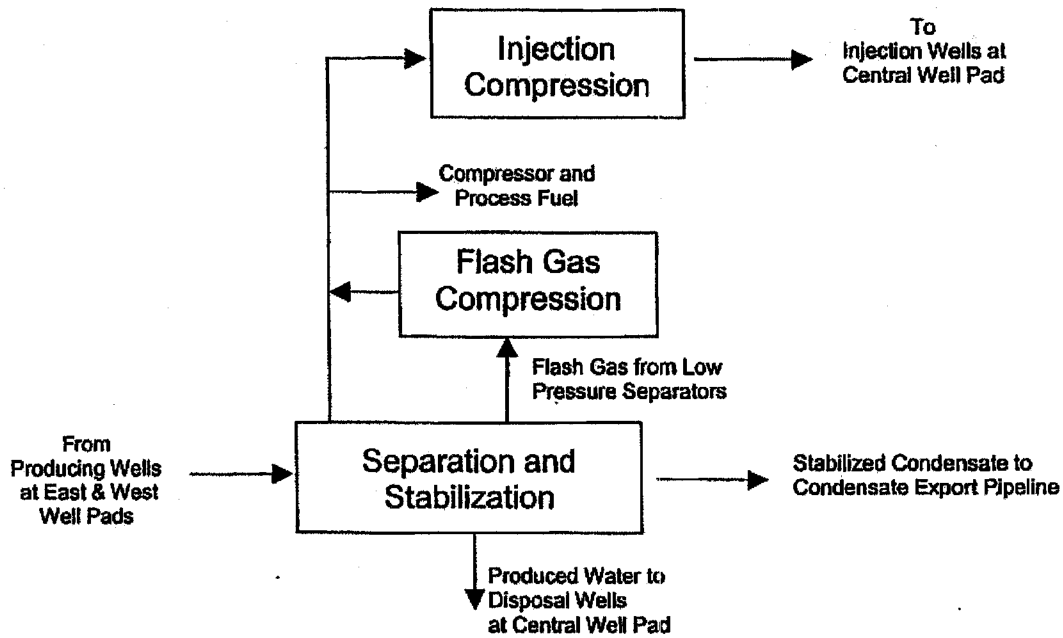
3.0 PROJECT DESCRIPTION

3.1 DEVELOPMENT PLAN

The progression used in this evaluation is development of the Point Thomson field first as a gas cycling project with the possibility of gas sales following at an unspecified future date. Under this development plan, 3-phase full well stream production gathered from two remote well pads (East and West Well Pads) is sent to a Central Processing Facility (CPF) where the gas condensate is separated and stabilized so that it meets sales pipeline specifications. The remaining gas is then compressed and re-injected at an adjacent Central Well Pad (CWP). Figure 3-1 is a simplified flow diagram showing the basic CPF process. Figure 3-2 is a map showing the overall layout of the well pads, CPF, and related pipelines and infrastructure (roads, dock, airstrip, etc.).

Figure 3-1 Point Thomson Gas Cycling Project Simplified Flow Diagram



Alternative development components of the gas cycling project are analyzed and rationale for selection of proposed components are described in Section 2.0. Section 3.0 describes the components of the proposed development plan. The development basis consists of a three-train case in which production rates are dictated by the capacities of the three injection compressor trains. The term "train" is used to define a collection of facility components, usually organized in series, which together perform a basic process function. This term is typically used when referring to the number of similar groupings of components that are parts of an overall plant or facility. Therefore, "three trains" of injection compression indicates that there are three sets of equipment of similar design and capacity (Figure 3-3). Each train is discrete and does not share components with the other train. For the three train cycling case there are three trains of injection compression and two trains of flash gas compression.

In addition to condensate which is separated from the three-phase stream, the Point Thomson Sand has a shallow oil rim which may contribute a heavier oil that will be produced through the planned producer wells, separated in the gas cycling facilities, and sold along with the condensate.

In the same area as the Point Thomson field, several accumulations of Brookian-age reservoirs are thought to exist at shallower depths, and to be of the same general type as the Flaxman, Sourdough, and Badami reservoirs. Based on current evaluations, it is questionable whether the Brookian-Age reservoirs can be economically produced at this time. The potential of these reservoirs will be further explored while drilling through them to Point Thomson sand targets, but no pre-investment or special designs to facilitate their production are currently anticipated.

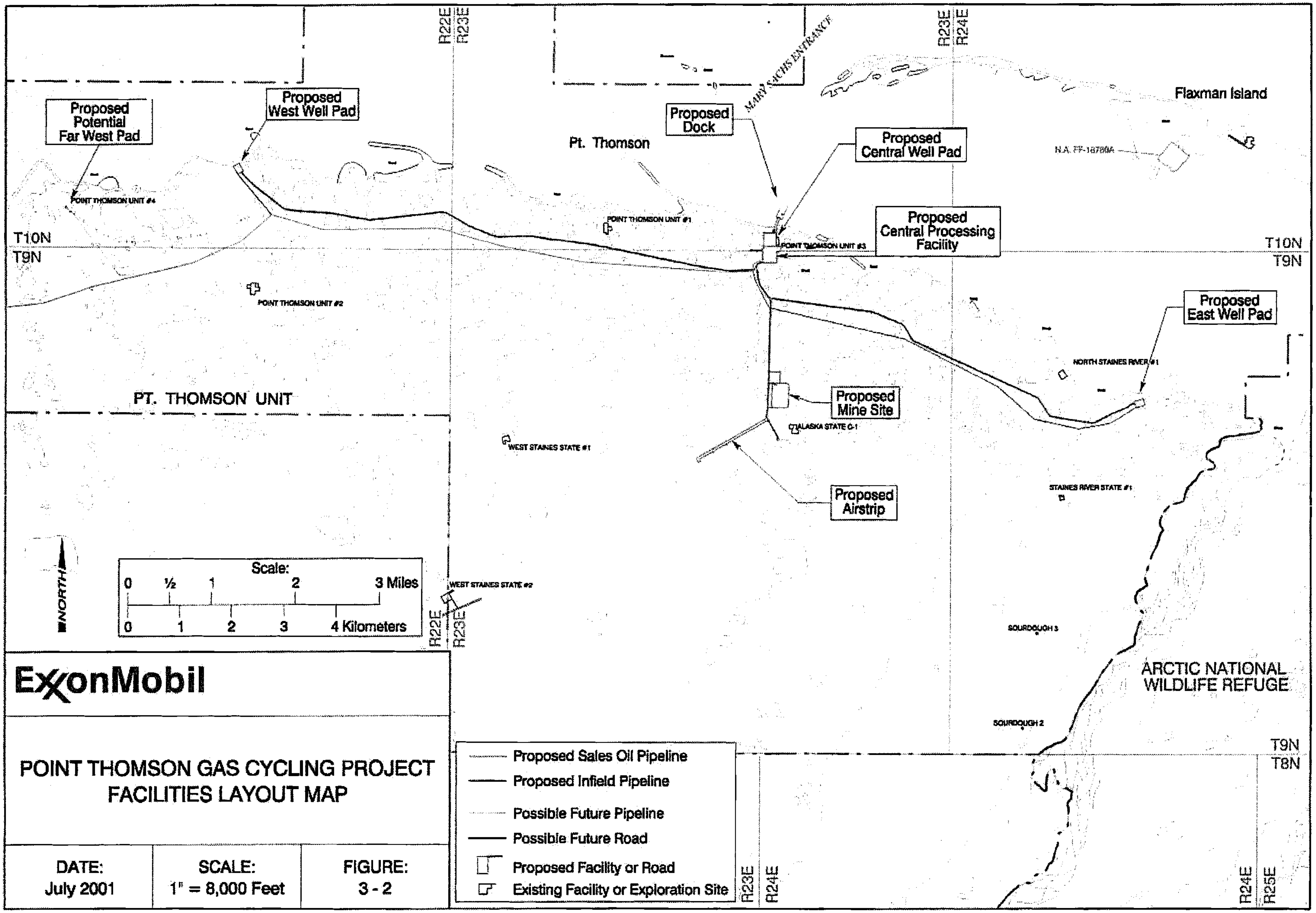
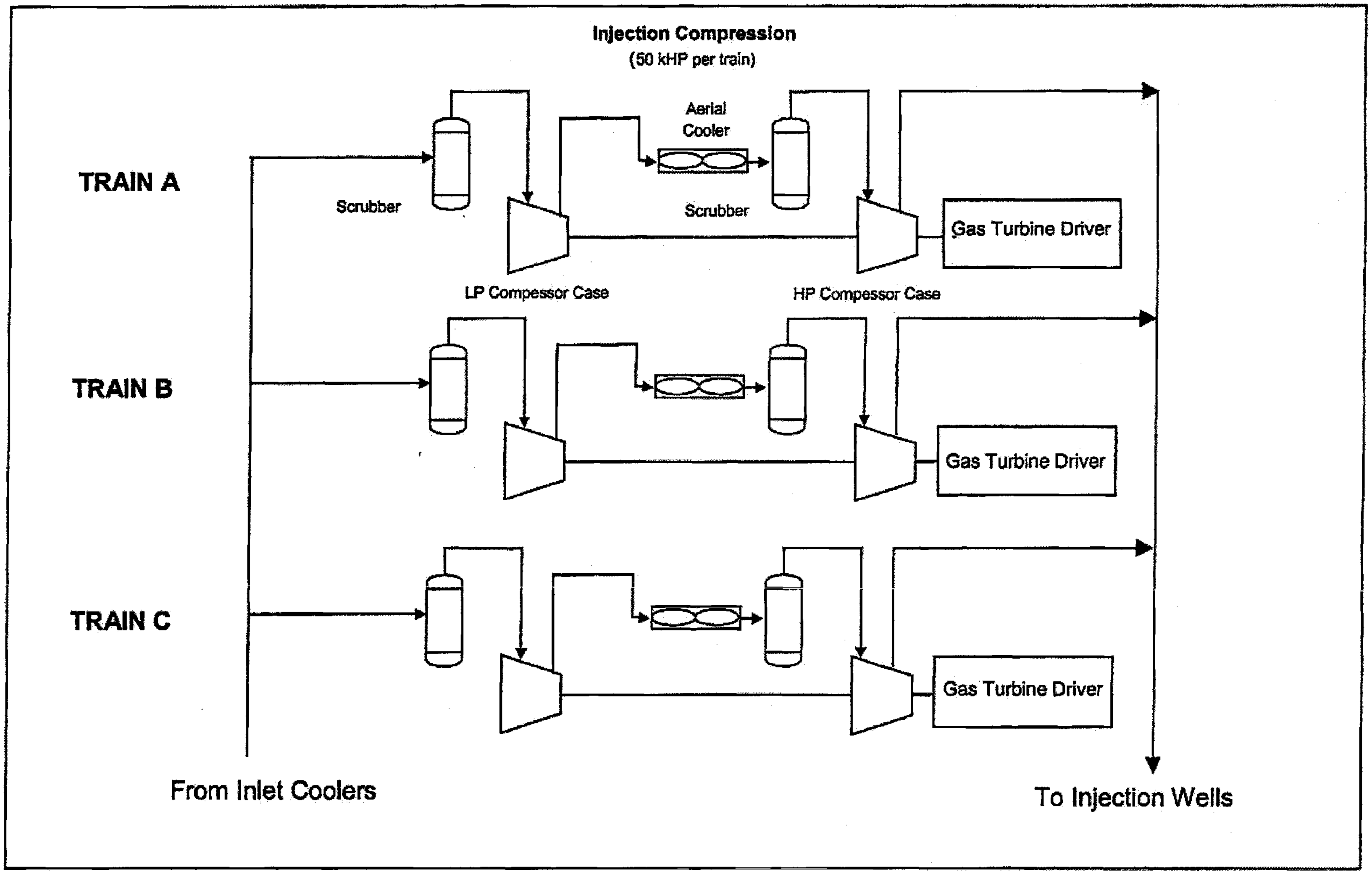

Proposed Potential Far West Pad
Proposed West Well Pad
Pt. Thomson
Proposed Dock
MARY SACHS ENTRANCE
Proposed Central Well Pad
Flaxman Island
Proposed Central Processing Facility
Proposed East Well Pad
Proposed Mine Site
Proposed Airstrip
POINT THOMSON UNIT #4
POINT THOMSON UNIT #1
POINT THOMSON UNIT #3
POINT THOMSON UNIT #2
NORTH STAINES RIVER #1
ALASKA STATE C-1
WEST STAINES STATE #1
WEST STAINES STATE #2
STAINES RIVER STATE #1
SOURDOUGH 3
SOURDOUGH 2
PT. THOMSON UNIT
ARCTIC NATIONAL WILDLIFE REFUGE
T10N
T9N
T8N
R22E
R23E
R24E
R25E
NORTH
Scale:
0 ½ 1 2 3 Miles
0 1 2 3 4 Kilometers
Proposed Sales Oil Pipeline
Proposed Infield Pipeline
Possible Future Pipeline
Possible Future Road
Proposed Facility or Road
Existing Facility or Exploration Site
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT FACILITIES LAYOUT MAP
DATE: July 2001
SCALE: 1" = 8,000 Feet
FIGURE: 3 - 2

Fig3_2.dgn

Figure 3-3 Three Train Injection Case



3.2 DRILLING PLAN

Point Thomson wells will be drilled to a vertical depth of approximately 13,000 feet (ft) (3,962 meters [m]) and use extended reach drilling to reach targets extending out to 20,000 ft (6,096 m). The production and injection wells will be large bore with 7-inch (in) (18-centimeter [cm]) nominal diameter tubing. Two rigs will be used and the rigs will likely be mobilized by barge a year before the CPF modules are delivered to Point Thomson. As an alternative, the rigs could be brought to the Point Thomson area over the seasonal sea ice road from Endicott.

Cuttings from the drilling rig(s) will be transported to a grind and inject (G&I) unit located at the CWP. A description of the G&I process is provided in Section 3.6.3. The first well drilled will be a United States Environmental Protection Agency (EPA) Class I non-hazardous disposal well. This well will be used initially to dispose of the ground slurry from the G&I unit. Later, this same well will be used to dispose of produced water and wastewater effluent from the camps.

This page intentionally left blank

3.3 ROAD SYSTEMS

Both temporary and permanent road systems will be required for the project. Temporary roads will be ice roads, either constructed on land or on the grounded sea-ice adjacent to the shoreline. Permanent gravel roads will link facility pads, airstrip, and dock facilities.

3.3.1 Sea Ice Road – Endicott to Point Thomson

A sea ice road will be constructed from the existing permanent road system at Endicott to Point Thomson following the shoreline. The road from Endicott to Point Thomson will be approximately 42 mi(mi) (68 kilometers [km]) in length and will consist primarily of seawater with a fresh water cap. Several stubs to on-land water sources will also be required. The sea ice road will be necessary for the two construction seasons (as described in Section 3.10) and, depending on special activities and related logistics, may be required on occasion once the facilities are in operation. During the drilling and construction phase of the project, the sea ice road will be used to transport heavy equipment, materials, and supplies. The general route for the proposed sea ice road is shown on Figure 3-4.

3.3.2 Land Based Ice Roads

Ice roads on land will be required during the first two construction seasons. During the first winter, one road, approximately 3 mi (5 km) long, will extend from the general location of the CWP, past the proposed gravel mine site, to the fresh water source at the former gravel mine, as shown in Figure 3-5. The ice road for the pad and early gravel road construction will be approximately 40 ft (12 m) wide and 6 in (15 centimeters [cm]) thick.

During the second winter, land ice roads are also required along the pipeline right-of-way. They become the travel and working surface off of which the pipeline is built. Figures 3-6 and 3-7 show the proposed route of pipeline construction ice roads from East Well Pad to CPF (about 6 mi [9.7 km]), CPF to West Well Pad (about 7 mi [11 km]), and West Well Pad to Badami (about 16 mi [26 km]). The width of an ice road for pipeline construction is generally about 100 ft (30.5 m).

3.3.3 Permanent Gravel Roads

Permanent all-weather gravel roads are required to connect the well pads, airstrip, gravel mine, and fresh water supply source to the central CPF Pad. In addition, a gravel roadway is required from the dock site to the CPF Pad. Permanent roads and pads and the airstrip will be constructed during the winter from locally mined gravel to a nominal thickness above the tundra of 6 ft (1.8 m). Side slopes of the roads, pads, and airstrip will be constructed initially to a slope of approximately 1.7:1, horizontal to vertical. Following thawing, settling, and final grading and grooming during the ensuing spring, summer and fall, the nominal finished thickness of roads, pads, and the airstrip will be 5 ft (1.5m) and finished side slopes will be 2:1. Gravel roads for vehicle traffic are generally 30 to 35 ft (9 to 11 m) wide. However, the road from the dock to the CPF Pad is about 50 ft (15 m) wide to facilitate movement of the large, heavy modules brought in by sea lift.

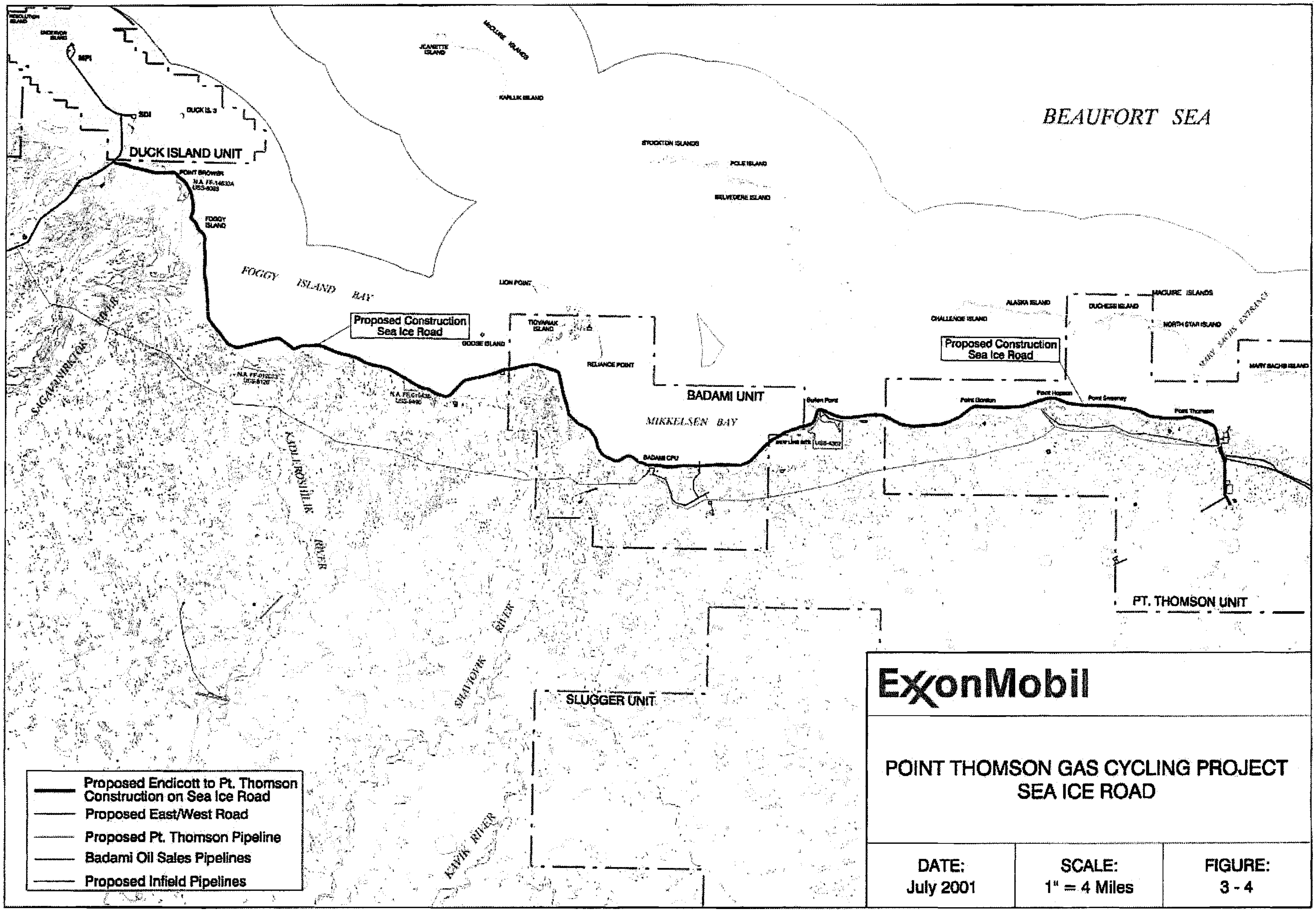
The minimum permitted footprint for roads, pads, and the airstrip must have the dimensions of the finished surface plus an approximately 10-ft (3-m) wide shoulder per side to account for the side slopes. An additional buffer area around the entire footprint perimeter (i.e., beyond the traveled surface plus side slopes) will also be included in the permitted area for construction. This additional buffer area at the perimeter is necessary as material will invariably spread beyond the toe over time, despite maintenance, due to the steepness of the side slopes prior to compaction of the surface to 5 ft (1.5 m). Table 3-1 summarizes the details of the various roads, and Figure 3-8 depicts typical road cross sections.

