering using a barge as a temporary construction camp adjacent to Liberty Island to support module installation. The camp barge will provide more space for personnel and supplies, thus increasing human activities at the island during that open water season. The barge and associated human presence will generate waste that must be handled and transported away from the site, and this may also increase the potential for barge-to-island spills of contaminants. These effects are expected to be minimal and restricted to the open water season of 2001 only (and 2002 if the barge is overwintered). If an intense storm develops when the barge is moored to the island, there is a potential for accidental spills of materials on the barge as it is buffeted by seas or as the barge is moved to the lee of the island.

The camp barge will provide lodging and work space for personnel during facilities installation on the island. This will reduce the frequency and number of shore-to-island trips of vessels and aircraft that would be required to transport people and supplies to the Liberty Island construction site. This would reduce the disturbance to the region's wildlife from helicopter and crew boat travel, reduce the potential for contaminant spills from boat and helicopter activity, and reduce the potential for accidents associated with vessel and aircraft movement.

5.1.4 Increased Transportation Levels

BPXA has revised upward the estimates of crew boat, barge, helicopter, and vehicle over-ice transport activities associated with construction and operation of the Liberty Development (Table 4-2, DPP). In addition, diesel fuel supplies for permanent operations will be delivered by barge during summer and possibly by ice road during winter. No impacts on the environment that have not already been described (LGL et al. 1998) will occur from these revised traffic forecasts. Increases in vessel, vehicle, and aircraft traffic will increase the potential for accidents and contaminant spills. Standard North Slope industry practices for fueling and transport of fuels, lubricants, and other potential contaminants will minimize spills. More frequent on-ice vehicle activity may increase disturbances to ringed seals and polar bears, and more frequent helicopter overflights and vessel trips to the island may increase disturbance to marine mammals, waterfowl, and marine and coastal birds.

5.1.5 Use of Hydraulic Dredging for Pipeline Trench Excavation and Cleanout

Hydraulic dredging equipment may be employed to improve precision of the trenching for pipeline installation during the final stages of trenching to clean out the bottom of the trench and to smooth the grade upon which the pipe string will be laid. The hydraulic dredging equipment is fitted to a backhoe and is operated from the ice surface concurrent with placement of the pipeline in the trench. Sediment pumped from the trench will be piped back into or adjacent to the trench. More information regarding the effects of pipeline construction on water quality is provided in Section 5.2.

5.1.6 Automatic Shutoff Valve at Shore Crossing

An automatic shutoff valve will be fitted in the oil pipeline at the shore crossing. The previous design included a manual shutoff valve at this location. In the event of an offshore pipeline rupture, the automatic valve would close and limit the size of the oil spill. The automatic valve will reduce the volume of crude oil spilled into the environment from the offshore segment of the pipeline by about 1020 barrels, under a complete pipeline rupture scenario. Less crude oil would be spilled into the marine environment, thereby reducing impacts on marine organisms and habitats.

5.1.7 Gravel Bags on Pipeline Before Burial

After excavation of the pipeline trench and placement of the pipe string, BPXA will place gravel-filled geotextile bags over the top of the pipeline in the trench. A backhoe fitted with specially designed tongs will be used to place the bags so as to not rupture the fabric during installation. Spoil removed from the trench will then be placed back into the trench over the pipeline string, completely burying the gravel-filled bags at depth. There will be no additional environmental effects from using gravel-filled bags to anchor the pipe string.

5.1.8 Increased Diesel Fuel Storage on Island

BPXA has calculated that approximately 15,000 barrels of diesel fuel will be stored temporarily on the Liberty Island during construction. This increased volume of diesel is required to meet demands from drilling and construction activities, and will not be needed after construction. With increased diesel fuel storage comes increased potential for accidents and spills. BPXA has recognized this risk in its spill response planning, and will implement best management practices for fuel handling on the island to minimize the potential for spills of diesel fuel.

5.1.9 Increased Crude Oil Production Option

BPXA is considering increasing production of crude oil from the field to a peak of 75,000 barrels per day. This increase in production would not increase any discharges permitted under the NPDES nor would this level of production increase other wastes or emissions. No new or additional environmental effects would occur due to an increase in crude oil production.

5.1.10 Increased Size of Island Footprint

The Liberty island has a design bottom dimension of 635 ft x 970 ft (as opposed to the original design footprint of 630-670 ft x 960-1000 ft). The actual island footprint is likely to be larger than the design bottom dimensions. During the process of construction, gravel will be dropped through the water column to build the island structure up from the seafloor. In this process, not all gravel will fall precisely within the design footprint. To accommodate this construction uncertainty, BPXA has identified a construction footprint of about 835 feet by 1170 feet; this footprint includes an extra 100 feet around the perimeter of the design island bottom dimensions.

This area is slightly greater than the original low estimate, but the additional benthic habitat covered by gravel materials is negligible. Under-ice surveys of the benthic environment in April 1998 confirmed that no Boulder Patch habitats occur at the island site.

5.1.11 Elimination of Island Stormwater Discharge

Storm water collected on the Liberty Island will be injected into the underground waste disposal well. Environmental effects of the previously-described stormwater discharge into the marine environment will be eliminated.

5.2 EFFECTS OF PROJECT CONSTRUCTION ON WATER QUALITY

This section discusses effects of island construction, pipeline construction, and possible ocean disposal of excess pipeline trench materials on marine water quality. It is based on scope refinements and additional information available since February 1998.

5.2.1 Island Construction Related Sediment Suspension and Deposition

Initial analysis of sediment transport from a plume created by island construction assumed that the prevailing currents were unidirectional, extending from the island toward the northeast. However, the typical current regime flows easterly approximately 70 percent of the time, and thus, the predicted sediment plume in the February 1998 Environmental Report depicts the worst-case potential impact to Boulder Patch communities. It is anticipated that westerly currents will occur approximately 30 percent of the time, with the resulting sediment plume extending west of the island during those periods. The initial analysis assumed no ice-cover, and a maximum water depth of 22 feet. Because sediment transport is dependent on water depth, particles travel a greater distance as water depth increases. Therefore, effects predicted in the Environmental Report conservatively predict the extent of the sediment plume. It is anticipated that the actual sediment plume will be somewhat smaller, since the available water depth will be about 16 feet.

The sediment grain-size distribution collected at the gravel mine site in 1998 determined that the fines fraction was 10% of the total weight. The fines fraction at the selected gravel source is the same as that used in the February 1998 Liberty Environmental Report to characterize the sediment plume from island construction. The conclusions drawn in this report for sedimentation and suspended sediments during island construction are valid for the selected gravel source.

5.2.2 Pipeline Construction Related Deposition and Sediment Suspension

Sediment Deposition

The 1998 geotechnical exploration program collected geotechnical and physical properties measurements from 18 borings positioned along the proposed pipeline route (Duane Miller & Associates 1998). On average, grain-size samples collected within depths designated for trenching contained approximately 24 percent fines (less than 0.075 mm); which is slightly coarser than grain-size assumptions presented in the February 1998 Liberty Environmental Report.

The clay size fraction tends to be cohesive and form large clumps when disturbed. These clay clumps are expected to fall out of the water column at the location of disturbance. However, a portion of the clay sized particles will disperse into the water column increasing the TSS in waters adjacent to the excavation. Stokes' Law can be used to estimate the extent of sedimentation down current from the excavation.

To determine the probable maximum particle deposition from construction, Stokes' Law is used to calculate the mean fall velocity (w) of particles of a unique diameter through the water column. The fall velocity can be computed by the following equation:

$$w = \frac{gd^2\left(\frac{\gamma_s - \gamma}{\gamma}\right)}{18\nu} \qquad (1)$$

where:

- w is fall velocity (m/s)
- g is the acceleration due to gravity (9.75 m/s^2)
- d is a particle-size diameter based on the average trench material grain-size distribution
- γ_s is the specific gravity of the particle (2.6)
- γ is the specific gravity of seawater (1.026)
- ν is the kinematic viscosity of seawater (1.80×10^{-6} m^2/s)

The effective theoretical downstream distance required to capture suspended particles can be calculated using the following equation:

$$D = \left(\frac{\mu}{w}\right)H \qquad (2)$$

Where:

- μ is the current speed (m/s)

w is the fall velocity for a given particle size (calculated in equation #1)

H is the height of the water column (m)

For grain-size particles with a diameter of 0.075 mm, it is estimated that the downstream distance will be 213 m (700 feet) for water depths of 6.7 m (22 feet). About 75 percent of particles that will be excavated from the trench have diameters greater than 0.075 mm, thus, it is anticipated that 75 percent of the suspended sediment will settle out within 213 m (700 feet) of the excavation. As water depths decrease, the downstream distance also decreases, such that for water depths of 2.1 m (7 feet), particles with diameters greater than 0.074 mm will settle out within 70 m (230 feet) of the excavation. Furthermore, during winter when excavation will occur, the available water depth will be reduced by approximately 1.7 m (5.6 foot) of ice, so the actual area of deposition will be smaller.

While particles greater than 0.075 mm are expected to settle within 213 m (700 ft) of the excavation, finer-grained particles will continue downstream. However, deposition will be negligible beyond 213 m (700 ft), since the plume area for the remaining suspended sediment continues to increase as the downstream distance increases. This results in a significant reduction in TSS concentrations, and consequently, a significant reduction in sediment deposition. The actual thickness of deposits will depend upon the amount of available sediment suspended by backhoe and hydraulic dredging, but the overall size of deposition site is not dependent on the volume of sediment available.

Suspended Sediments

Suspended sediment (TSS) concentration is dependent on the rate of sediment input into the water body, and grain-size. TSS values will typically increase above ambient water concentrations when sufficient sediment is suspended by natural processes or construction activities. As demonstrated by Stokes' Law, larger diameter particles settle to the seafloor at a faster rate than finer-grained particles. It is apparent that trench excavation activities will increase TSS concentrations above State of Alaska waster quality standards, thus, BPXA will request a short-term variance as set forth in 18 Alaska Administrative Code (AAC) 70.015.

Excavation methods used along the offshore portion of the Liberty Development pipeline will be similar to methods and equipment used to construct the offshore Northstar Development pipeline. The primary excavation tool will be the backhoe with a bucket capacity of 2 to 4 cubic yards. The grain-size distributions for spoil materials at the Northstar Development test trench were found to be finer than grain-size distributions collected within Foggy Island Bay. Approximately 24 percent of the Foggy Island Bay sediment consisted of fines (less than 0.075 mm), while the Northstar test trench sediments contained approximately 50 percent fines.