Culverts or bridges will be used to cross creeks and small streams. The largest streams in the project area are East and West Badami creeks. The design selected will depend on the various stream widths at the crossings. For the smaller streams, both culverts and "mini-span" bridges will be considered. Figures 3-9A through 3-9D detail half-pipe configurations used for typical large stream crossings. For small drainages, 18 in (46 cm) steel culverts will be used.

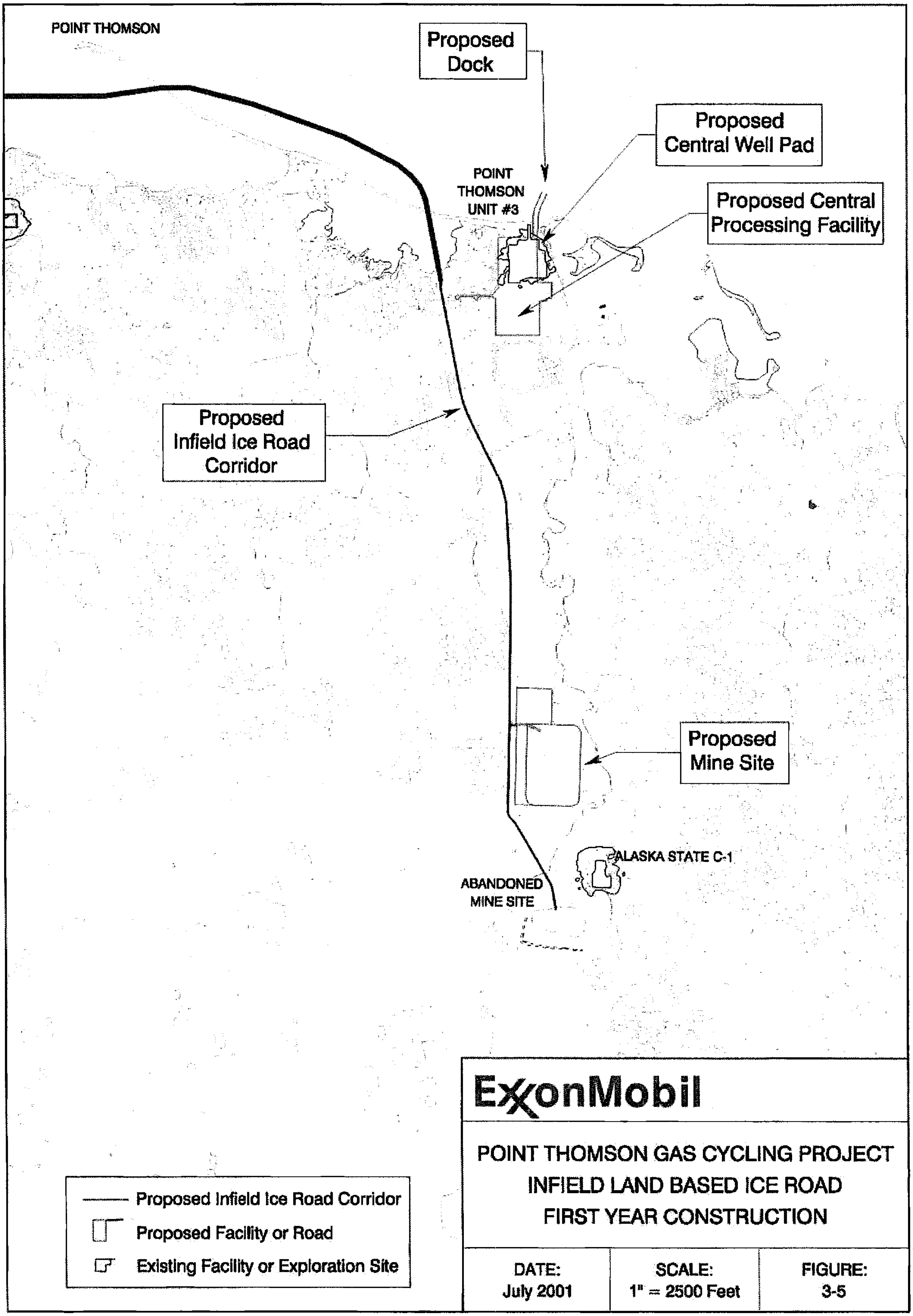
Table 3-1 Summary of Gravel Road Details

DESCRIPTION	APPROXIMATE DIMENSIONS
CPF to AIRSTRIP[1]	
Length	1.4 mi (2.3 km)
Width	30 ft (9 m)
Gravel Quantity	67,000 cy (51.225 m^3)
Year Constructed	1st winter
ABANDONED MINE SITE ROAD[2]	
Length	0.26 mi (0.4 km)
Width	30 ft (91 m)
Gravel Quantity	15,000 cy (11,468 m^3)
Year Constructed	1st winter
CPF to EAST WELL PAD	
Length	5.7 mi (9.1 km)
Width	35 ft (11 m)
Gravel Quantity	305,000 cy (233,000m^3)
Year Constructed	1st winter
CPF to WEST WELL PAD	
Length	6.6 mi (10.6 km)
Width	35 ft (11 m)
Gravel Quantity	365,000 cy (280,000m^3)
Year Constructed	1st winter
CPF to DOCK (Functional part of the CPF & CWP)	
Length	0.3 mi (0.4 km)
Width	50 ft (15 m)
Gravel Quantity	20,000 cy (15,000m^3)
Year Constructed	1st winter

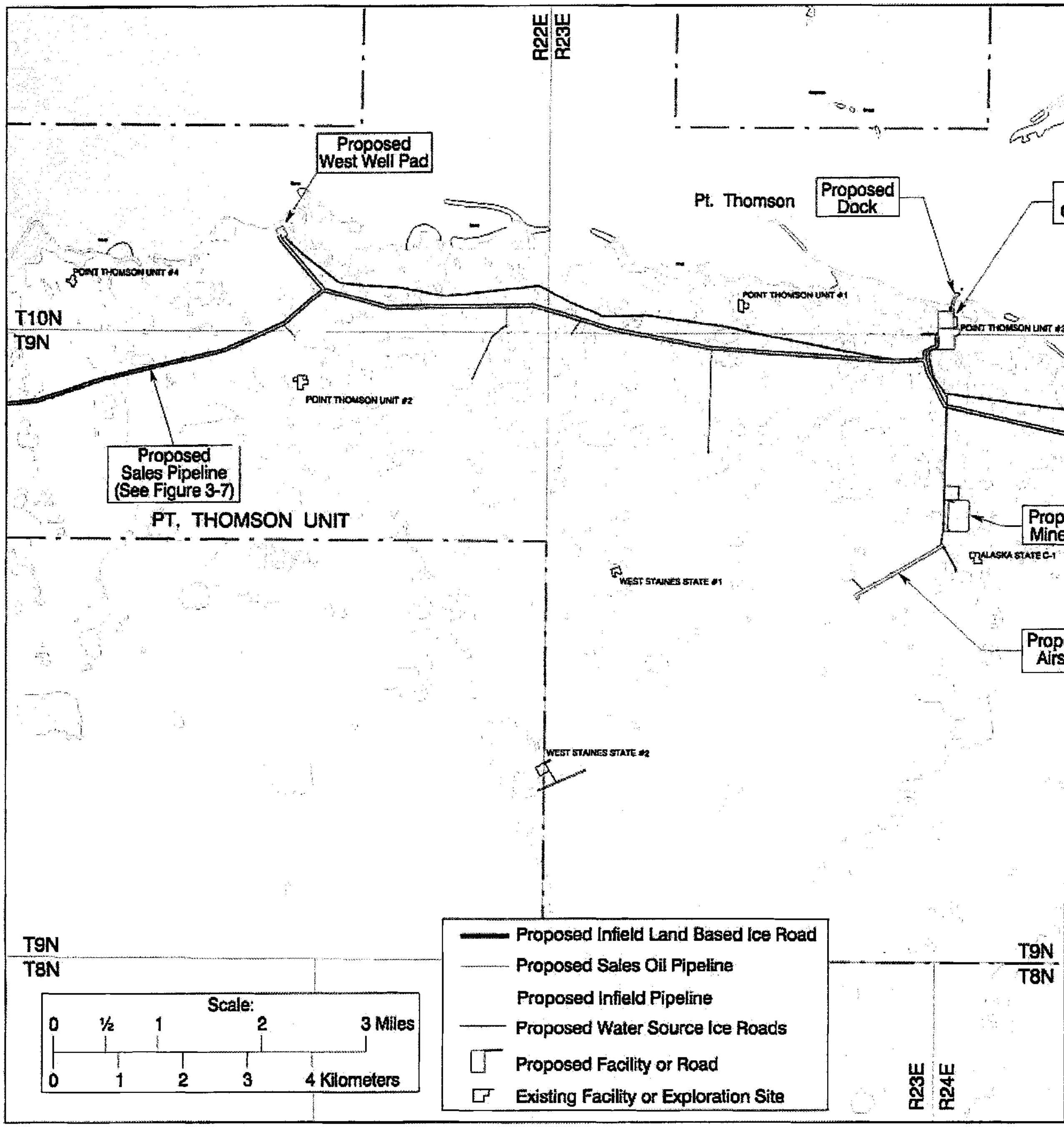
[1]Gravel volume includes spur roads to mine site, gravel storage pad, and abandoned mine site.



BEAUFORT SEA
JEANETTE ISLAND
MCCLURE ISLANDS
KARLUK ISLAND
STOCKTON ISLANDS
POLE ISLAND
BELVEDERE ISLAND
MPI
SDI
DUCK IS. 3
DUCK ISLAND UNIT
POINT BROWER
FOGGY ISLAND
FOGGY ISLAND BAY
LION POINT
Proposed Construction Sea Ice Road
GOOSE ISLAND
TIGVARIAK ISLAND
RELIANCE POINT
BADAMI UNIT
MIKKELSEN BAY
BADAMI CPU
SAGAVANIRKTOK RIVER
KADLEROSHILIK RIVER
SHAVIOVIK RIVER
KAVIK RIVER
MAGUIRE ISLANDS
ALASKA ISLAND
CHALLENGE ISLAND
DUCHESS ISLAND
NORTH STAR ISLAND
MARY SACHS ENTRANCE
MARY SACHS ISLAND
Proposed Construction Sea Ice Road
Point Gordon
Point Hopson
Point Sweeney
Point Thomson
PT. THOMSON UNIT
SLUGGER UNIT
Proposed Endicott to Pt. Thomson Construction on Sea Ice Road
Proposed East/West Road
Proposed Pt. Thomson Pipeline
Badami Oil Sales Pipelines
Proposed Infield Pipelines
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
SEA ICE ROAD
DATE: July 2001
SCALE: 1" = 4 Miles
FIGURE: 3 - 4


POINT THOMSON
Proposed Dock
Proposed Central Well Pad
POINT THOMSON UNIT #3
Proposed Central Processing Facility
Proposed Infield Ice Road Corridor
Proposed Mine Site
ALASKA STATE C-1
ABANDONED MINE SITE
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
INFIELD LAND BASED ICE ROAD
FIRST YEAR CONSTRUCTION
DATE: July 2001
SCALE: 1" = 2500 Feet
FIGURE: 3-5
Proposed Infield Ice Road Corridor
Proposed Facility or Road
Existing Facility or Exploration Site

fio3 5.dgn

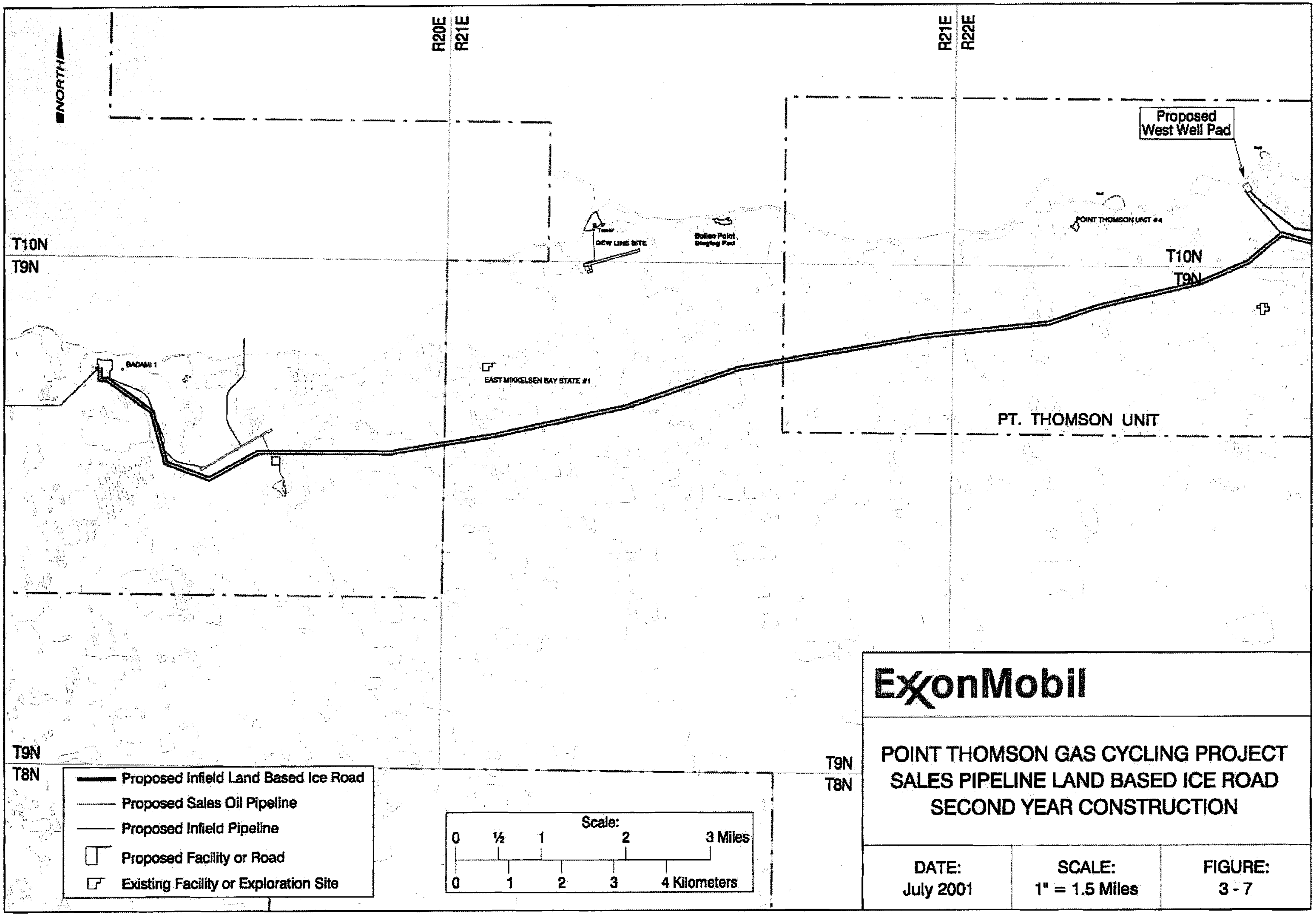


ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
INFIELD LAND BASED ICE ROAD
SECOND YEAR CONSTRUCTION

DATE:	SCALE:	FIGURE:
July 2001	1" = 1.5 Miles	3 - 6

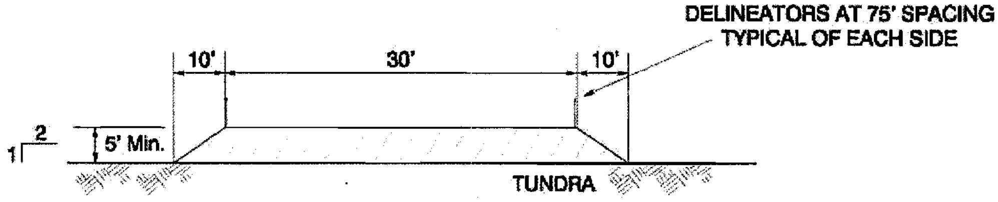
fig3 6.dgn



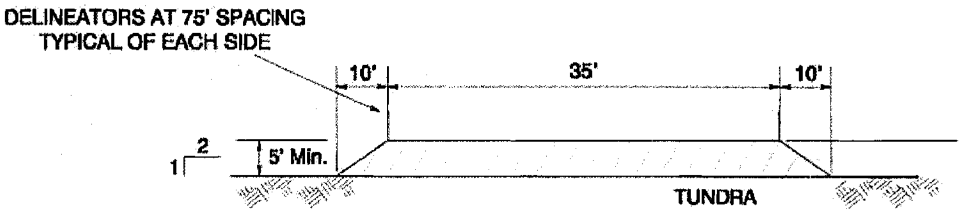
POINT THOMSON GAS CYCLING PROJECT
SALES PIPELINE LAND BASED ICE ROAD
SECOND YEAR CONSTRUCTION