During the 1996 winter season, test trench activities were conducted along the proposed pipeline route for the Northstar Development. Monitoring stations were established up to 300 m (1,000 ft) from the excavation parallel and perpendicular the principal current axis to observe physical changes in the water column (Montgomery Watson 1996). Prior to backhoe trenching activities, the ambient TSS concentrations were below analytical detection limits. A water sample collected at the seafloor during trenching operations resulted in a TSS concentration of

885 mg/l. After trenching operations began, TSS concentrations within 150 m (500 ft) of the excavation were between 20 to 121 mg/l. Beyond 150 m (500 ft), TSS concentrations ranged from 19 to 35 mg/l (Montgomery Watson 1996).

It is expected that TSS associated with trench activities in Foggy Island Bay will be similar adjacent to the excavation site (about 1,000 mg/l); but, concentrations should be slightly lower down current. This is due to lower percentage of fine-grained sediments documented for the Foggy Island Bay excavation as compared to the Northstar test trench. Based on TSS values from the Northstar test trench program, TSS values will drop to about 35 mg/l above ambient conditions within 150 m (500 ft) of the excavation. Elevated TSS concentrations related to pipeline construction will occur from approximately the 7-ft isobath to the island. Excavation activities within the grounded ice zone, shore to 7-ft isobath, is expected to have very little free water in the excavation, and thus, no TSS.

A hydraulic dredge will be used within the excavated pipeline trench to assure that the bottom grade meets engineering requirements for pipelaying. The discharge height of the discharge hose will be within or adjacent to the trench, and most of the larger diameter particles will be deposited in these areas. Finer-grained particles will be suspended beyond the trench, resulting in localized elevated TSS concentrations. However, observed downstream TSS concentrations should not be significantly greater than conditions created as a result of backhoe operations.

5.2.3 Effects of Pipeline Trench Spoil Disposal

In the process of trench excavation, BPXA intends to minimize the amount of construction spoil requiring disposal by re-using this material as trench backfill to the maximum extent possible. Situations requiring disposal of excess backfill may result due to several factors, including displacement by the pipeline, the use of select backfill (e.g. gravel), and bulking due to the natural swell of excavated materials placed back into the trench. Another case may result from uncontrolled circumstances (e.g., bad weather) that may force construction crews to abandon the site before all operations have been completed, leaving some excavated material on the ice surface. Depending therefore, on site specific circumstances, work may result in ocean disposal of up to 110,000 cubic yards of dredged material spoils.

Two sites for spoil storage and possible disposal are proposed (see Figure 8-2 of the DPP). The first storage site (Zone 1) will be located on the west side of the pipeline right-of-way on grounded sea ice outside the 5-foot isobath. Approximate maximum dimensions of the site will be 5,000 feet by 2,000 feet (230 acres), and up to 100,000 cubic yards of material could be disposed of at the site.

Zone 1 was selected based on results of BPXA Boulder Patch surveys and ongoing agency coordination and guidance. A major criterion used in selecting the 5,000 by 2,000 foot site was avoidance of impacts to the Boulder Patch habitats, by not placing the disposal site directly over known Boulder Patch, and maintaining distance from known Boulder Patch to minimize any effects from the disposal activity, given consideration of normal oceanographic conditions. Other important criteria include maintaining a safe distance from active pipelaying operations, reasonable hauling distance, water depth greater than five feet, and local fate and transport mechanisms.

The second disposal site (Zone 2) is a 200-foot wide section along the west side of the pipeline trench from the island to shore. Zone 2a is that segment in water depths less than approximately 16 feet; Zone 2b is that segment located on floating ice, in water depths greater than 16 feet. Up to 10,000 cubic yards of material could be disposed of at the site.

During breakup, most remaining spoil materials at both sites will settle to the sea floor. Since the Zone 1 site is located in an area affected by grounded ice and wave action, the benthic community underneath the spoils will not be well developed and the effects of sedimentation at this site will be negligible. Materials remaining at the Zone 1 site will not settle onto Boulder patch habitats. Spoil materials remaining at breakup along the Zone 2 spoil disposal corridor (over floating ice) will settle onto the sea floor under the site, and finer materials will be carried downstream from the site due to water current transport. Dispersal of these sediments released by melting of the sea ice will be assisted by flooding from the Sagavanirktok River during breakup and by wind-aided movement of thawing ice fragments.

Additional detail on sediment dispersal from the two spoil disposal sites is contained in the Draft Section 103 Ocean Dumping Site Evaluation submitted by BPXA in support of its application for a Section 404/10/103 permit from the U.S. Army Corps of Engineers. This document contains a conservative analysis of predicted effects of disposal on marine water quality. In this analysis, assuming that disposed materials are released into the water column as individual particles, rather than as cohesive clumps. This release scenario is unlikely, but was used for evaluation purposes to determine the maximum sedimentation that could theoretically occur.

The analysis predicts that the maximum thickness of dredge material deposited on the seafloor would be approximately 8.4 inches in the vicinity of Zone 1. Sediment deposition was predicted to rapidly decrease to a thickness of 0.4 inches within a radius of about 1,740 feet from the Zone 1 stockpile, and within 3,280 feet of the stockpile sedimentation was predicted to the less than 0.2 inches. Deposition resulting from material stored at Zone 2 was predicted to be no greater than 0.3 inches at the stockpile location, and 0.04 inches approximately 600 feet from the stockpile location.

Material to be disposed of consists of sand and silt of local origin. Low concentrations of naturally occurring metals are found throughout the project area and have been detected in both surficial and sub-bottom sediment samples. No significant impact on water quality is anticipated due to the low concentrations of naturally occurring metals and significant dispersion of disposed material expected to occur during spring breakup.

Marine water in the project area is likely to be highly turbid during spring breakup and any time high wind events occur during the open-water season. The proposed disposal of dredged material is not expected to have significant impacts on water quality since disposal would be of short duration, and the timing of deposition coincides with naturally-occurring high turbidity levels.

Some turbidity in the water column will result from the settling of fine particulate spoils downstream from the disposal areas, possible reducing light levels reaching Boulder Patch communities growing in these areas and settling in a fine layer on these communities. However, since nearly all algal plant growth occurs during summer months, the localized turbidity and reduced light penetration near the dredging operations will have no real consequence to algal growth.

6. MITIGATION MEASURES

The February 17, 1998 Environmental Report contains a comprehensive list of mitigation incorporated into project planning, design, construction, and operation. Scope changes identified after submittal of that report (as described in Revision 1 of the DPP) resulted in further mitigation of project impacts. These mitigation measures include:

- elimination of discharges associated with deck drainage
- placing an automated valve at the pipeline shorecrossing pad (versus the originally proposed manual valve). Use of an automated valve at this location causes an estimated decrease of about 1,000 barrels from a leak resulting from a complete rupture of the offshore oil pipeline.
- possible use of construction camp barge would reduce levels of helicopter and vessel traffic needed to support construction
- two season gravel mining plan incorporates rehabilitation measures
- proposed location of disposal site for any excess materials excavated from pipeline trench was selected in consultation with agencies to minimize impacts to marine environment

7. COORDINATION AND CONSULTATION

BPXA continued its process of agency coordination and local liaison since submission of the original ER in February 1998. This section provides updated information on that process.

7.1 AGENCY LIAISON

Table 3 lists major agency coordination meetings held since February 1998.

7.2 LOCAL LIAISON

Table 4 lists meetings between BPXA representatives and North Slope community representatives that have occurred since January 1998.

TABLE 3

MAJOR AGENCY COORDINATION MEETINGS (SINCE MID-FEBRUARY 1998)

DATE	PURPOSE	ATTENDEES
2/19/98	Permitting Issues/Project Coordination	MMS, BPXA
2/24/98	Permitting Issues/Project Coordination	MMS, BPXA
3/11/98	Permitting Issues/Project Coordination	MMS, BPXA
3/25/98	Permitting Issues/Project Coordination	MMS, BPXA
3/26/98	Permitting Issues/Project Coordination	DGC, MMS, BPXA
4/3/98	Pipeline permitting Issues	MMS, SPCO, BPXA
4/6/98	Permitting Issues/Project Coordination	MMS, BPXA
4/13/98	Permitting Issues/Project Coordination	MMS, BPXA
4/14/98	Permitting Issues/Project Coordination	MMS, BPXA
4/20/98	Project Coordination	EIS Team, BPXA
4/24/98	Permitting Issues, Project Coordination	MMS, BPXA
4/29/98	Project Coordination	EIS Team, BPXA
4/29/98	Project Coordination	DGC, BPXA
5/6/98	Project Coordination	EIS Team, BPXA
5/13/98	Project Coordination	EIS Team, BPXA
5/14/98	Project Coordination	EPA, NMFS, BPXA
5/20/98	Project Coordination	EIS Team, BPXA
6/1/98	Pipeline Permitting Issues	MMS, SPCO, BPXA
6/4/98	Permitting Issues/Project Coordination	MMS, BPXA
6/17/98	Project Permitting Issues	MMS, USCG, BPXA
6/26/98	Permitting Issues/Project Coordination	MMS, BPXA
7/9/98	Air Permitting Issues	USEPA, BPXA
7/22/98	Project Coordination	EIS Team, BPXA
7/24/98	Permitting Issues/Project Coordination	MMS, BPXA
7/30/98	Pipeline Permitting Issues	MMS, SPCO, BPXA
7/31/98	Permitting Issues/Project Coordination	MMS, BPXA
8/10/98	Project Coordination	EPA, BPXA
8/12/98	Project Coordination	EIS Team, BPXA

TABLE 3 (CONT'D)

MAJOR AGENCY COORDINATION MEETINGS (SINCE MID-FEBRUARY 1998)

DATE	PURPOSE	ATTENDEES
8/19/98	Project Coordination	EIS Team, BPXA
8/26/98	Project Coordination	EIS Team, BPXA
9/3/98	Permitting Issues/Project Coordination	MMS, BPXA
9/11/98	Pipeline Permitting Issues	MMS, SPCO, BPXA
9/11/98	Pipeline Permitting Issues	MMS, SPCO, BPXA
9/16/98	Permitting Issues/Project Coordination	MMS, BPXA
9/30/98	Permitting Issues/Project Coordination	MMS, BPXA
10/15/98	Permitting Issues/Project Coordination	USACE, BPXA
10/15/98	Air Permitting Issues	USEPA, BPXA
10/21/98	Permitting Issues/Project Coordination	MMS, BPXA
10/26/98	Permitting Issues/Project Coordination	USACE, BPXA
11/5/98	Permitting Issues/Project Coordination	MMS, USACE, BPXA