DATE:	SCALE:	FIGURE:
July 2001	1" = 1.5 Miles	3 - 7

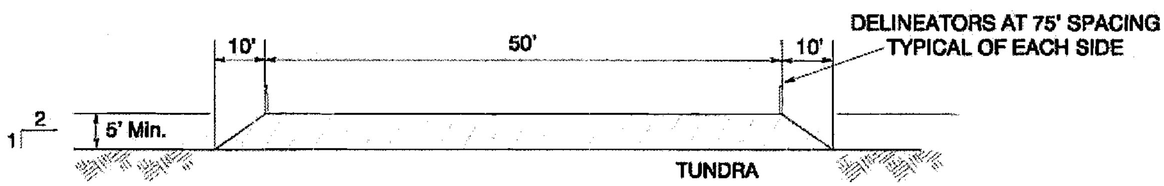
fig3 7.dgn



TYPICAL 30' ROAD SECTION



TYPICAL 35' ROAD SECTION



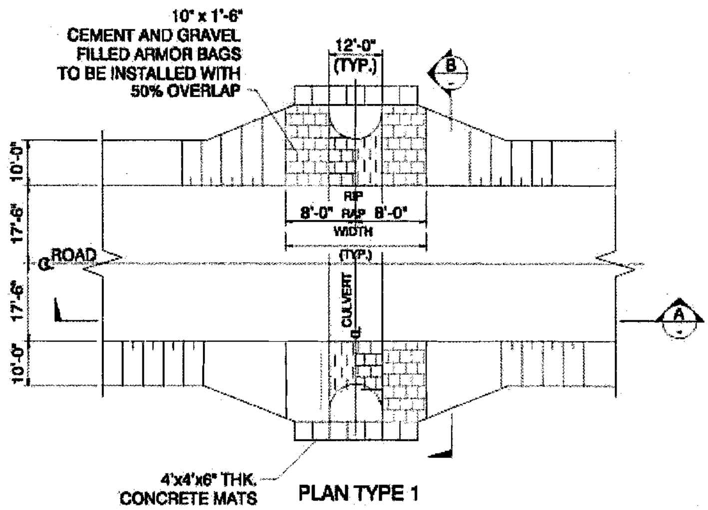
TYPICAL 50' ROAD SECTION

ExxonMobil

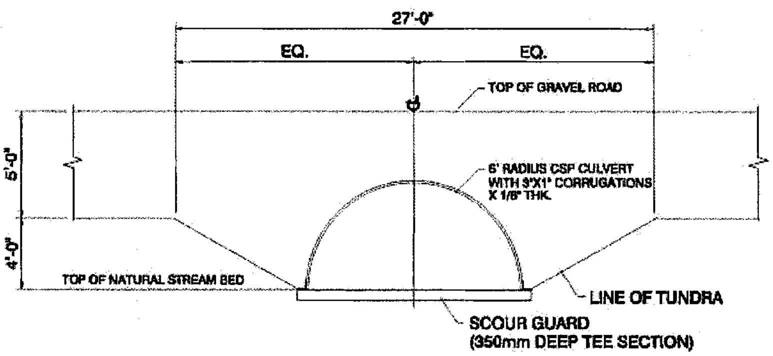
POINT THOMSON GAS CYCLING PROJECT
TYPICAL 30-FT, 35-FT, AND 50-FT
ROAD CROSS SECTIONS

DATE:	SCALE:	FIGURE:
JULY 2001	Not to Scale	3-8

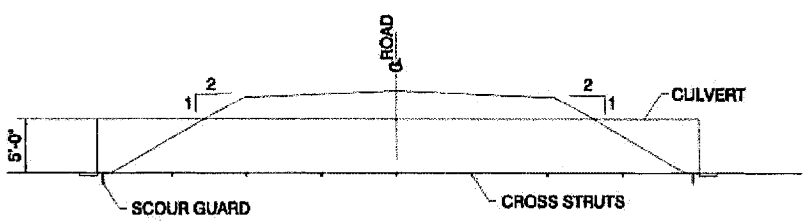
ex14464cross.dgn



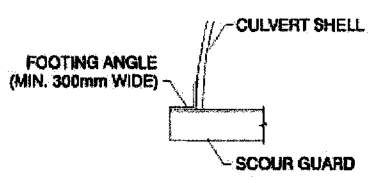
PLAN TYPE 1



SECTION A



SECTION B



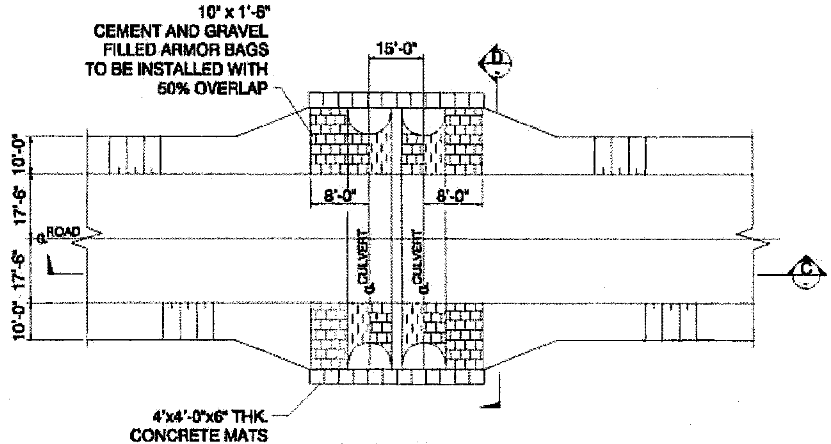
DETAIL 1

ExxonMobil

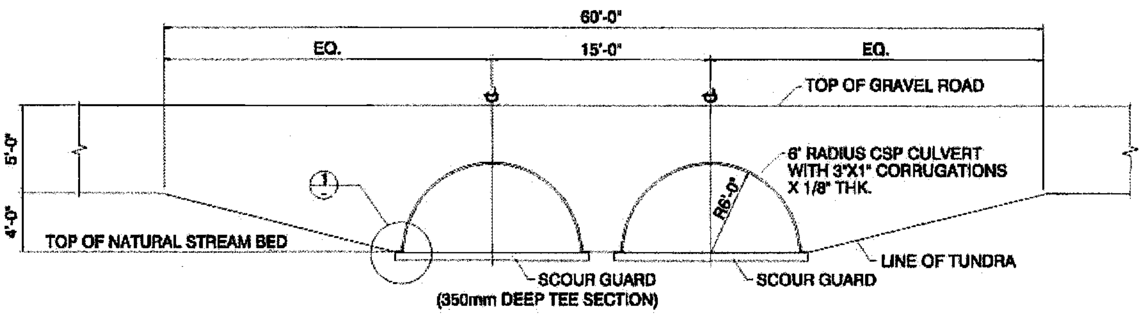
POINT THOMSON GAS CYCLING PROJECT
SINGLE CULVERT

DATE:	SCALE:	FIGURE:
July 2001	Not To Scale	3 - 9A

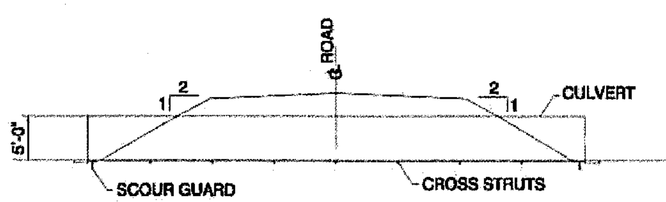
ex14464cross.dgn



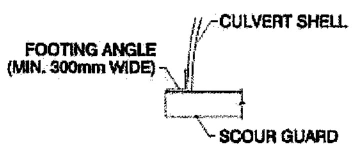
PLAN TYPE 2



SECTION C



SECTION D

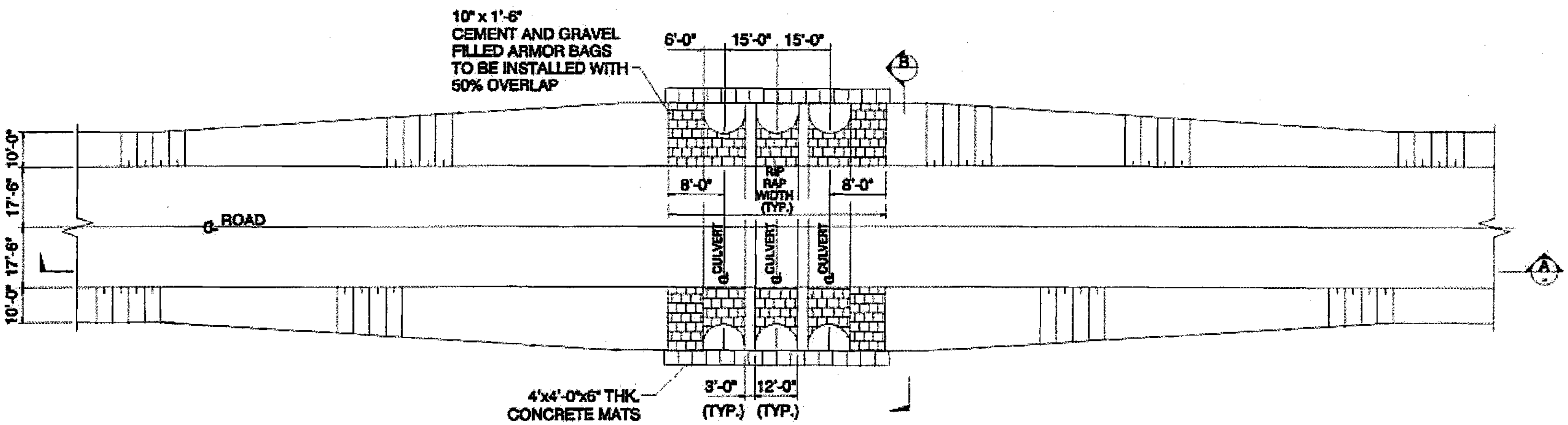


DETAIL 1

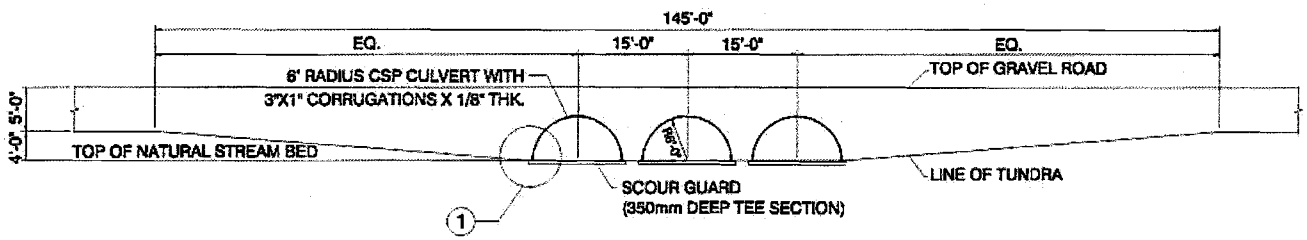
ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
DOUBLE CULVERTS

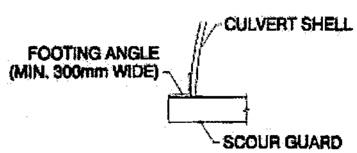
DATE:	SCALE:	FIGURE:
July 2001	Not To Scale	3 - 9B



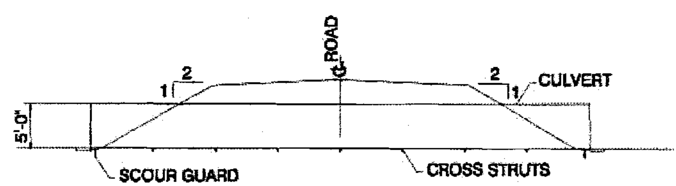
PLAN TYPE 3



SECTION A



DETAIL 1



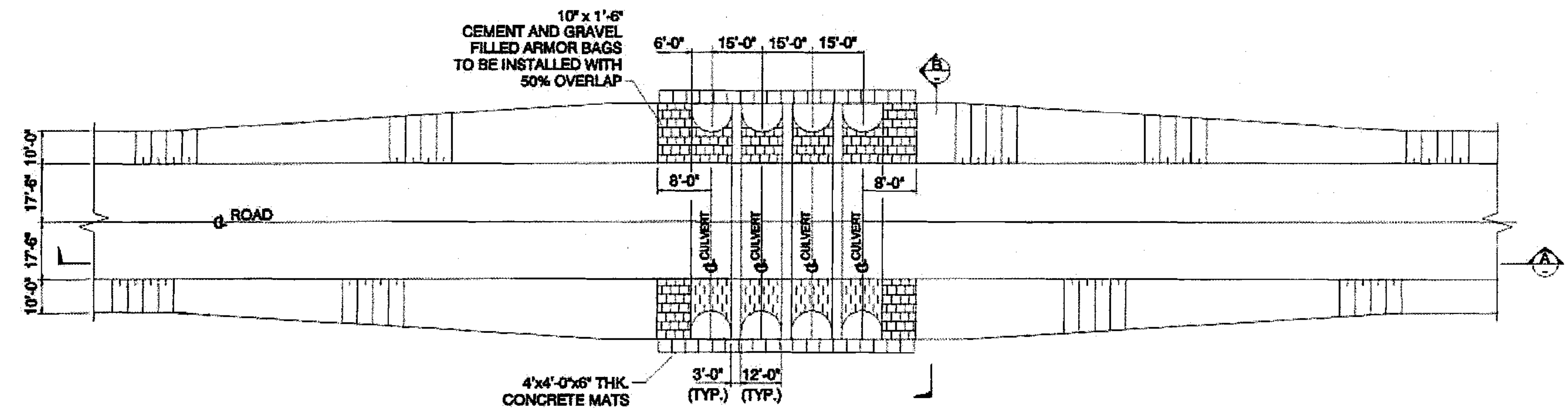
SECTION B

ExxonMobil

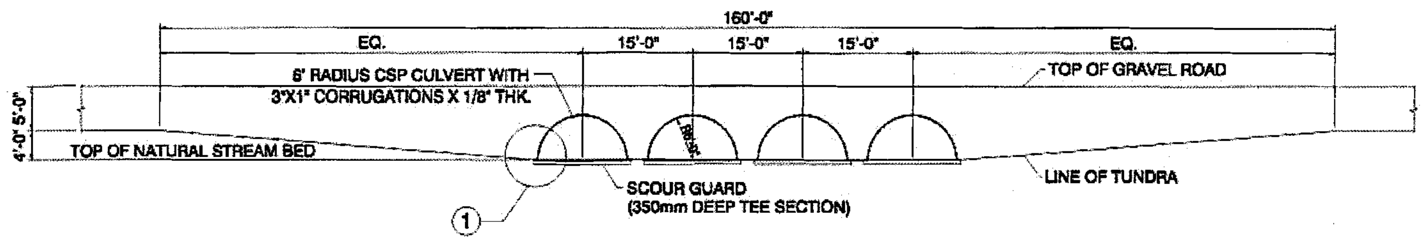
POINT THOMSON GAS CYCLING PROJECT
TRIPLE CULVERTS

DATE:	SCALE:	FIGURE:
July 2001	Not To scale	3 - 9C

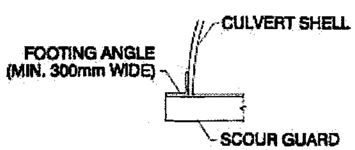
ex14464cross.dgn



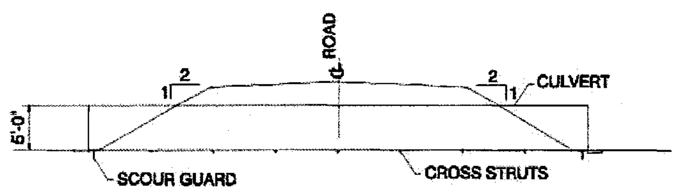
PLAN TYPE 4



SECTION A



DETAIL 1



SECTION B

ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
FOUR CULVERTS

DATE:	SCALE:	FIGURE:
July 2001	Not To scale	3 - 9D

ex14464cross.dgn

3.4 AIRSTRIP

Due to Point Thomson's remote location, an airstrip that is operable on a year-round basis is essential for the safety of plant operators as well as emergency response. Additionally, an airstrip provides a means of transporting people, supplies, and materials during those periods when access is not possible by either ice road or barge. The proposed location of the airstrip is approximately 2 mi (3.2 km) from the coast, south of the CPF Pad. Factors considered in the location were:

- Proximity to CPF and camp facilities,
- Location should be several mi from the coast to minimize fog restrictions,
- Alignment with prevailing winds,
- Proximity to a gravel source,
- Avoidance of any creeks or lakes, and
- Proximity to existing access roads.

The location of the is shown on the facilities layout (Figure 3-2) and details of its construction are provided on Figures 3-10A through 3-10C.

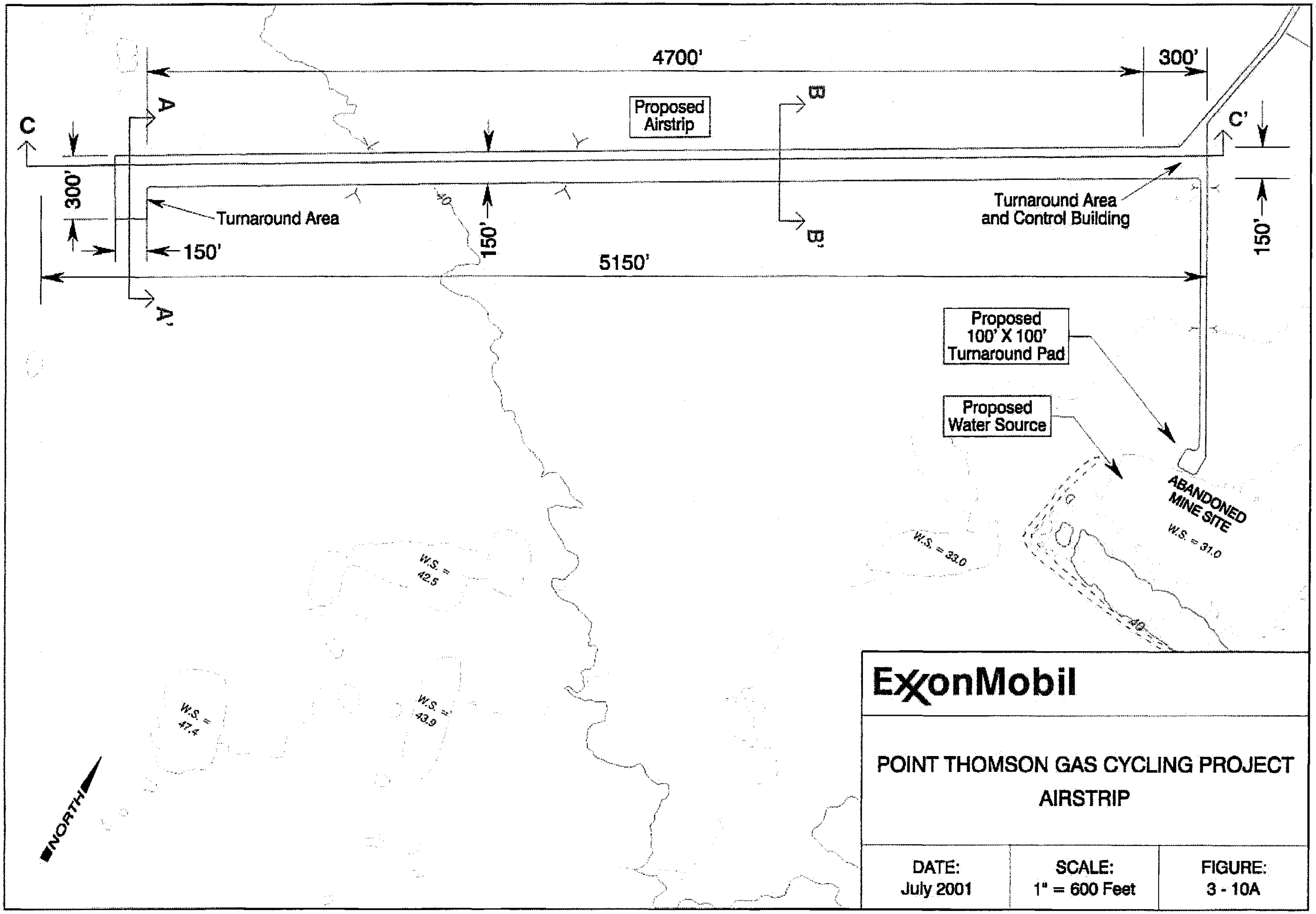
During operations the types of aircraft utilizing the strip most frequently will be the size of a Twin Otter for bringing in crew changes and supplies. However, for maintenance and servicing of large equipment, the runway must be large enough to provide landing and take-off capabilities for a fully loaded Hercules C-130. For potentially larger crew changes during the construction phase and for emergency evacuation of personnel, the airstrip must also be adequate for a Boeing 737 jet aircraft. A 5,150 ft (1,570 m) by 150 ft (46 m) airstrip is proposed. This length and width will satisfy the requirements of regular use by Twin Otters, Hercules C-130, and Boeing 737 aircraft.