TABLE 4

LOCAL LIAISON

DATE	EVENT
5/18/98	Meetings in Nuiqsut to discuss Liberty project, plan technology workshops, with Leonard Lampe, George Sielak, Joe Aiken, Thomas Napageak.
5/25/98	First 1998 issue of "Northern Report" newsletter is published and distributed.
5/26/98	Itqanaiygvik job training program is announced in Barrow, to train North Slope residents in oil field jobs.
5/27/98	Meetings in Barrow to discuss Liberty project with North Slope Borough Planning Commission. Radio program on Liberty project also conducted over local station KBRW.
6/19/98	Meetings in Nuiqsut to introduce Liberty managers to Thomas Napageak and other whalers and community leaders.
6/20/98	Meetings in Kaktovik to discuss technology workshops.
6/30/98	Meetings in Nuiqsut to plan technology workshop, with Leonard Lampe and James.
7/1/98	Meetings in Nuiqsut to plan offshore technology workshop, with Joe Nukapigak, Isaac Nukapigak, Frank Long Jr.
7/7/98	Second 1998 issue of "Northern Report" newsletter is published and distributed.
8/4/98	Community workshop in Nuiqsut on subsea pipeline construction, pipeline integrity, oil spill contingency planning and cleanup capabilities. Attending were Lloyd Ahvakana, Lloyd Ipalook, Alice Ipalook, Emily Wilson, Ruth Nukapigak, Isaac Nukapigak, Lucy Nukapigak, Dora Nukapigak, Doreen Nukapigak, Erick Leavitt, Thomas Napageak, Johnny Ahtuangaruak, Job Woods Sr., Joe Ericklook, Emma Ericklook, Maggie Hopson, Emily Panigeo, Archie Ahkiviana, Charles Ahkiviana, David Masuleak, Willie Sielak, Clyde Sielak, Gordon Matumeak, Dora Panigeo, Rosie Rollund, Cheryl Kaigelak, Margaret Brower, Leonard Tukle, Sarah Kunaknana, Joe Nukapigak.
11-5/98 through 11/13/98	Community meetings are held in North Slope villages to describe Itqanaiygvik job training programs.
11/10/98	Third issue of Northern Report newsletter is published.

BPXA will continue to involve representatives of the communities in the planning phase of the Liberty Development Project. BPXA managers will meet with the communities periodically in workshops on project specifics such as project design and engineering, and oil spill response planning. The purpose of these meetings will be to provide updated information on the project and to discuss, in greater detail, specific issues.

BPXA will hold at least six community workshops in 1999, four in Nuiqsut, the community closest to the project, and two in Kaktovik and Barrow, two other communities potentially affected by the project. The schedule of the workshops is to be worked out between community leaders and BPX.

Issues to be discussed in the workshops will include:

- Oil spill prevention and contingency planning.
- Island design, pipeline integrity and leak detection.
- Potential marine mammal disturbance. Disturbance to bowhead whales during the fall migration is of particular concern to local residents. BPXA will be prepared to answer questions and discuss marine mammal disturbance issues at these meetings.
- Employment and business opportunities.

BPXA will publish informational newsletters on each of these topics periodically during the year, supplemented with video materials and radio programs.

BPXA will organize a program to incorporate the knowledge of village elders, whaling captains and subsistence hunters into project planning. The program will primarily involve Nuiqsut, the closest community to the Liberty project, but may include, if necessary, Kaktovik and Barrow.

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9. REFERENCES CITED

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APPENDIX B

LIBERTY DEVELOPMENT PROJECT
ENVIRONMENTAL REPORT SUPPLEMENT

TABLE OF CONTENTS

1. INTRODUCTION

This Environmental Report (ER) Supplement has been prepared in conjunction with issuance of Revision 2 of the BP Exploration (Alaska) Inc. (BPXA) Liberty Development and Production Plan (DPP). The DPP and supporting ER were originally submitted to MMS on February 17, 1998. This ER Supplement meets two major objectives:

1. Identifying and describing additional data concerning the Liberty project available since submission of the February 17, 1998 DPP and ER. This additional data includes reports of 1997 and 1998 field studies and/or analyses.
2. Briefly summarizing any change in project impacts expected as a result of project scope changes (as identified in the Note to Reader in Revision 2 of the DPP).

The basic content of Section 1 of the February 17, 1998 ER, which described the overall purpose and need of the project and the scope of the ER is still valid. The schedule, however, has been substantially changed, as discussed in Section 2 of the DPP. In addition, Table 1-1 of the DPP lists new permits and approvals needed for the Liberty project.

This Supplement is to be used in conjunction with the original February 17, 1998 Environmental Report as follows:

Environmental Report (2/17/98 version)	Effect of Rev. 2 of DPP and of Supplement
Section 1	See revised schedule information in Rev. 2 of the DPP
Section 2	Supplement describes additional evaluation of alternatives.
Section 3	February 17, 1998 version superseded by Rev. 2 of the DPP
Section 4	Supplement describes additional data forwarded to MMS subsequent to February 17, 1998
Section 5	Supplement briefly assesses any impacts of scope changes and provides an updated analysis of the effects of project construction on water quality
Section 6	Supplement updates
Section 7	Supplement updates
Section 8	Supplement updates
Section 9	Supplement updates

2. DEVELOPMENT ALTERNATIVES

Development alternatives for Liberty were identified as part of the conceptual engineering process. BPXA has prepared a more detailed discussion of these alternatives as described in a report submitted to MMS titled; "Liberty Field Development Alternatives, 4/24/98".

In 1999, BPXA retained Intec Engineering to provide a conceptual level comparison of offshore pipeline system alternatives for export of sales quality oil from Liberty. The purpose of the study was to provide additional information about subsea pipeline alternatives for use in the project Environmental Impact Statement.

3. PROJECT DESCRIPTION

The Project Description contained in the February 17, 1998 ER has been superseded by Revision 2 of the DPP.

4. AFFECTED ENVIRONMENT

At the time the February 17, 1998 ER was issued, BPXA and its contractors were in the process of preparing reports on field research conducted in 1997, and planning for field work to be conducted in 1998. Additional information that has been provided to MMS subsequent to issuance of the original ER is listed in Table 1. None of the additional background data collected revealed a need to alter project siting or design.

5. ENVIRONMENTAL CONSEQUENCES

This section describes the general environmental effects of engineering design and schedule changes to the Liberty Development Project, and also provides supplemental information about effects of project construction on water quality.

5.1 TWO YEAR CONSTRUCTION SCHEDULE

BPXA intends to construct the Liberty Project over two years, with gravel island construction starting in January Year 2 and pipeline construction in starting in January Year 3.

TABLE 1

ADDITIONAL INFORMATION SUBMITTED TO MMS IN SUPPORT OF LIBERTY DEVELOPMENT AND PRODUCTION PLAN AND ENVIRONMENTAL REPORT (AFTER FEBRUARY 17, 1998)

DATE SUBMITTED	DESCRIPTION
April 14, 1998	Chemical characterization of Liberty crude oil
April 14, 1998	BPXA estimates of Liberty production data and estimated revenues from the Liberty project by year
April 22, 1998	Field acoustical data collected while drilling the Liberty #1 Exploration Well, in a report:
	"Under Ice Drill Rig Sound, Sound Transmission Loss, and Ambient Noise Near Tern Island, Foggy Island Bay, Alaska, February 1997", prepared by Greeneridge Sciences and LGL Alaska Research Associates
April 22, 1998	BPXA estimates of Alaskan employment from the Liberty Project
April 22, 1998	A summary and overview of the contents of BPXA's February 13, 1998 Part 55 Air Quality Application for Liberty Project
April 27, 1998	Additional analytic information characterizing the risk and nature of a spill from the products pipeline
April 30, 1998	Field data and engineering analysis of the proposed shore crossing location, in a report:
	"Coastal Stability Analysis - liberty Pipeline Shore Crossing, December 1997", prepared by Coastal Frontiers Corporation
May 29, 1998	Additional public geologic information in response to scoping comments
June 4, 1998	Video tapes of 1998 ROV survey in Foggy Island Bay
June 4, 1998	Background socioeconomic data and revenue forecasts in a report:
	"Liberty Development Project", May 1998, prepared by Northern Economics
July 13, 1998	Data report:
	"Laboratory Testing to Determine Spill Related Properties of Liberty Crude Oil", prepared by SL Ross Environmental Research Ltd. June, 1998
July 20, 1998	Geotechnical data regarding pipeline route and island location, in report:
	"Geotechnical Exploration Liberty Development, North Slope, Alaska", prepared by Duane Miller & Associates on July 6, 1998.

TABLE 1 (CONT'D)

ADDITIONAL INFORMATION SUBMITTED TO MMS IN SUPPORT OF LIBERTY DEVELOPMENT AND PRODUCTION PLAN AND ENVIRONMENTAL REPORT (AFTER FEBRUARY 17, 1998)

July 27, 1998	Results of Summer 1997 and Winter 1998 Boulder Patch Survey, in report: "Liberty Development 1997-1998 Boulder Patch Survey", prepared by Coastal Frontiers Corporation and LGL Ecological Research Associates, July, 1998.
August 26, 1998	Field acoustical data collected in Summer 1997, in a report: "Underwater Acoustic Noise and Transmission Loss During Summer at BP's Liberty Prospect in Foggy Island Bay, Alaska Beaufort Sea", prepared by Greeneridge Sciences and LGL Alaska Research Associates
September 11, 1998	Results of field vegetation site inspections at proposed mine site, shorecrossing pad, and pipeline tie-in September 11, 1998 Trip Report summarizing Wetland and Vegetation Information for Liberty EIS, prepared by LGL
September 30, 1998	Background water and sediment sample data collected in winter 1998, in report: "Liberty Island Route Water/Sediment Sampling, March 28-29, 1998", prepared by Montgomery Watson
December 14, 1998 (in letter to Corps of Engineers)	Evaluation of effects of excess dredged material disposal in report: "Draft Section 103 Marine Protection, Research and Sanctuaries Act Dredged Material Disposal Site Evaluation dated November 1998", prepared by URS Greiner Woodward Clyde
January 6, 1999	Assessment of Offshore Cultural Resources in report: "Liberty Cultural Resource Assessment, Foggy Island Bay in Steffanson Sound, Alaska", prepared by Watson Company, Inc. 1998.
July 15, 1999	Effects of construction on Boulder Patch in report: "Liberty Development: Construction Effects on Boulder Patch Kelp Production", prepared by Ban et al, 1999.
November 1, 1999	Analysis of pipeline design alternatives in report: "Pipeline System Alternatives - Liberty Development Project Conceptual Engineering", prepared by Intec Engineering, Inc.

Project effects will be essentially the same as described in the Environmental Report (LGL et al. 1998); these effects will occur over two years rather than one. No new impacts on the environment will occur; the timing of some of the disturbances will occur in one or the other, or in both, construction years, as opposed to occurring only in one year.