Other proposed features of the airstrip are:

- Turn-around locations at each end measuring approximately 150 ft by 300 ft (45 m by 90 m),
- An all-weather road to the CPF Pad,
- A 10 ft by 20 ft (3 m by 6 m) control building,
- Electrical service via cable buried in the road from the power generating facilities at the CPF,
- Control and communication links to the CPF using fiber-optic cable, and
- Navigation and communication controls and an instrumentation system that provides 24 hour operation under conditions with a minimum half-mile visibility and a 200 ft (61 m) ceiling.

Gravel will be placed for the airstrip during the first winter's construction. Grading and compaction will be done through spring and early summer. Approximately 205,000 cubic yards (cy) (157,000 cubic meters [m^3]) of gravel will be required for the airstrip and associated features. The airstrip is expected to be ready for use by mid to late summer of the first year's construction.

This page intentionally left blank



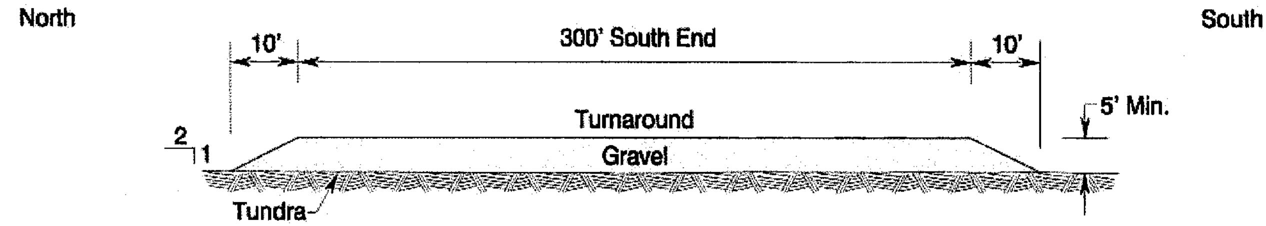
ExxonMobil

POINT THOMSON GAS CYCLING PROJECT

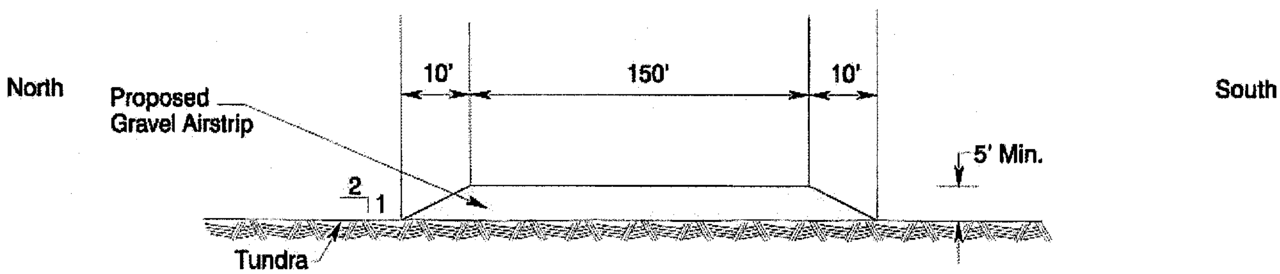
AIRSTRIP

DATE:	SCALE:	FIGURE:
July 2001	1" = 600 Feet	3 - 10A

ex14464plan.dgn



Section A - A'



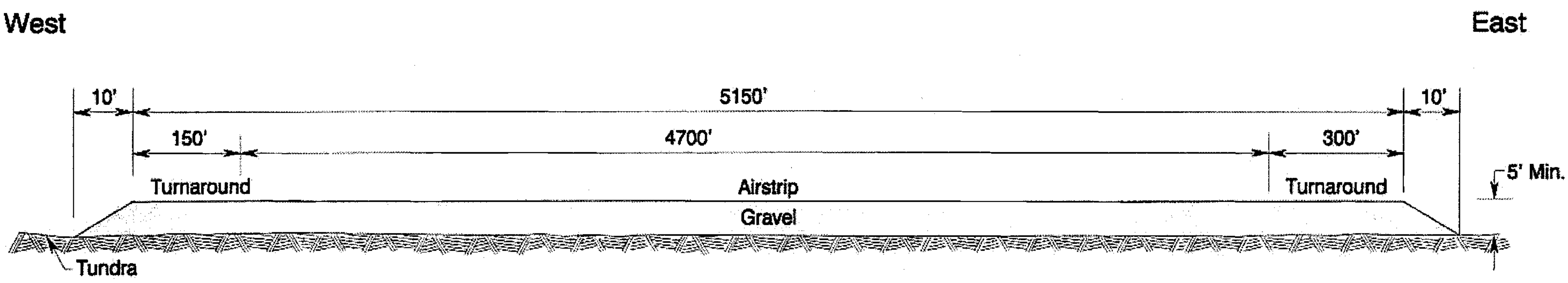
Section B - B'

ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
AIRSTRIP CROSS - SECTIONS
(A - A' AND B - B')

DATE:	SCALE:	FIGURE:
July 2001	Not to Scale	3 - 10B

ex14464cross.dgn



Section C - C'

ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
PROPOSED AIRSTRIP
CROSS - SECTION (C - C')

DATE:	SCALE:	FIGURE:
July 2001	Not to Scale	3 - 10C

ex14464cross

3.5 DOCK

Due to Point Thomson's remote location, all major equipment and facilities required for the drilling and construction phase of the project must be brought in over ice roads in the winter or by sea lift with barges during the summer months. However, smaller loads and supplies could be brought in by air. Following construction, supplies for the on-going operation of the plant must also be brought in by one of these methods as well.

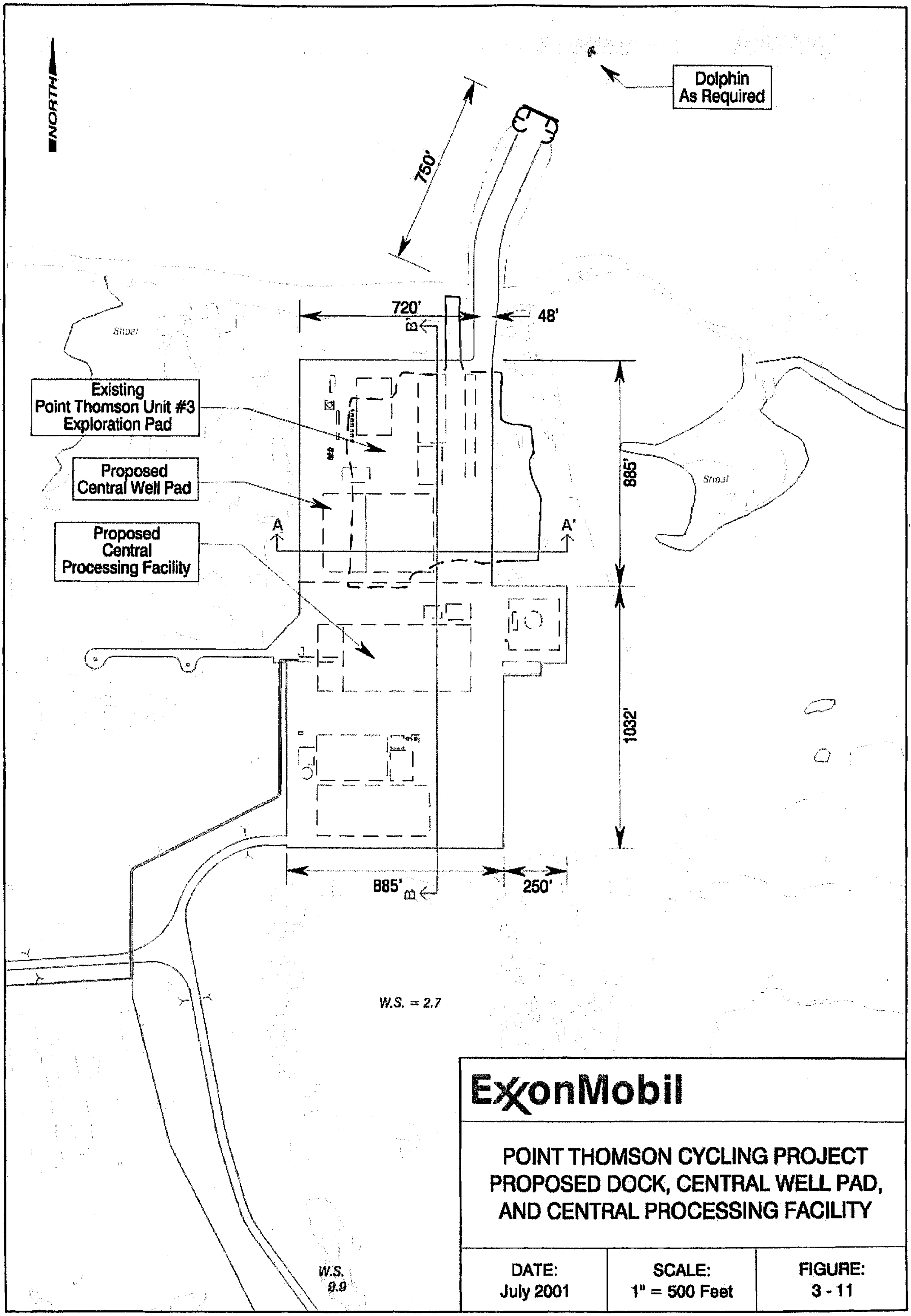
A dock will be used for delivery of drilling rigs and major sealifted facilities modules. It is also the most effective means of supplying large quantities of bulk materials during construction, drilling, and operations phases. It is also important for providing spill response capabilities. Facilities studies have concluded that the dock should be capable of landing barges transporting CPF modules weighing up to 6,000 tons (5,443 metric tons). This requires approximately 9 ft (3 m) of water depth. Figure 3-11 shows the dock in relation to the CWP and CPF Pad.

There are many economic, technical, and environmental issues related to the dock and its construction. The alternatives associated with dock construction are analyzed in Section 2.3.1. Analysis of various dock options concluded that a 750-ft (229-m) long dock reaching 7 ft (2 m) water depth combined with dredging to a water depth of 9 ft (3 m) at the dock face was the preferred alternative to provide this capability.

The dock will consist of a 750-ft (229-m) long by 100-ft (30-m) wide armored gravel fill structure. The dockhead will be 150-ft (46-m) by 100-ft (30-m) complete with sheet piling, cell walls, fenders, bollards, and face beams. Approximately 100,000 cy (76,500 m^3) of gravel are required for dock construction. It will be constructed during the first winter. Figures 3-12 and 3-13 provide dock plan view and cross section, respectively.

The following summer, a channel will be dredged to the 9-ft (3-m) isobath to accommodate unloading of the 6,000-ton (5,443 metric ton) modules. The shallow dredged area, shown in Figure 3-12, is estimated to be approximately 1,000 ft by 400 ft (305 m by 122 m). One or two 10 to 12 in (25 to 30 cm) suction dredges will be used to conduct the dredging process. The spoils [up to 30,000 cy (22,940 m^3) will be loaded onto barges for disposal at sea.

This page intentionally left blank

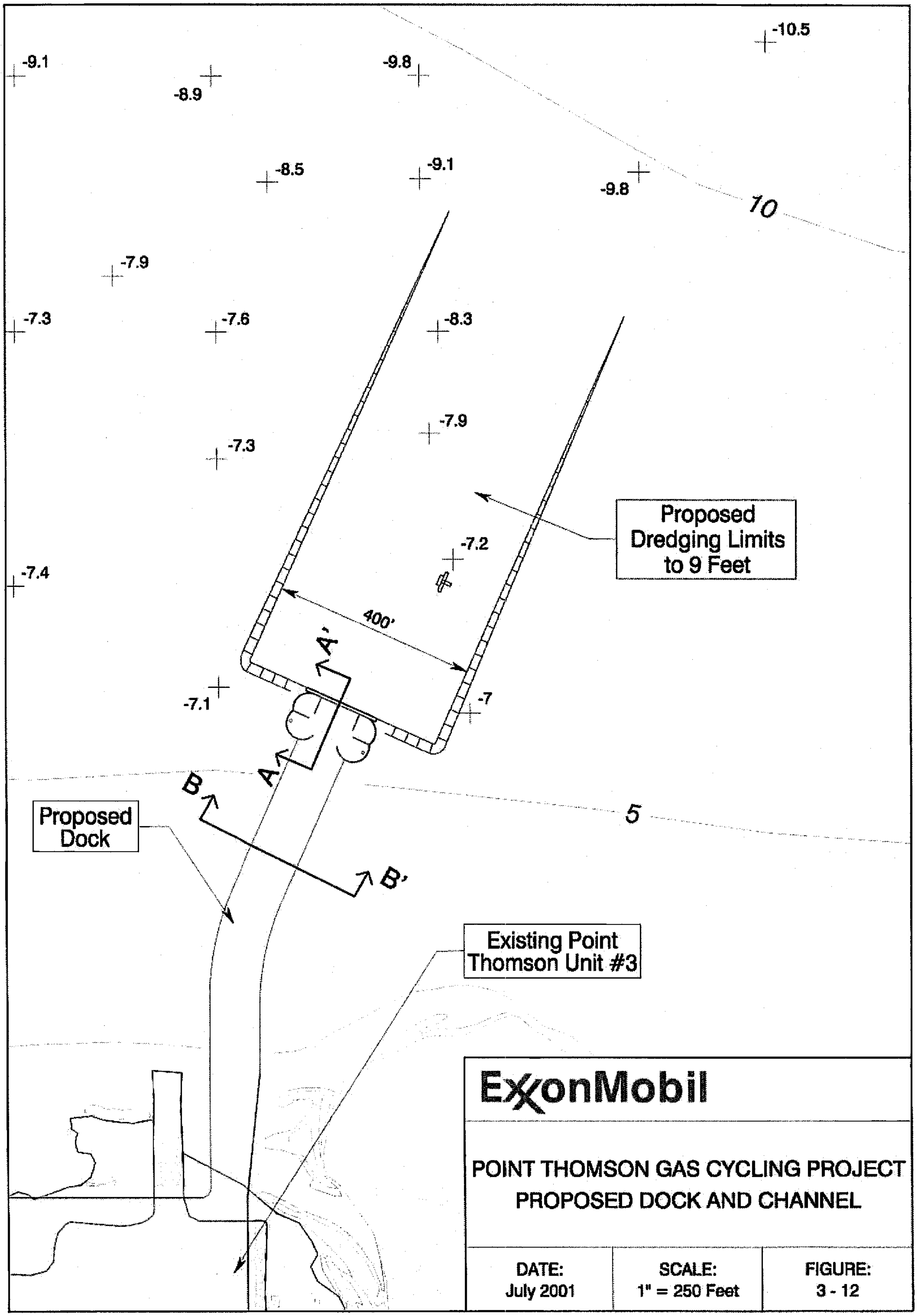


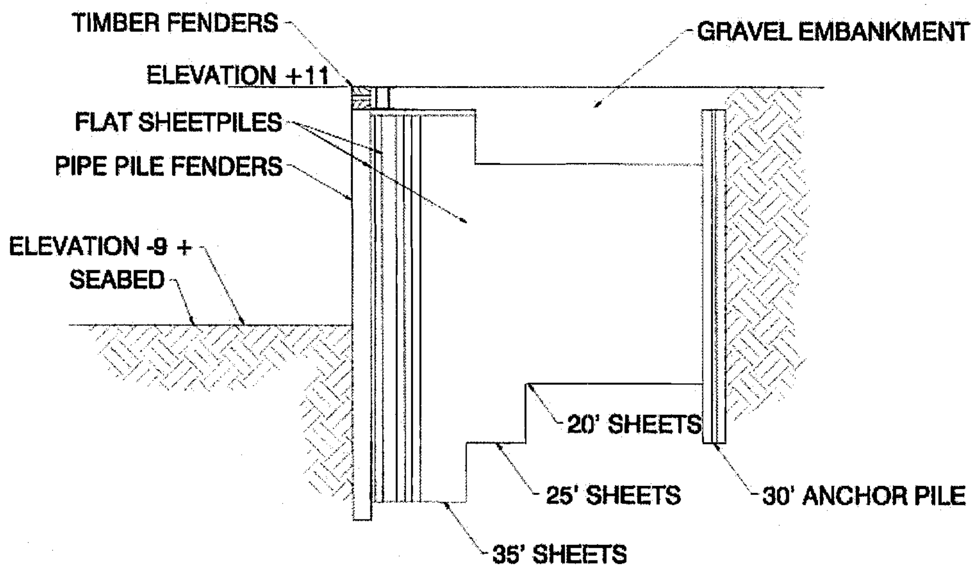
ExxonMobil

POINT THOMSON CYCLING PROJECT
PROPOSED DOCK, CENTRAL WELL PAD,
AND CENTRAL PROCESSING FACILITY

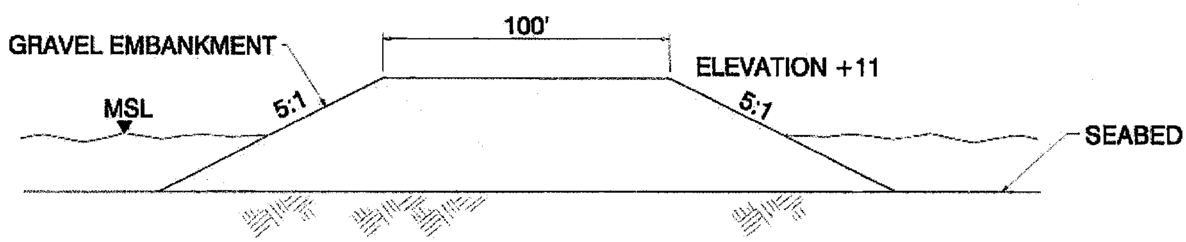
DATE:	SCALE:	FIGURE:
July 2001	1" = 500 Feet	3 - 11

ex14464plan.dgn


-10.5
-9.1
-8.9
-9.8
-8.5
-9.1
-9.8
10
-7.9
-7.3
-7.6
-8.3
-7.9
-7.3
Proposed
Dredging Limits
to 9 Feet
-7.2
-7.4
400'
A'
-7.1
-7
A
B
5
Proposed
Dock
B'
Existing Point
Thomson Unit #3
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
PROPOSED DOCK AND CHANNEL
DATE:
July 2001
SCALE:
1" = 250 Feet
FIGURE:
3 - 12



SECTION A



SECTION B

ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
DOCK CROSS-SECTION

DATE:	SCALE:	FIGURE:
July 2001	Not To Scale	3 - 13

3.6 GRAVEL PADS

3.6.1 General

Before any permanent facility construction or drilling can take place, gravel work pads must be constructed. They are built using gravel mined locally during the winter months, then graded and compacted during the following summer.