Construction ice roads will be built over two winter seasons. In the first season, roads supporting island construction will be built, and in the second season, roads supporting pipeline construction will be built. With a two year construction schedule, marine mammal disturbance from heavy equipment usage during the construction and use of the ice road complexes will occur over two winters. With a two- rather than a one-season winter construction program, some additional disturbance of ringed seals and polar bears may result from the use of heavy equipment and the presence of human activities on nearshore and offshore ice over two winters instead of one winter. If polar bear den sites, seal breathing holes, or seal birthing lairs are identified in the project area during either year, BPXA will avoid these sites. Regardless of whether the Liberty Development is built over one or two years, ice road complexes are planned to be constructed annually throughout the production life of the development; thus the incremental effects from an additional year's construction season will be negligible.

As previously described in LGL et al. (1998), marine water turbidity levels will increase slightly due to the island and pipeline construction activities, potentially affecting the nearby Boulder Patch benthic communities. With the island construction occurring in year one and the pipeline construction in year two, these turbidity effects will extend over two years. Impacts of this construction are addressed in Ban et al. 1999.

With a two-year construction scenario, gravel removal at the Kadleroshilik River mine site will occur in two winter seasons, not one. Since gravel excavation and transport from the mine site will be limited to the winter season, no additional effects on birds or mammals that may use habitat at the mine site will occur. No additional acreage will be disturbed. Reclamation of the mine site will be conducted after all gravel removal activities have been completed.

With movement of construction vehicles and supplies extended over two seasons, there will be some additional potential for small fuel spills. However, spills are very unlikely given the fuel handling and transport procedures practiced by industry on the North Slope. Fuel and other contaminant safe handling practices will be followed throughout the two-year construction season and throughout the operational life of the Liberty Development.

The overall effects of a two-year construction schedule will be of little additional consequence to the environment or biological resources in this region, since during each year a different area will be affected (island site versus pipeline corridor). There will be cumulative effects over two successive seasons rather than one, but the net increase in impact on the environment will be negligible.

5.2 DETAILED MINING PLAN

A detailed gravel mining and rehabilitation plan was developed subsequent to submittal of the February 1998 Environmental Report. The final plan was based on project gravel needs and site investigation. The surface acreage in the mine site area is approximately 53 acres, which represents a "planning footprint". Within the 53± acres, it is estimated that approximately 31 acres will be directly affected by mining to support project development. The remaining 22± acre "reserve area" is available to support temporary mining activities (stockpiling on an ice pad) and future emergency gravel supply.

Phased development of the mine is currently planned, with the proposed 31± acre excavation area developed as two cells, to match the two year project construction schedule. One cell of the mine would be developed each winter construction season, with gravel extracted and site rehabilitation initiated by breakup of that year. Mining plans for the primary excavation area, as well as for the reserve area, are similar.

The mine site is in a region of riverine barrens and flood plain alluvium. From aerial photo interpretation and a site visit, it is estimated that the 53 acre mine site area is about 40 percent dry dwarf shrub/lichen tundra, 10 percent dry barren/dwarf shrub, forb grass complex, and 50 percent river gravels. The site investigation showed evidence of grazing by caribou and muskoxen.

5.3 CAMP BARGE DURING CONSTRUCTION

BPXA is considering using a barge as a temporary construction camp adjacent to Liberty Island to support module installation. The camp barge will provide more space for personnel and supplies, thus increasing human activities at the island during that open water season. The barge and associated human presence will generate waste that must be handled and transported away from the site, and this may also increase the potential for barge-to-island spills of contaminants. These effects are expected to be minimal and restricted to the open water season of Year 3 only (and Year 4 if the barge is overwintered). If an intense storm develops when the barge is moored to the island, there is a potential for accidental spills of materials on the barge as it is buffeted by seas or as the barge is moved to the lee of the island.

The camp barge will provide lodging and work space for personnel during facilities installation on the island. This will reduce the frequency and number of shore-to-island trips of vessels and aircraft that would be required to transport people and supplies to the Liberty Island construction site. This would reduce the disturbance to the region's wildlife from helicopter and crew boat travel, reduce the potential for contaminant spills from boat and helicopter activity, and reduce the potential for accidents associated with vessel and aircraft movement.

5.4 INCREASED TRANSPORTATION LEVELS

BPXA has revised upward the original estimates of crew boat, barge, helicopter, and vehicle over-ice transport activities associated with construction and operation of the Liberty Development (Table 4-2, DPP). In addition, diesel fuel supplies for permanent operations will be delivered by barge during summer and possibly by ice road during winter. No impacts on the environment that have not already been described (LGL et al. 1998) will occur from these revised traffic forecasts. Increases in vessel, vehicle, and aircraft traffic will increase the potential for accidents and contaminant spills. Standard North Slope industry practices for fueling and transport of fuels, lubricants, and other potential contaminants will minimize spills. More frequent on-ice vehicle activity may increase disturbances to ringed seals and polar bears, and more frequent helicopter overflights and vessel trips to the island may increase disturbance to marine mammals, waterfowl, and marine and coastal birds.

5.5 USE OF HYDRAULIC DREDGING FOR PIPELINE TRENCH EXCAVATION AND CLEANOUT

Hydraulic dredging equipment may be employed to improve precision of the trenching for pipeline installation during the final stages of trenching to clean out the bottom of the trench and to smooth the grade upon which the pipe string will be laid. The hydraulic dredging equipment is fitted to a backhoe and is operated from the ice surface concurrent with placement of the pipeline in the trench. Sediment pumped from the trench will be piped back into or adjacent to the trench. More information regarding the effects of pipeline construction on water quality is provided in Ban et al. 1999.