Pads must be of sufficient thickness to protect the underlying tundra and permafrost from thawing. Experience has shown that a finished pad thickness of 5-ft (1.5-m) is adequate for this protection. However, because construction usually takes place during winter months using frozen material, additional material is added to account for settlement and compaction that occurs during the summer following initial construction.

There are four facility/well pads and a gravel storage pad proposed for the Point Thomson Gas Cycling Project (See Figure 3-2). Two pads are for production wells, one is for gas injection and waste disposal wells, and the fourth pad serves as a location for the CPF and all related infrastructure, support equipment, and required services. A fifth pad is located adjacent to the gravel mine where gravel is stockpiled for future maintenance needs.

The nomenclature adopted for these pads is the "East and West Well Pads" for production wells; the "CPF Pad" where the Central Production Facility is located including process modules, personnel camps, and related facilities; and the "CWP", or Central Well Pad, for the injection and disposal wells. The CPF Pad and the CWP are adjacent, separated only by a common area that facilitates drainage.

Any run-off collected in this common area will be contained by berms and disposed of appropriately (see Section 3.12.1). The CWP is located approximately 200 ft (61 m) from the high water mark on the coast. The West Well Pad is 7 mi (11 km) from the CPF Pad in a north-westerly direction along the coastline; the East Well Pad is nearly 6 mi (9.6 km) south east of the CPF Pad.

The location of the pads within the Point Thomson Unit have been chosen based on a combination of environmental considerations and the requirement to reach bottom hole objectives in the Point Thomson Sands reservoir. Although most bottom hole targets are located offshore, the facilities will be located onshore and extended reach drilling, with a 20,000-ft (6,096-m) reach capability, will be used to minimize environmental impacts. In general, the West Well Pad will draw from one end of the reservoir, the East Well Pad will draw from the opposite end, and the CWP will be used to inject the gas back into the reservoir at the center.

As the project proceeds and additional information is obtained on the Point Thomson Sands reservoir an additional pad may be necessary to fully develop the reservoir. The additional pad would potentially be located about 3 to 6 mi (5 to 10 km) to the west of the West Well Pad. This pad is discussed in more detail in Section 3.6.5.

The locations of the pads for the development plan are shown on Figure 3-2. Table 3-2 lists the features of the pads, and a description of the facilities located on each pad is provided in the following sections.

Table 3-2 Summary of Gravel Pads

DESCRIPTION	APPROXIMATE SIZES
EAST WELL PAD	
Size (L X W - ft)	570 X 420 (174 m X 128 m)
No. of Wells (P = prod., I = Inj.)	7P and space for 2 future wells
Gravel Volume (cubic yard)	56,000 (43,000 m^3)
Year of Construction	1st Winter
WEST WELL PAD	
Size (L X W - ft)	550 X 410 (167 m X 125 m)
No. of Wells (P = prod., I = Inj.)	6P and space for 2 future wells
Gravel Volume (cubic yard)	53,000 (40,500 m^3)
Year of Construction	1st Winter
CENTRAL WELL PAD (includes portions of the 50-ft Dock Road)	
Size (L X W - ft)	885 X 768 (270 m X 234 m)
No. of Wells (P = prod., I = Inj., D = Disposal.)	8I, 1D and space for 2 future wells
Gravel Volume (cubic yard)	155,000 (119,000 m^3)
Year of Construction	1st Winter
CPF PAD (includes portions of the 50-ft Dock Road)	
Size (L X W - ft)	1,030 X 885 (313 m X 270 m)
No. of Wells (P = prod., I = Inj.)	N/A
Gravel Volume (cubic yard)	238,000 (181,000 m^3)
Year of Construction	1st Winter
GRAVEL STORAGE PAD/ MAINTENANCE STOCKPILE	
Size (L X W – ft)	700 X 700 (213 m X 213 m)
Gravel Volume (cubic yard)	200,000 (153,000 m^3)
Year of Construction	1st Winter

3.6.2 CPF Pad

The CPF Pad is the largest of the gravel pads and the location for the Central Production Facility which includes the main gas processing modules and related support and infrastructure facilities.

Figure 3-14A provides the plan view and Figure 3-14B shows the cross section of the CPF Pad. Some of the significant features of this pad are:

- Approximate area of 21 acres (85,000 square meters [m^2]),
- Finished (compacted) thickness is 5 ft (1.5 m),
- Constructed during the first winter's construction season, and
- Graded to provide drainage to one end – common with the CWP.

3.6.3 Central Well Pad

The CWP is located adjacent to and directly north of the CPF Pad. It contains the gas injection wells, the G&I facility, an electrical building, an early fuel gas treating facility, and storage areas for drilling activities.

Figures 3-15A and 3-15B provide the plan view and cross section of the CWP. Significant features of the CWP include:

- Approximate area of 15 acres (61,000 m^2),
- Incorporates existing Pt. Thomson #3 exploratory gravel pad,
- Finished (compacted) thickness is 5 ft (1.5 m),
- Constructed during the first winter's construction season at the same time the CPF Pad is constructed, and
- Graded to provide drainage to one end – common with the CPF Pad.

The Point Thomson G&I facility was designed to inject ground drill cuttings, waste mud and water from drilling activities, wastewater from construction camp and permanent camp operations, and produced water from operation of the Point Thomson facility. The G&I system will be located at the CWP and cuttings from the East and West Well Pads will be trucked to the G&I facility for processing and downhole disposal. Surface gravel from the upper holes will be washed and used for road and pad maintenance, rather than being processed at the G&I. At the drill site, the larger rock (1/8-in and bigger is allowed by permits for other recent projects) will be screened out, washed, and spread on the back slopes of existing pads and roads.

The G&I system has the capacity to grind the remaining cuttings to a 20 mesh size. Each mill train is capable of grinding approximately 6 cubic yards (cy) of rock per hour, which is more than 100 percent (%)of the volume of material expected. It is estimated that approximately 1.1 cy (0.84 m^3) of rock per hour will be produced from each drilling rig operation at Point Thomson.

Grinding and injection is generally performed in batches with a fixed volume ground up and converted to slurry for injection. The slurry injection pumps with capacities of approximately 125 gallons per minute (473 liters per minute) and maximum discharge pressures of approximately 5,000 pounds per square inch (psi) (3,515,000 kilograms per square meter [kg/m^2]) are typically used (Actual injection pressures of 3,000 psi [2,109,000 kg/m^2] are normal).

3.6.4 East and West Well Pads

These pads are both production well pads. The West Well Pad is located approximately 7 mi (11 km) northwest of the CPF Pad; the East Well Pad approximately 6 mi (9 km) southeast. Figure 3-16 shows the plan view for the East Well Pad and Figure 3-17 shows the plan view for the West Well Pad. Significant features and approximate dimensions of the East and West Well Pads include:

- West Well Pad which can accommodate up to eight wells is approximately 5 acres (20,200 m^2);
- East Well Pad which can accommodate up to nine wells is about 6 acres (24,000 m^2);
- Finished (compacted) thickness is 5 ft (1.5 m);
- Constructed during the first winter's construction season at the same time the CPF Pad is constructed; and
- Graded to provide drainage to one side.

3.6.5 Far West Well Pad

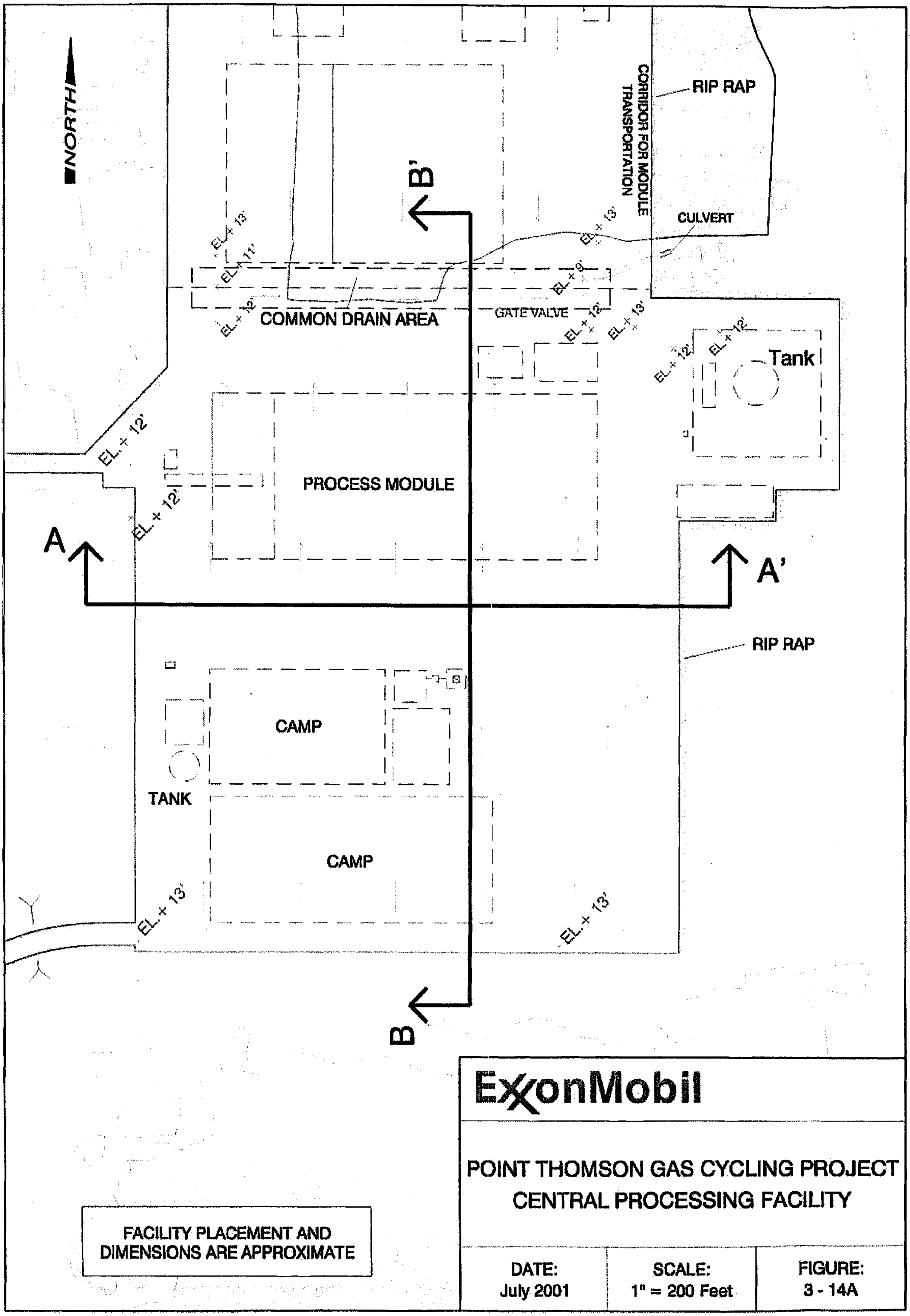
A potential additional production well pad location has been identified approximately 3 to 6 mi (5 to 10 km) further to the west from the West Well Pad. This Far West Well Pad would be approximately 5 acres (20,200 m^2) and accommodate possibly four to six wells. Although current plans do not include drilling and development for this pad, it may be determined that additional wells from this pad are necessary for optimum development of the reservoir. Should such a location prove necessary the road and pipeline systems would be extended to join this pad.

3.6.6 Maintenance Gravel Stockpile/Pad

A stockpile of gravel will be required to provide for maintenance of gravel roads and pads. This stockpile is created during the first winter's gravel mining operation. It is necessary to do this during the initial mining phases because it is anticipated that the gravel mine will flood with water following the first winter and become abandoned to further gravel mining.

The size of the stockpile is planned to be approximately 200,000 cy (153,000 m^3). This amount should be large enough to maintain road and pad systems for at least 20 years. Historically, the quantity has been estimated to be 10 to 15% of the total gravel requirement for the project.

A secondary use of the large gravel surface provided by the stockpile is to serve as a storage area. This will be particularly useful during the drilling phase of the project. The gravel storage pad will be immediately adjacent and north of the proposed mine site, with the west side of the pad adjoining the CPF/airstrip infield road. The gravel storage pad will cover approximately 11 acres (44,500 m^2).

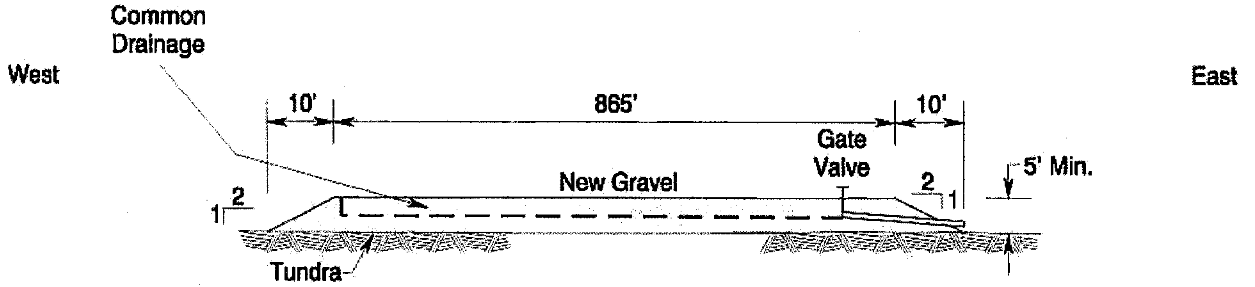


ExxonMobil

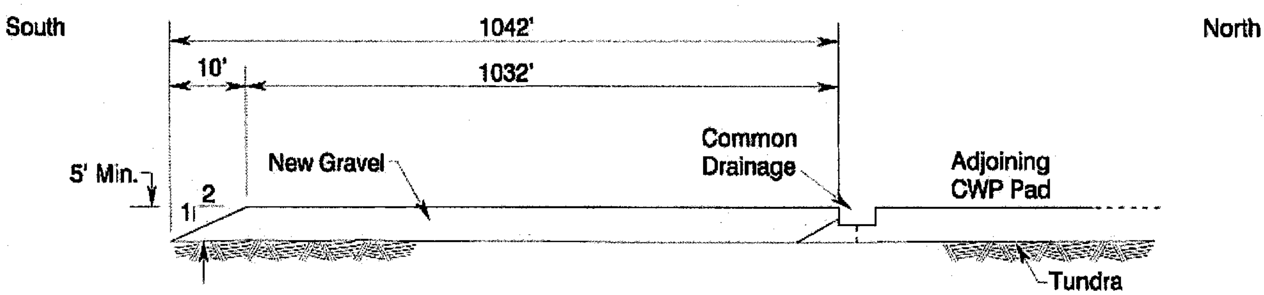
POINT THOMSON GAS CYCLING PROJECT
CENTRAL PROCESSING FACILITY

DATE:	SCALE:	FIGURE:
July 2001	1" = 200 Feet	3 - 14A

fig3 14a.dgn



Section A - A'



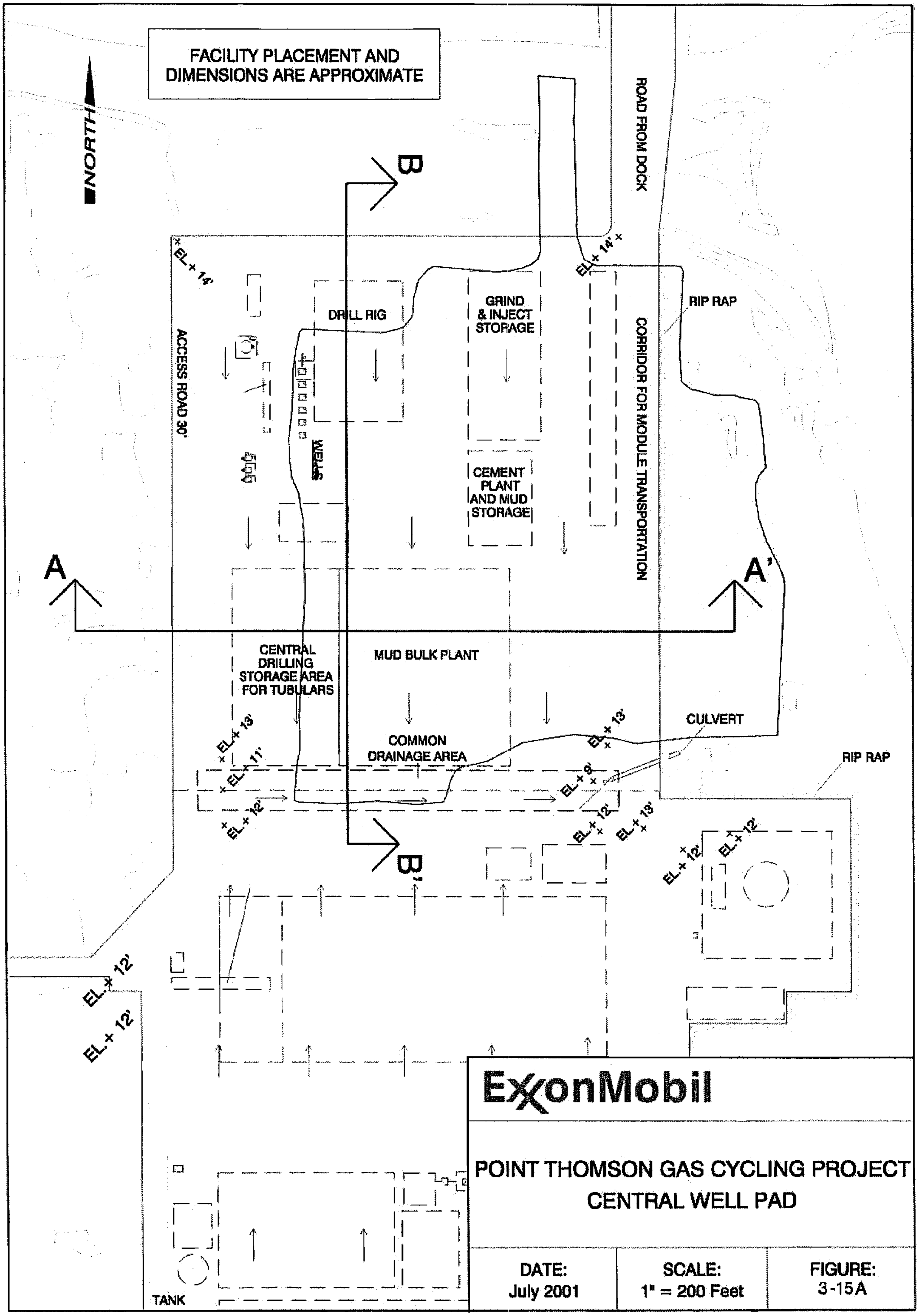
Section B - B'

ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
CENTRAL PROCESSING FACILITY PAD
CROSS - SECTIONS

DATE:	SCALE:	FIGURE:
July 2001	NOT TO SCALE	3-14B

ex14464cross.dgn

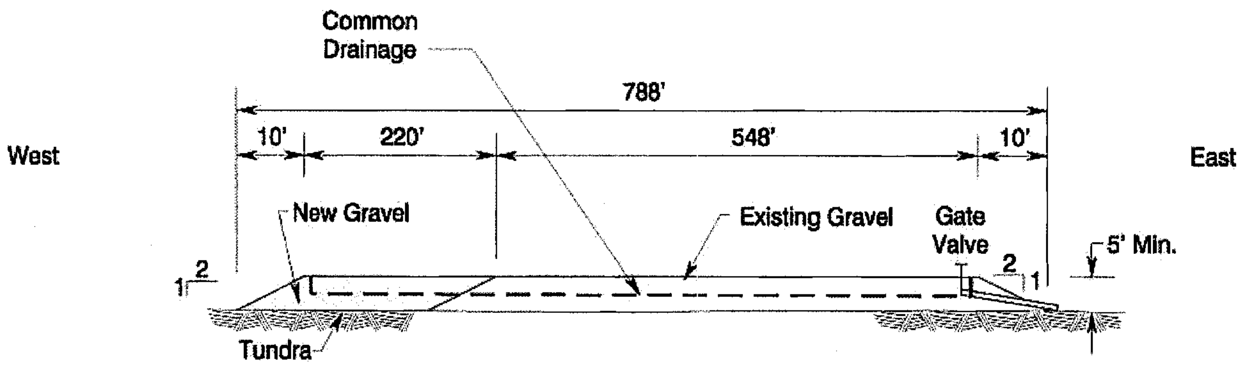


ExxonMobil

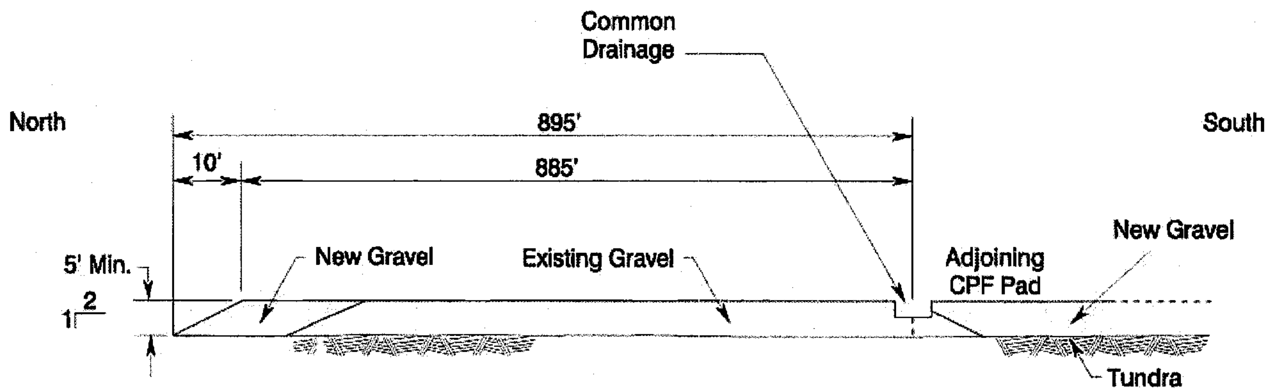
POINT THOMSON GAS CYCLING PROJECT
CENTRAL WELL PAD

DATE:	SCALE:	FIGURE:
July 2001	1" = 200 Feet	3-15A

fig3 15a.dgn



Section A - A'



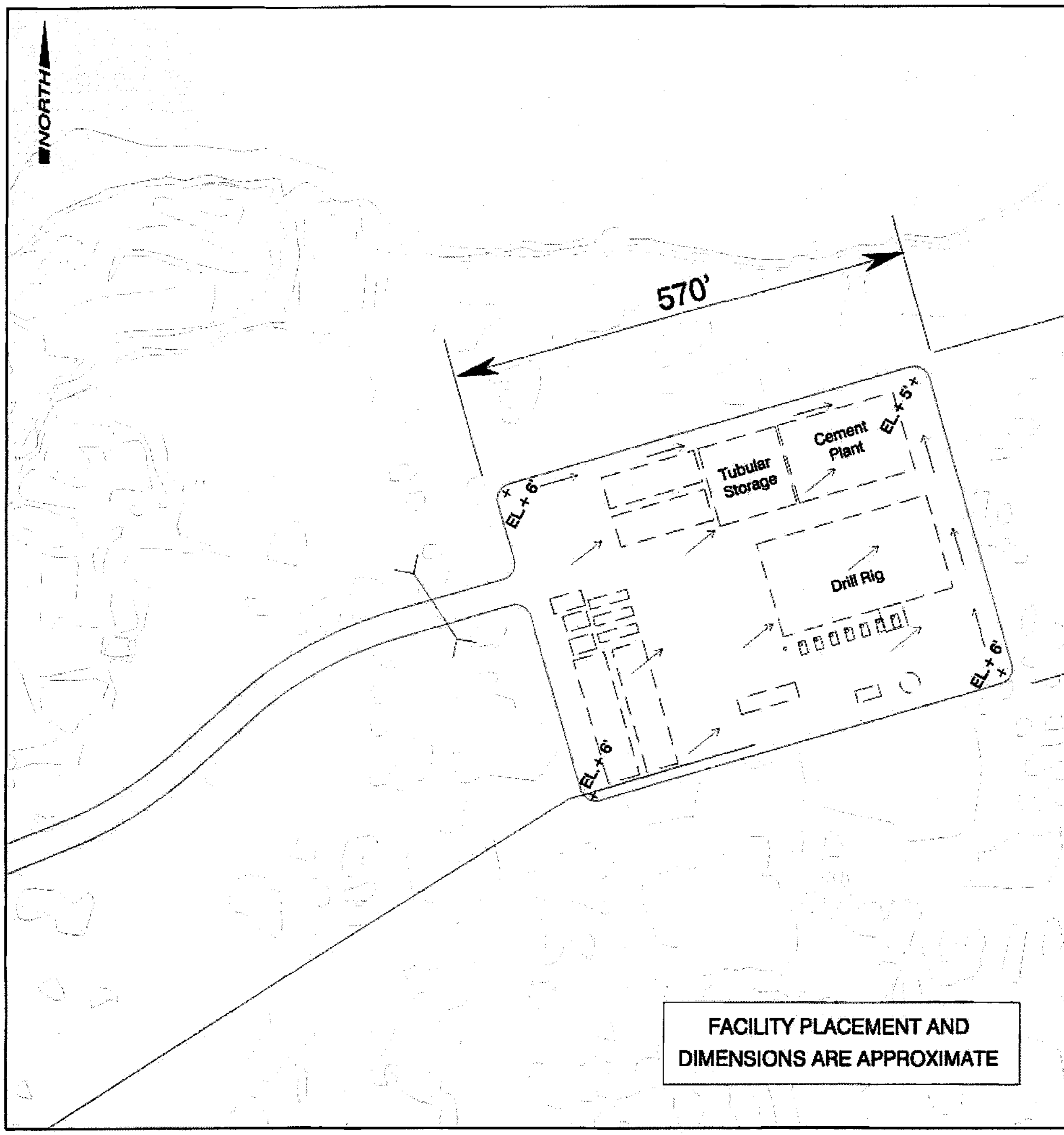
Section B - B'

ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
CENTRAL WELL PAD
CROSS - SECTIONS

DATE:	SCALE:	FIGURE:
July 2001	NOT TO SCALE	3-15B

ex14464cross.dgn

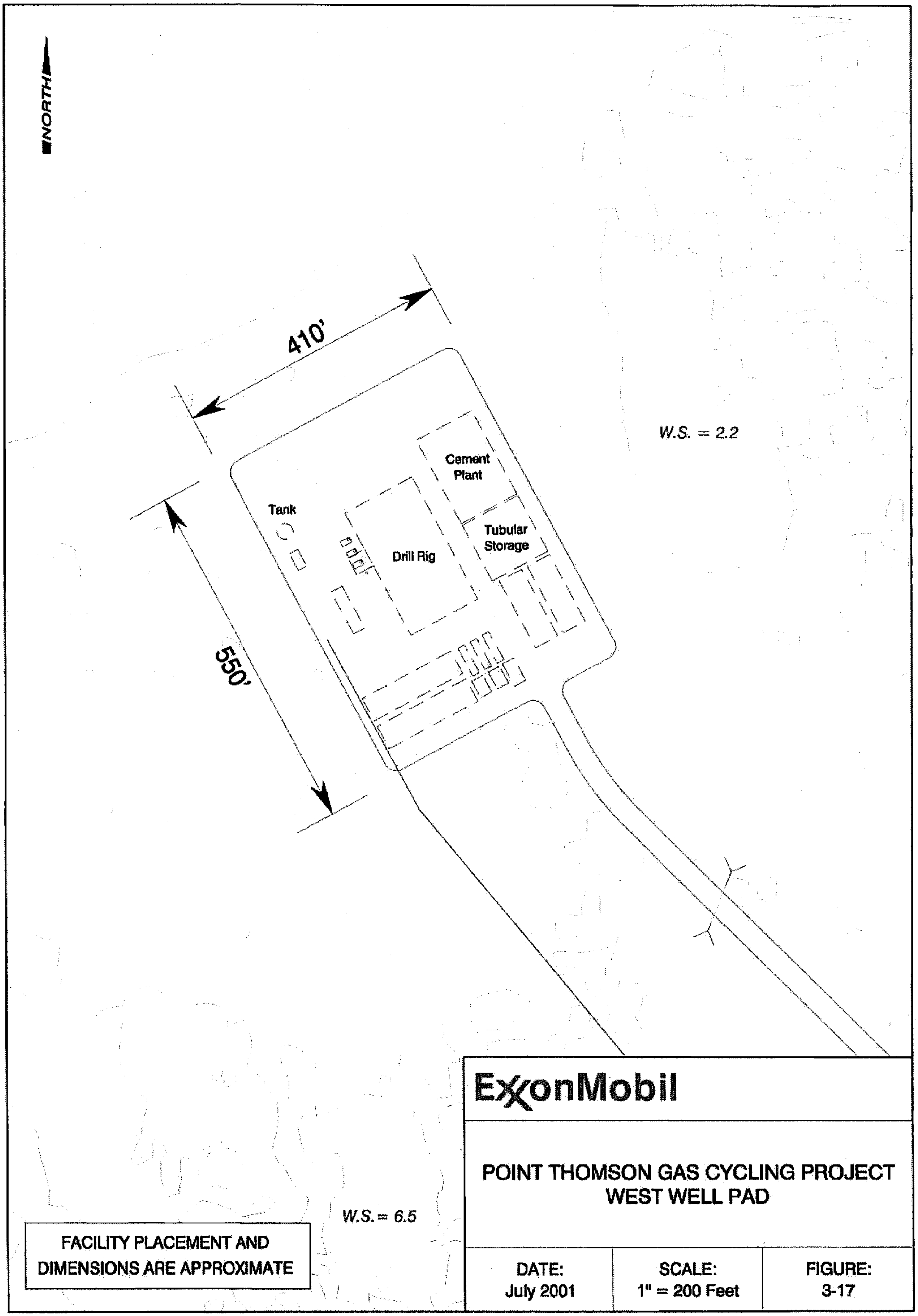


ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
EAST WELL PAD

DATE:	SCALE:	FIGURE:
July 2001	1" = 300 Feet	3 - 16

ex14464plan.dgn



ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
WEST WELL PAD

DATE:	SCALE:	FIGURE:
July 2001	1" = 200 Feet	3-17

ex14464plan.dgn

3.7 GRAVEL SOURCES

Potential gravel sources for new roads and pads are analyzed in Section 2.5 of this Environmental Report. The GM-2 gravel mine option is currently the preferred location for obtaining gravel for use in construction of the Point Thomson Gas Cycling Project.

Section 2.5 also analyzes the reuse of gravel from existing abandoned pads in the Point Thomson area. Site assessments of the existing pads will be conducted to determine the suitability of the sites for gravel reuse. Pt. Thomson Unit #3 is located at the proposed location of the CWP and will be reused *in situ* during the construction of the new pad.

Approximately 2,000,000 cy (1,529,110 m^3) of gravel and 470,000 cy (359,340 m^3) of tundra overburden are anticipated to be removed from the 38.9 acre (157,400 m^2) mine site. Use of recycled gravel from other locations (see Section 2.5.3) may reduce these volumes. The proposed mine site will be located approximately 220 ft (67 m) east of the CPF/Airstrip infield road and connected with this road by a short (220 ft [67 m]) access road located at the extreme north end of the mine site. Figures 3-18A and 3-18B show the plan view and cross section of the proposed gravel mine site, respectively. At this point in time, mitigating measures for impacts associated with mine site development are currently being developed. These will be refined and selected based on continued agency consultation.

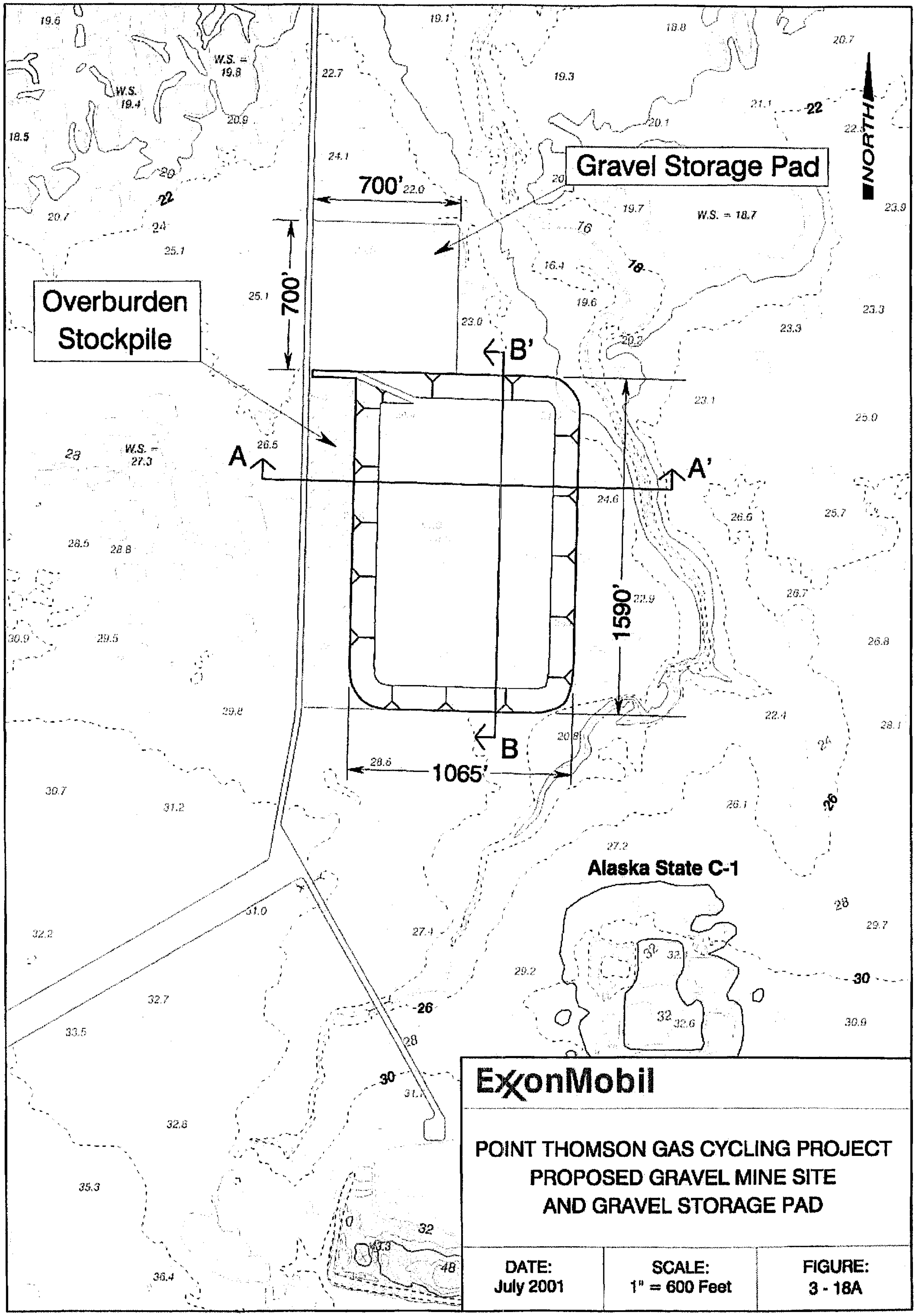
The excavation pit will be mined on a one-time basis throughout the first winter construction season. Previous geotechnical investigations determined that the tundra organics (i.e. peat) and silt overburden is approximately 3.5 ft (1 m) to 12 ft (3.6 m) thick within the preferred gravel mine site (D. Miller & Associates 2000). It is anticipated that construction grade gravel extends throughout the site to a depth of 30 ft (9 m) to 40 ft (12 m).

Approximately 470,000 cy (359,340 m^3) of tundra organics (peat) and silt overburden will be removed and placed in a 220-ft (67 m) by 1,590-ft (485 m) stockpile located immediately adjacent to the west side of the gravel mine site, as shown in Figure 3-18A. The anticipated maximum height of the overburden stockpile is estimated to be 30 ft (9 m). It is anticipated that the majority of the overburden will remain as stockpiled material to support future restoration efforts; however, a portion of the stockpiled overburden could be returned to the mine site excavation immediately prior to completion of the mining operations.

Blasting is anticipated to be conducted in 20-ft (6 m) lifts to loosen the material for use as construction material. Excavation within the gravel pit may extend to a maximum depth of 60 ft (18 m) below the original ground surface (21 to 28 ft [6.4 to 8.5 m] above mean sea level), depending on the total gravel volume requirements and the quality of available material.

Once the gravel extraction activity is completed, it is anticipated that the mine site will fill with water during spring breakup, and provide an additional freshwater source for continued use throughout the project life span.