5.6 AUTOMATIC SHUTOFF VALVE AT SHORE CROSSING

An automatic shutoff valve will be fitted in the oil pipeline at the shore crossing. The option of using a vertical loop will be considered in final design. The original design included a manual shutoff valve at the shore crossing location. In the event of an offshore pipeline rupture, an automatic valve would close and limit the size of the oil spill. The automatic valve (versus a manual valve) will reduce the volume of crude oil spilled into the environment from the offshore segment of the pipeline by about 1020 barrels, under a complete pipeline rupture scenario. Less crude oil would be spilled into the marine environment, thereby reducing impacts on marine organisms and habitats. The use of a vertical loop is also expected to reduce the size of a spill versus the size that could be expected if a manual valve were in place.

5.7 GRAVEL BAGS ON PIPELINE BEFORE BURIAL

After excavation of the pipeline trench and placement of the pipe string, BPXA will place gravel-filled geotextile bags over the top of the pipeline in the trench. A backhoe fitted with specially designed tongs will be used to place the bags so as to not rupture the fabric during installation. Spoil removed from the trench will then be placed back into the trench over the pipeline string, completely burying the gravel-filled bags at depth. There will be no additional environmental effects from using gravel-filled bags to anchor the pipe string.

5.8 INCREASED DIESEL FUEL STORAGE ON ISLAND

BPXA has calculated that approximately 21,000 barrels of diesel fuel will be stored temporarily on the Liberty Island during construction. This increased volume of diesel is required to meet demands from drilling and construction activities; a much smaller volume (3,000 barrels) will be needed after construction. With increased diesel fuel storage comes increased potential for accidents and spills. BPXA has recognized this risk in its spill response planning, and will implement best management practices for fuel handling on the island to minimize the potential for spills of diesel fuel.

5.9 INCREASED CRUDE OIL PRODUCTION OPTION

BPXA is considering increasing production of crude oil from the field to a peak of 75,000 barrels per day. This increase in production would not increase any discharges permitted under the NPDES nor would this level of production increase other wastes or emissions. No new or additional environmental effects would occur due to an increase in crude oil production.

5.10 INCREASED SIZE OF ISLAND FOOTPRINT

The Liberty island has a design bottom dimension of 635 ft x 970 ft (as opposed to the original design footprint of 630-670 ft x 960-1000 ft). The actual island footprint is likely to be larger than the design bottom dimensions. During the process of construction, gravel will be dropped through the water column to build the island structure up from the seafloor. In this process, not all gravel will fall precisely within the design footprint. To accommodate this construction uncertainty, BPXA has identified a construction footprint of about 835 feet by 1170 feet; this footprint includes an extra 100 feet around the perimeter of the design island bottom dimensions.

This area is slightly greater than the original low estimate, but the additional benthic habitat covered by gravel materials is negligible. Under-ice surveys of the benthic environment in April 1998 confirmed that no Boulder Patch habitat occurs at the island site.

5.11 ELIMINATION OF ISLAND STORMWATER DISCHARGE

Storm water collected on the Liberty Island will be injected into the waste disposal well. Environmental effects of the previously-described stormwater discharge into the marine environment will be eliminated.

6. MITIGATION MEASURES

The February 17, 1998 Environmental Report contains a comprehensive list of mitigation incorporated into project planning, design, construction, and operation. Scope changes identified after submittal of that report (as described in Revision 1 of the DPP) resulted in further mitigation of project impacts. These mitigation measures include:

- elimination of discharges associated with deck drainage

- placing an automated valve or a vertical loop at the pipeline shorecrossing pad (versus the originally proposed manual valve). Use of an automated valve at this location causes an estimated decrease of about 1,020 barrels from a leak resulting from a complete rupture of the offshore oil pipeline with a manual valve
- possible use of construction camp barge would reduce levels of helicopter and vessel traffic needed to support construction
- two season gravel mining plan incorporates rehabilitation measures
- proposed location of disposal site for any excess materials excavated from pipeline trench was selected in consultation with agencies to minimize impacts to marine environment
- commitment to continue consultation with resource agencies on means to reduce impacts of overflights
- supplemental leak detection system (LEOS)

7. COORDINATION AND CONSULTATION

BPXA will continue to involve representatives of the communities in the planning phase of the Liberty Development Project. BPXA managers will meet with the communities periodically in workshops on project specifics such as project design and engineering, and oil spill response planning. The purpose of these meetings will be to provide updated information on the project and to discuss, in greater detail, specific issues.

In ongoing consultation, BPXA will hold community workshops in Nuiqsut, the community closest to the project, and in Kaktovik and Barrow, two other communities potentially affected by the project. BPXA will also coordinate with other North Slope communities. The schedule of the workshops is to be worked out between community leaders and BPX.

Issues to be discussed in the workshops will include:

- Oil spill prevention and contingency planning.
- Island design, pipeline integrity and leak detection.
- Potential marine mammal disturbance. Disturbance to bowhead whales during the fall migration is of particular concern to local residents. BPXA will be prepared to answer questions and discuss marine mammal disturbance issues at these meetings.
- Employment and business opportunities.

BPXA will publish informational newsletters on each of these topics periodically during the year, supplemented with video materials and radio programs.

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9. REFERENCES CITED

Ban, Suzanne M., Colonell, J., Dunton, K., Gallaway, B., and Martin, L. Liberty Development: Construction Effects on Boulder Patch Kelp Production. Report for BP Exploration (Alaska) Inc., May 27, 1999, Anchorage, AK.

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