This page intentionally left blank

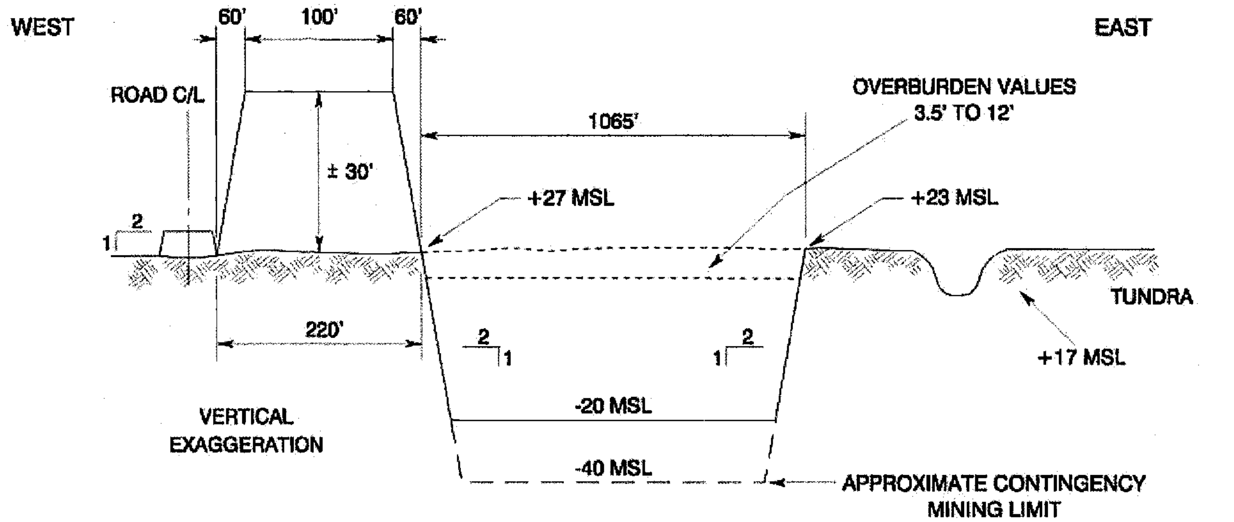


ExxonMobil

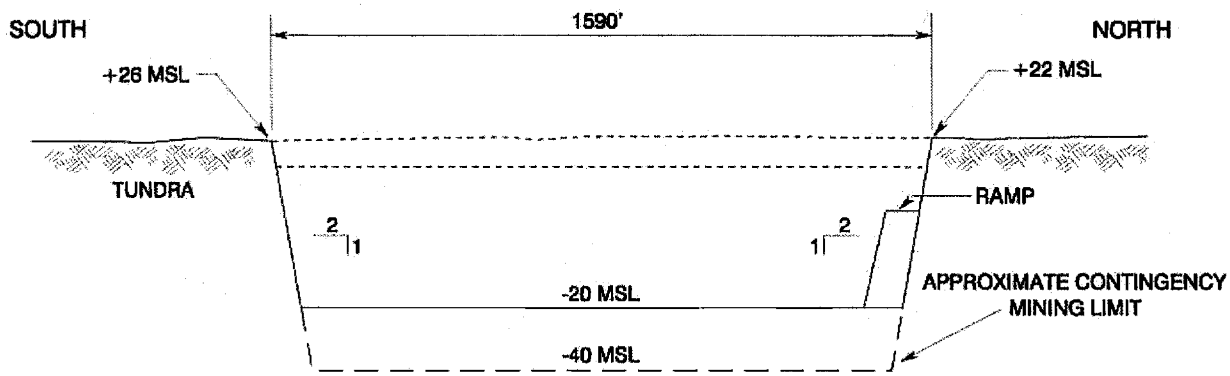
POINT THOMSON GAS CYCLING PROJECT
PROPOSED GRAVEL MINE SITE
AND GRAVEL STORAGE PAD

DATE:	SCALE:	FIGURE:
July 2001	1" = 600 Feet	3 - 18A

fig3_18a.dgn



SECTION A - A'

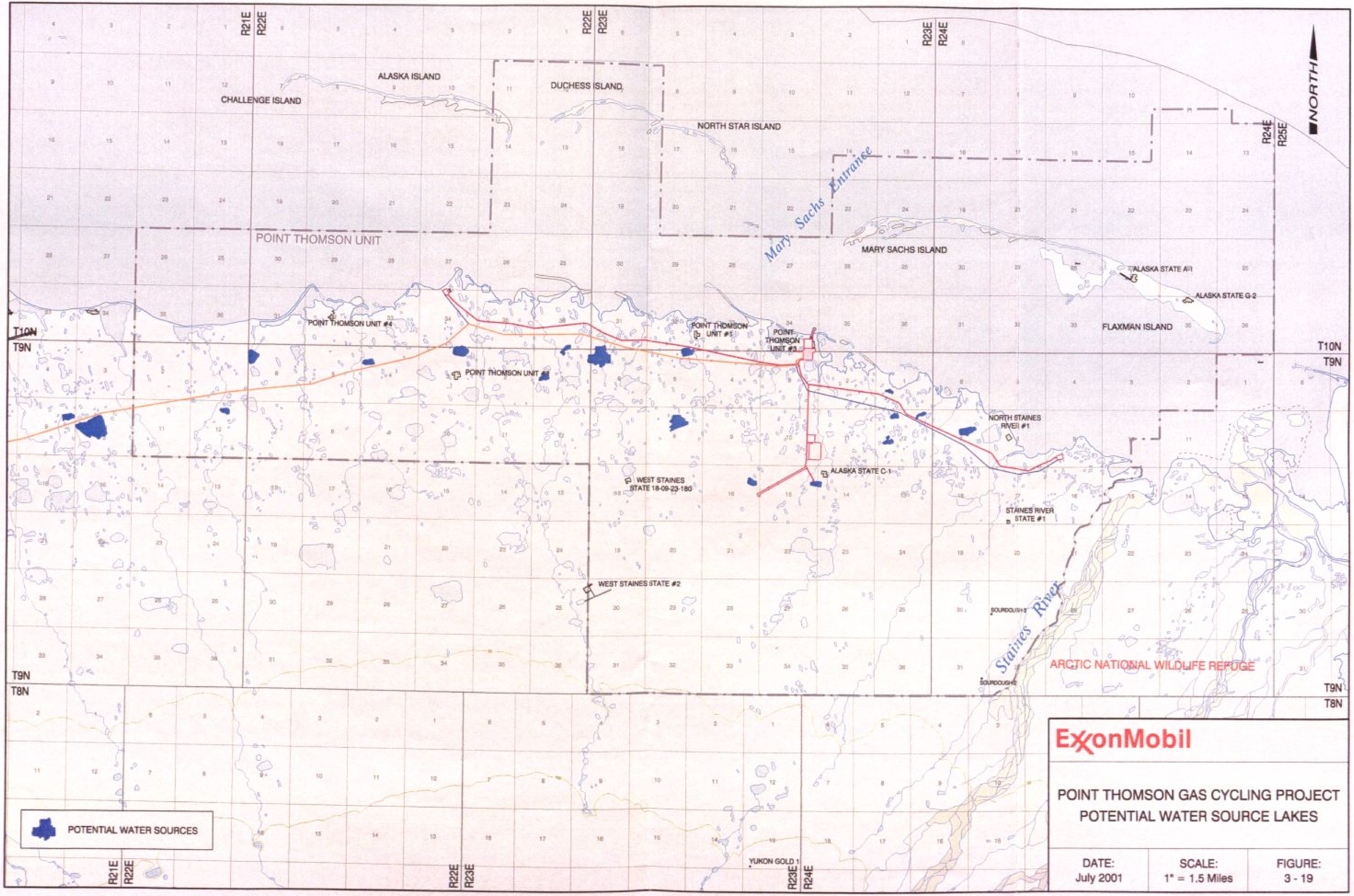


SECTION B - B'

ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
PROPOSED MINE SITE
CROSS SECTIONS

DATE:	SCALE:	FIGURE:
July 2001		3 - 18B



ALASKA ISLAND
CHALLENGE ISLAND
DUCHESS ISLAND
NORTH STAR ISLAND
Mary Sachs Entrance
POINT THOMSON UNIT
MARY SACHS ISLAND
ALASKA STATE A-1
ALASKA STATE G-2
FLAXMAN ISLAND
POINT THOMSON UNIT #4
POINT THOMSON UNIT #1
POINT THOMSON UNIT #3
POINT THOMSON UNIT #2
NORTH STAINES RIVER #1
ALASKA STATE C-1
WEST STAINES STATE 18-09-23-180
STAINES RIVER STATE #1
WEST STAINES STATE #2
Staines River
ARCTIC NATIONAL WILDLIFE REFUGE
YUKON GOLD 1
T10N
T9N
T8N
R21E
R22E
R23E
R24E
R25E
NORTH
POTENTIAL WATER SOURCES
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
POTENTIAL WATER SOURCE LAKES
DATE: July 2001
SCALE: 1" = 1.5 Miles
FIGURE: 3 - 19

fig3_19.dgn

3.8 FIELD FACILITIES

Wells, equipment, modules, buildings, and other infrastructure facilities located on the pads will be constructed or assembled over a two-year period. Initially, those components required to support the drilling and construction activities will be installed, followed by operation facilities.

3.8.1 Central Production Facility

3.8.1.1 Process Facilities, Pipelines, and Other Infrastructure

The processing modules, storage tanks, living quarters, and utility modules are located on the CPF Pad. The CPF Pad is the terminal end of the gathering pipelines and the origination point for the export condensate pipeline. High-pressure gas pipelines and utility lines extend northward for approximately 1,000 ft (305 m) to the CWP. High and low pressure flare lines connect to the flares located directly to the west of the CPF pad. Other infrastructure also located at the CPF includes the emergency and normal power generators, control room, warehouse and shops, operations and construction camps, and related storage and utilities.

A simplified flow diagram showing the basic CPF process was shown on Figure 3-1. Major rotating equipment includes injection compressor trains driven by three (3) gas turbines [approximately 50,000 horsepower each], flash gas compression (two trains of turbine-driven centrifugal compression), and product shipping pumps (three pumps sized for 50-percent capacity each). Other equipment includes a fired process heater, high-pressure aerial coolers for inlet, interstage, process and utilities cooling, separators, scrubbers, a condensate stabilizer, and an electrostatic treater.

3.8.1.2 Flare System

The bulk of the flammable fluid in the Point Thomson gathering system, plant, and gas injection system is natural gas. The flare system is used to safely burn gases which may occasionally need to be released when pipelines and facilities are depressurized for maintenance or when there is a temporary facilities upset. Depressurization and flaring might also be necessary if there is an emergency in the facility. Vented gas first flows to flare knock-out drums where liquids are separated prior to the gas being sent to the flare. There are two separate flare systems one for high pressure gases and one for low pressure gases. Emissions from the flare events are expected to consist mostly of methane, with small amounts of propane and carbon dioxide. Noise associated with high flare rate excursions is expected to be similar to that generated at other North Slope operations.

Gas flaring is limited to serious plant emergencies and when necessitated by maintenance. Two flare scenarios are assumed: maximum and typical. The maximum gas flow rate to the flare system is in the order of 1.5 billion cubic ft per day (42.5 million cubic meters per day). This scenario represents an abnormal emergency situation where gas is being vented at high rates from the gathering and injection pipelines and/or the plant vessels and piping. These are likely to be very rare events. The typical flare scenario represents minimal flaring at times when a single compression train is removed from service for routine or unplanned maintenance. These events could occur several times a year, and are likely to decrease in frequency as problems with new equipment are resolved.

Only flare pilot and purge volumes are burned during normal (non-flaring) conditions. There will be little perceivable noise from this normal state. Air emissions from the pilot and purge are included in the inventory for the CPF.

High and low-pressure system flare stacks will be located just to the west of the CPF Pad. Each flare stack will be approximately 100 ft (46 m) above the ground surface. Gas and air mix at the flare tips located at the top of the stacks. The flare stack height also aids in dispersion of the combustion products and reduces ground level heat radiation. To protect humans and wildlife from entering the zone of possible heat radiation, a fence will enclose the area beneath the flare stacks.

The location of the flare stacks was selected to meet a number of criteria. First, the stacks need to be located as close to the plant site as practical in order to minimize the length and resulting pressure drop of the flare lines. Secondly, the flares are located such that the heat radiation limit at any occupied area of the plant, roads or pipeline right-of-way is maintained below a heat radiation limit of 500 British thermal units (BTU) per hour per square foot. The flares are also located downwind of the plant (based on the prevailing wind direction). Finally, the stacks are situated such that the microwave path between Point Thomson and Badami is not obstructed during flaring.

3.8.2 Central Well Pad Facilities

During the early construction phase of the project, the CWP will be used primarily to support drilling operations. A Class I disposal well, G&I facilities, drilling equipment, drilling supplies, mud plant, temporary storage pit for drill cuttings, and the early fuel gas system will all be located at the CWP. A disposal well and approximately 8 injection wells will be drilled from the CWP. Space is also required for two additional wells on the CWP in the event that additional injection well capacity is required by operations and/or additional production well(s) are drilled from this pad. High-pressure gas pipelines will transport the gas from the CPF Pad to the injection wells located at the CWP.

Wells on the CWP will be aligned in a row and spaced 20 ft (6 m) apart. Flow meters will be installed on each injection well to measure the volume of gas injected. Separate pipelines will transport treated camp gray water and produced water from facilities on the CPF to the EPA Class I Underground Injection Certification waste disposal facilities (i.e., piping manifolds and disposal pumps) on the CWP.

3.8.3 East Well Pad Facilities

The East Well Pad will have approximately seven production wells with space provided for up to two additional wells, if needed. During the drilling phase, much of the pad area will be taken up with facilities and services to support drilling. When production begins, the facilities located on this pad will include production manifolds, well metering and control facilities, an electrical building, methanol tank and injection system, and a gathering pipeline pig launcher. Production wells will be aligned in a row and spaced 20 ft (6 m) apart. This spacing is larger than that for recent non-gas projects (as low as 10 ft) simply because the well count for a gas cycling project is very low and hence, the facilities' sizes, rather than the well count, is the driving factor determining pad size. In addition, the wider well spacing helps ensure underlying permafrost integrity and provides an additional safety margin in the event of a well control incident.

Production from each well will be measured using three phase meters, and thus, a test separator is not required.

3.8.4 West Well Pad Facilities

The facilities provided on the West Well Pad are very similar to those on the East Well Pad. Differences arise due to the number of wells planned. Approximately six production wells are currently envisioned for the West Well Pad, with space provided for up to two additional wells.

3.9 PIPELINE SYSTEMS

Corrosion-resistant alloy gathering pipelines (maximum working pressure [MWP] approximately 3,600 pounds per square inch gauge (psig)) will be used to transport three-phase production fluid from the production wells to the CPF. Pig launchers and receivers are incorporated into each gathering pipeline.

High-pressure (approximately 12,500 psig MWP) carbon steel pipelines will serve to move gas from the compressors at the CPF approximately 1,000 ft (305 m) to the CWP injection well.

A carbon steel pipeline (approximately 1,415 psig MWP and approximately 22 mi [35 km] long) will be used to transport condensate from the CPF to a connection point with the existing Badami pipeline. Pig launchers and receivers are included on this pipeline. From the tie-in point, the existing 12-in (30.5-cm) Badami pipeline extends another 25 mi (40 km) to tie-in with the Endicott pipeline. The Endicott pipeline extends another 16 mi (26 km) before connecting to the Trans Alaska Pipeline System Pump Station No. 1 at Prudhoe Bay.

Approximate nominal pipeline diameters will be as follows:

- Gathering lines (Well Pads to CPF) – 18 to 24 in. (46 to 61 cm)
- Condensate export line – 12 in (30.5 cm)
- Gas injection system – 6 to 10 in. (15 to 25 cm) (number and size to be determined later)

All of these pipelines will be insulated and installed aboveground (maintaining minimum 5 ft (1.5 m) clearance to bottom of pipe) on vertical support members (VSMs). Vibration dampeners will be installed, as needed, along the pipelines to prevent wind induced vibration. These will be located either above the pipe, or below the pipe with five feet of ground clearance.

This page intentionally left blank

3.10 CONSTRUCTION PLAN

3.10.1 First Year Construction Scope

The objective of the first construction year is to have all required drilling support infrastructure in place by September 2005, the proposed start of development drilling. Scope of work includes gravel mine site development, construction of all pads, dock, and airstrip; and installation and commissioning of equipment required to support subsequent drilling operations as detailed in the previous section.

Civil construction is planned as a winter-only activity utilizing both sea and inland ice roads to minimize the tundra impact. Construction methods utilize proven conventional arctic onshore equipment and techniques. The construction schedule has been developed in consultation with Alaska-based contractors and BP Exploration (Alaska), Inc.

The majority of civil construction is expected to be complete by April 2005 with the exception of final gravel compaction and shaping activities during the June to July time frame. By late summer 2005 the dock and the airstrip are expected to be fully operational. All early infrastructure equipment will be installed and fully commissioned prior to start-up of drilling activities. Construction camps will be provided as self-contained units in terms of utilities such as water and waste treatment.

3.10.1.1 Ice Roads

Depending upon weather conditions, construction of a grounded sea ice road connecting Endicott to Point Thomson could begin late November 2004 and is expected to be completed towards late December to early January 2005. About 33 vehicle trips from Endicott to Point Thomson may be required for sea ice road construction. Up to 28 vehicle trips per day are expected on this road during the first year's construction to transport heavy equipment, construction camps, and personnel to the site.

The inland ice road runs from the dock location to the mine site to facilitate mine development activities. Construction of the inland road will start once construction equipment can be mobilized to the site. Fresh water from nearby permitted lakes will be the primary source for inland ice road construction. Ice chips can also be used to reduce the amount of free water that is withdrawn from the lakes. Ice road maintenance will continue throughout the winter season. Construction crews will be located at either a re-commissioned Badami construction camp or the Prudhoe Bay area until the Point Thomson construction camp is in place.

3.10.1.2 Gravel Haul and Placement

Gravel haul and placement activities include gravel mine development to support construction of the roads, pads, airstrip, dock, and gravel stockpile for future road maintenance. Construction activity for field development will begin as soon as possible in the winter of 2004-2005. A sea ice road will be constructed to mobilize equipment and materials to the Point Thomson area.

During the winter months, the gravel mine site will be developed, and gravel from the mine will be used to construct the field facilities (pads, dock, airstrip, in-field road system). Snow and ice will be removed from the tundra surface and stored near the construction sites. Gravel will then be laid, graded, and compacted. Typical construction equipment to be used will include bulldozers, front-end loaders, rollers, trucks, and other heavy equipment. Infield traffic for gravel placement during the January to April construction period may consist of more than 300 vehicle trips per day on the gravel roads from the gravel mine to the CPF Pad, airstrip, and dock locations plus another 200 gravel haul trips per day from the CPF Pad to the East and West Well Pads.

The dock will be constructed by flooding as necessary to ground the sea ice, then removing ice in the construction area. Final dock construction (sheet piles, dock head, etc.) and gravel compaction and shaping for all areas will continue through to July 2005. Gravel will be laid on the exposed sea-bed to construct the dock.

After the spring of 2005, some thawing and subsequent settlement of the gravel structures is expected to occur. These gravel structures will be regraded and recompacted as necessary while they are thawed in the summer of 2005.

Most of the heavy construction equipment will be demobilized from the site via ice road prior to the ice road being no longer serviceable in late April or early May 2005. Remaining heavy equipment will be demobilized via barge during July and August 2005.

All equipment and modules will be transported via sea ice-road or barge depending on supply and manufacturing lead times. Both the construction camp and the permanent camp, along with the utility module, will be installed during 2005 to support simultaneous pipeline construction and drilling activities during 2006. The civil contractor will provide temporary site communications until the permanent communications tower and equipment are installed.

All early power generation equipment, including the fuel gas treatment skids, power generators, and power building will be prepackaged and either trucked or barged to the site by August 2005. Final hook-up and commissioning of this equipment will be dictated by the drilling schedule. The G&I module will be prefabricated and transported to Point Thomson by August 2005.

3.10.1.3 Nearshore Dredging

As described previously, it will be necessary to dredge a shallow (1-2 ft) channel extending about 1,000 ft (305 m) from the end of the dock to the 9-ft (3-m) isobath. The dredging will be conducted during the summer after the first winter construction period (2005). One or two 10 to 12 in (25 to 30 cm) suction dredges will be shipped to Prudhoe Bay. As soon as possible after breakup, the dredges will be transported by barge to the Point Thomson area and dredging activities will commence. The operation is expected to take from 3 to 4 weeks and will be completed prior to the beginning of the fall whale hunt and associated offshore travel restrictions. Up to 30,000 cy (23,000 m^3) of spoils removed during dredging will be placed on several barges and transported to a permitted offshore dumpsite, planned to be located seaward of the barrier island complex.

3.10.2 Second Year Construction Scope

The objective of the second construction year is to install and commission all pipelines, the CPF modules, well pad facilities and remaining telecommunications and controls equipment to support fourth quarter 2006 first production. Pipeline construction is a winter-only activity utilizing both sea and inland ice roads to minimize impact to the tundra. About 70 vehicle trips per day will be required from the CPF Pad to each of the well pads and about 90 trips per day on the ice road to Badami. All pipelines are installed aboveground using VSMs. Other than possibly hydrostatic testing and caliper pigging activities, no summer construction work is planned for the pipelines. The construction schedule has been developed with input by, and consultation with, an Alaska-based contractor.

Construction workforce is expected to peak during the second quarter 2006 with simultaneous drilling operations, pipeline construction, and civil construction works for the CPF modules. Should actual workforce requirements exceed the combined construction and permanent camp facilities capacity, the Badami construction camp can serve as overflow contingency along with other available facilities in the Deadhorse area.

3.10.2.1 Second Year Ice Roads

Construction lead-time and vehicle trips for the sea ice road is similar to that of the first year, beginning November 2005, weather permitting, and completing towards early January 2006. Up to 36 vehicle trips per day are expected on this road to support pipeline construction and drilling in the second year.

Construction of the inland ice roads for both the infield gathering lines and export condensate pipeline is expected to begin mid-January 2006 based on the anticipated opening date for tundra travel, and will be complete by mid-February 2006. Construction of the ice road may require up to 75 vehicle trips per day from the CPF Pad to Badami.

Pipeline construction is planned to begin mid-January 2006 and finish by April 2006. Scope of work includes the gathering pipelines from both the East and West Well Pads, high-pressure gas pipelines from the CPF to the CWP Pad, and condensate export pipeline from the CPF Pad to the Badami tie-in. The gathering and export pipelines will be constructed simultaneously using proven conventional arctic onshore equipment and techniques.

The sales pipeline will be pre-insulated offsite and transported to the site by ice roads. All other pipeline materials (VSMs, piperacks, pipe spools, pig launch and receiver skids, etc.) will be prefabricated and trucked to Point Thomson beginning January 2006.

No field camps will be required on the pipeline right of way. Pipeline construction personnel will be housed in a temporary construction camp installed on the Point Thomson CPF Pad (Section 3.10.3). Warm-up shacks and on-site toilet facilities will be provided along the construction right-of-way and will be removed when construction is complete in spring 2006.

A firm plan has not been established for hydrostatic testing and caliper pigging of the pipeline. These activities may be performed during the summer and fall months prior to initiation of production if not completed during the winter construction. Three scenarios are being considered:

- Drawing fresh water from local water sources, filter and dispose to tundra after hydrotest.
- Use seawater, filter and dispose back to ocean after test.
- Use Glycol water mixture; after use dispose in the Point Thomson disposal well or send back to Prudhoe to recycle.

3.10.2.2 Truckable Skids for Well Pad and CPF

The smaller sized facilities and infrastructure installed prior to the major facilities sealift in 2006 will be prefabricated and assembled into truckable skids and transported to Prudhoe Bay by truck and then by truck (sea ice road) or barge to the site. Examples of equipment and facilites delivered in this fashion include:

- Pipe rack modules,
- Well metering/manifold skids,
- Pig launcher/receiver skids,
- Well lines,
- Methanol tanks and injection skids,
- G&I module,
- Control Systems, and
- All yard piping and electrical.

Concurrent construction and drilling activities will take place during installation of the well pad modules. The strategy is to have as much of equipment installed as feasible prior to the arrival of the CPF modules to minimize the time required to first production. This will also serve to level the onsite construction manpower.

3.10.2.3 CPF Modules

Process modules will be sea-lifted and are expected to arrive at the Point Thomson dock by August 15, 2006 assuming timely open-water access to the Beaufort Sea. Three months has been allocated as the minimum time needed to install and commission the first production train to support first production startup by fourth quarter, 2006. The facility will be in full production when the drilling program is completed.

3.10.3 Construction Camp

The Point Thomson camp will be installed in the winter 2004-2005. The construction camp will be a self-contained unit with its own utility services such as water and wastewater treatment. Waste management is discussed in Section 3.12. The camp may be leased from the existing North Slope inventory of old construction camps or a new one may be purchased.

The camp will be trucked to the site on sea ice roads in stages as required. The construction camp will be built in stages to the ultimate projected peak requirement of 450-person capacity. The camp will be designed to accommodate both men and women.

3.11 SPILL PREVENTION AND RESPONSE

The Oil Discharge Prevention and Contingency Plan (C-Plan) will be developed to cover all site operations and spill response considerations. The C-Plan will include:

- A spill prevention section to cover facility and pipeline operations;
- Identification of spill response equipment to be staged and/or deployed at sensitive areas along the pipeline route (primarily river crossings);
- Equipment to be staged at the facility; and
- Spill prevention and response considerations for a remote facility that processes natural gas and condensate.

Operations cannot commence until the C-Plan is approved by the Alaska Department of Environmental Conservation (ADEC).

This page intentionally left blank

3.12 WASTE MANAGEMENT

All waste disposal procedures will conform to ADEC and EPA requirements. Project design goals are to minimize the use of freshwater and other environmental resources, and to ensure a zero drilling waste release into the environment.

3.12.1 Discharges

Liquid waste is to be disposed of in the disposal well and all solid waste is to be incinerated (where practical) and anything not burned is to be containerized and shipped to a suitable disposal site in Deadhorse or elsewhere. Domestic wastewater from the camp and collected stormwater runoff will be injected into the disposal well. Prior to drilling the disposal well, and should the well become inoperable, domestic wastes will be discharged to the tundra following permit requirements.

3.12.2 Wastes Generated

The majority of wastes generated during project construction will consist of drill cuttings and spent muds. Some drilling waste will also be generated during operations from well workover rigs. A temporary storage pit will be constructed to store the drilling cuttings until the Class 1 well is drilled and operational. In addition, this pit will provide temporary storage for the cuttings when the G&I facility is undergoing equipment repair. A critical factor for implementing the zero drilling discharge philosophy will be to grind any suitable solid or liquid waste and inject it down the disposal well. The G&I facility will contain systems for washing, classifying, screening, mixing, and injecting the solid and liquid waste. Drill cuttings obtained from installation of the surface casing will be washed and screened prior to injection. The larger particles may be retained as fill material (if clean) and the smaller particles, wash water, and fines will be transported to the onsite G&I facility for injection.

Domestic wastewater will be generated during both the construction and operations phases. During construction, a wastewater treatment system will be part of the construction camp (see Section 3.10.3). However, once the injection well is operational, domestic wastewater from the construction camp, and later the operations camp, will be injected. The volumes of camp sanitary and domestic waste expected to be generated has been estimated at 30,000 gallons per day (gpd) (114,000 liters per day) during the drilling phase and 7,500 gpd (28,400 liters per day) during the operating phase. If the injection well becomes temporarily unoperational, the wastewater will be discharged according to the appropriate permits.

In addition to the injectable wastes described above, solid wastes, including scrap metal and incinerator ash, will be generated during construction. These wastes along with trash and rubbish generated during operations, and will be hauled off-site for disposal at the North Slope Borough (NSB) landfill. Combustible wastes will be taken to the NSB incinerator or incinerated on-site. Waste lubricating oil will be packaged in drums for shipment to an approved recycling facility. Sewage sludge and combustible solid waste including kitchen waste will be incinerated on-site. The incinerator ash will be screened to remove any large pieces of unburned material and the fines will be disposed of using the on-site G&I facility. Only non-combustible, non-hazardous solid waste will be stored and transported off-site for disposal at the NSB waste disposal facility. Solid waste transportation could be by barge during open water, and by truck during winter on ice roads, and/or by aircraft.

Table 3-3 provides a summary of the expected per waste streams for the three train case.

Table 3-3 Waste Streams for the Three Train Case

DRILLING PHASE[1]			
Waste Stream	**Average Total Vol.**	**Average Daily Vol.**	**Max Daily Vol.**
Drilling cuttings (barrels [bbls])	5,000	80	125
Drilling fluids (bbls)	4,200	75	125
Water (bbls)	42,000	600	1000
Incineratorable Solid Wastes (pounds [lbs])	14,000	200	-
Non-incineratorable Solid Wastes (lbs)	21,000	300	-
OPERATING PHASE			
Produced Water (bbls)	N/A	5000	-
Camp Wastewater (bbls)	N/A	200	-
Incineratorable Solid Wastes (lbs)	N/A	300	-
Non-incineratorable Solid Wastes (lbs)	N/A	75	-

[1]Numbers shown for one drilling rig. Volumes will double during the time that two rigs are operated.

3.12.3 Waste Handling

Wastes that must be shipped off-site will be transported via winter sea ice roads or summer barges. Any wastes generated during spring and fall (when both sea ice road and barge travel could be interrupted by breakup and freeze-up) 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.

3.13 SUPPORT FACILITIES

3.13.1 Permanent Camp

The permanent camp will be located on the CPF Pad. The camp will be prefabricated and transported to site for installation. It will accommodate approximately 75 people (peak) with provisions to house both men and women.

3.13.2 Water Sources

Figure 3-19 shows the potential water source lakes for ice road construction and other activities in the Point Thomson area. Table 3-4 summarizes the anticipated water quantities and sources required for the Point Thomson project construction and operation. Table 3-5 provides previously permitted volumes for water sources used for earlier activities in the Point Thomson area and developments to the west.

3.13.3 Power

Early power generation equipment will be installed to supply power for the drilling and construction infrastructure and life support, at a minimum. Early power generation and distribution equipment will be the same size and type as will be required for the permanent facility. Fuel gas-fired turbine generators will provide for the main power generation needs, and reciprocating diesel generators will be available for any emergency and life support requirements. Additional backup power generators will be provided with the rig, camps and by the construction contractor.

The long-term power generation system will be configured with three fuel gas (produced natural gas back flowed from an early injection well) turbine generators each sized to handle 50 % of the permanent power load. Three emergency diesel generators will be available, each able to provide for 50 % of emergency and life support power requirements.

Power feeds to the East and West Well Pads will be stepped up 13.8-kilovolt through a transformer located at the generation module (where all power generation equipment will be connected) and reduced to operating voltages via transformers located at the well pads. Where practical, the power cables feeding the well pads will be incorporated into the permanent facilities design. Some of the early power may be provided through local above ground lines, but the permanent power cables will be buried in the gravel roads.

Table 3-4 Point Thomson Gas Cycling Project Water Use Plan – CPF Facility Construction and Operation

ACTIVITY	ITEM	WATER QTY (GALLONS)	POTENTIAL SOURCE(S)[1]
Ice roads	2005 sea ice road cap[2]	33,180,000	3,870,000 gallons (gal) from source(s) in the vicinity of the Pt. Thomson CPF and west production well pad; 14,310,000 gal from source(s) in the vicinity of the Badami Central Processing Unit (CPU); and 15,000,000 gal from source(s) in the vicinity of the Endicott causeway landfall.
	Point Thomson dock-to-mine site ice road construction[3]	1,480,000	Existing Point Thomson gravel mine site and shallow lakes between the Point Thomson dock and mine site.
	Spur ice roads to water sources[4]	11,390,000	6,000,000 gal from source(s) in the vicinity of the Pt. Thomson CPF and production well pads; and 5,390,000 gal from source(s) in the vicinity of the Badami CPU.
	2005 maintenance[5]	3,780,000	380,000 gal from source(s) in the vicinity of the Pt. Thomson CPF and production well pads; 1,400,000 gal from source(s) in the vicinity of the Badami CPU; and 2,000,000 gal from source(s) in the vicinity of the Endicott causeway landfall.
	2006 sea ice road cap[2]	33,180,000	3,870,000 gal from source(s) in the vicinity of the Pt. Thomson CPF and west production well pad; 14,310,000 gal from source(s) in the vicinity of the Badami CPU; and 15,000,000 gal from source(s) in the vicinity of the Endicott causeway landfall.
	Pipeline right-of-way ice road construction[6]	40,330,000	20,000,000 gal from source(s) in the vicinity of the Pt. Thomson CPF and the east and west production well pads; 20,330,000 gal from source(s) in the vicinity of the Badami CPU.
	Spur ice roads to water sources[4]	11,390,000	6,000,000 gal from source(s) in the vicinity of the Pt. Thomson CPF and production well pads; and 5,390,000 gal from source(s) in the vicinity of the Badami CPU.
	2006 maintenance[7]	7,560,000	760,000 gal from source(s) in the vicinity of the Pt. Thomson CPF and production well pads; 2,800,000 gal from source(s) in the vicinity of the Badami CPU; and 4,000,000 gal from source(s) in the vicinity of the Endicott causeway landfall.

Table 3-4 (Cont.) Point Thomson Gas Cycling Project Water Use Plan – CPF Facility Construction and Operation

ACTIVITY	ITEM	WATER QTY (GALLONS)	POTENTIAL SOURCE(S)[1]
Drilling & Construction[8]	2005 drilling[9]	10,620,000	Source(s) in the vicinity of the Pt. Thomson CPF and production well pads.
	2006 drilling[10]	19,470,000	Source(s) in the vicinity of the Pt. Thomson CPF and production well pads.
	2007 drilling[11]	8,850,000	Source(s) in the vicinity of the Pt. Thomson CPF and production well pads.
	Drilling fluid and cuttings disposal	NA	Not applicable
	2005 temporary construction camp[12]	8,760,000	Source(s) in the vicinity of the Pt. Thomson CPF.
	2006 temporary construction camp[12]	14,600,000	Source(s) in the vicinity of the Pt. Thomson CPF.
	2007 temporary construction camp[12]	5,480,000	Source(s) in the vicinity of the Pt. Thomson CPF.
	Camp waste disposal	NA	Not applicable
	VSM setting slurry	170,000	Source(s) in the vicinity of the Pt. Thomson CPF or the west production well pad.
Hydrostatic Testing	Gathering pipeline hydrostatic testing, summer/fall program[13]	550,000	Source(s) in the vicinity of the Pt. Thomson CPF and production well pads, accessible from the pads or access roads.
	Condensate export pipeline hydrostatic testing, summer/fall program[13]	720,000	Source(s) in the vicinity of the Badami CPU pad, accessible from the pads or access roads.
	Well pad and CPF piping and vessel testing	30,000	Source(s) in the vicinity of the Pt. Thomson CPF and production well pads, water will be blended with glycol to form a 60:40 mixture.
Commissioning	Fire water storage tank charge	510,000	Source(s) in the vicinity of the Pt. Thomson CPF.
	Potable water system initial charge	10,000	Source(s) in the vicinity of the Pt. Thomson CPF.
	Glycol heating and cooling systems initial charge, etc.	10,000	Source(s) in the vicinity of the Pt. Thomson CPF.
Operation	Permanent camp potable water, 7500 gal/day[14]	NA	Point Thomson gravel mine sites.
	CPF facility make-up water, 500 gal/year	NA	Point Thomson gravel mine sites.
2005 Totals	**Water use**	**69,210,000**	30,000,000 gal from source(s) in the vicinity of the Pt. Thomson CPF and production well pads; 24,210,000 gal from sources in the vicinity of the Badami CPU; and 15,000,000 from source(s) in the vicinity of the Endicott causeway landfall.
	20% contingency volume	**13,840,000**	Same as above.
	Total	**83,050,000**	

Table 3-4 (Cont.) Point Thomson Gas Cycling Project Water Use Plan – CPF and CPI Facilities Construction and Operation

ACTIVITY	ITEM	WATER QTY (GALLONS)	POTENTIAL SOURCE(S)[1]
2006 Totals	Water use	128,530,000	65,000,000 gal from source(s) in the vicinity of the Pt. Thomson CPF and production well pads; 46,530,000 gal from sources in the vicinity of the Badami CPU; and 17,000,000 gal from source(s) in the vicinity of the Endicott causeway landfall.
	20% contingency volume	25,700,000	Same as above.
	Total	154,230,000	
2007 Totals	Water use	14,330,000	All from source(s) in the vicinity of the Pt. Thomson CPF and production well pads.
	20% contingency volume	2,900,000	Same as above.
	Total	17,230,000	
Operations Totals	Water use	NA	7,500 gal/day from the Point Thomson gravel mine site or other sources in the area.

Notes:

1) Sources in the vicinity of the Pt. Thomson CPF include permitted Unnamed Lake and Pt. Thomson Old Mine Site as well as possible future permitted sources. Sources in the vicinity of Badami CPU include permitted Shaviovik Pit, Turkey Lake, and Badami Reservoir as well as possible future permitted sources. Sources in the vicinity of the Endicott causeway landfall include Duck Island Mine Site and Sag Mine Site C (a.k.a. Vern Lake) as well as possible future permitted sources.
2) Sea ice road cap is nominally 40 ft wide, 6 in thick and made from pure fresh water (790,000 gallons per mile [gal/mi] by 42 mi long).
3) Dock-to-mine site ice road is nominally 40 ft wide and 6 in thick, standard North Slope ice road construction from snow and fresh water (569,100 gal/mi by 2.6 mi long).
4) Spur roads to water sources will be nominally 40 ft wide and 6 in thick, standard North Slope ice road construction from snow and fresh water (569,100 gal/mi by 20 mi total length).
5) 90 day long maintenance period, 42,000 gal applied per day.
6) Pipeline right-of-way ice roads are nominally 100 ft wide and 6 in thick, standard North Slope ice road construction from snow and fresh water (1,430,000 gal/mi by 28.2 mi total length).
7) 90 day long maintenance period, 84,000 gal applied per day.
8) Water quantity for drilling includes sufficient water for the water-based drilling fluid, casing cement and operation of the G&I system for cuttings and drilling fluid disposal.
9) 3 wells at 1,770,000 gal fresh water per well.
10) 6 wells at 1,770,000 gal fresh water per well.
11) 4 wells at 1,770,000 gal fresh water per well.
12) 100 gal per day per person, average camp occupancy, 240, 400 and 150 persons in 2005, 2006 and 2007 respectively.
13) Hydrostatic testing could be conducted in the summer and fall following construction in which case access to the pipeline does not exist except at the trap and valve sites (i.e. located on pads). Pure fresh water would be used for testing and would be discharged onto the tundra following appropriate filtration and diffusion. Alternatively, the testing program could proceed in March and April, immediately after the pipelines are constructed in which case the ice roads are still in place and ambient temperature is still sub-freezing. A 60:40 water-glycol mixture would be used for testing and would be recovered and hauled to an approved facility for disposal upon completion of testing.
14) 100 gal per day per person, maximum camp occupancy 75 persons.

Table 3-5 Example Permitted Volumes for Water Sources in the Point Thomson Area and to the West

WATER SOURCE COMMON NAME	GENERAL LOCATION	CURRENT/PAST BPXA PERMIT #	PERMITTED VOLUME TOTAL FOR ALL SOURCES (CURRENT OR PAST)	ESTIMATED VOLUME (GAL)	ADF&G RESTRICTIONS?	COMMENTS
Duck Island Mine Site	Endicott Road	LAS 13290	221 acre ft per year (72,000,000 gal)	600,000,000	yes	past permitted volumes based on need rather than availability
Sag Mine Site C / aka Vern Lake	Endicott Road	LAS 13629		792,000,000	yes	
Badami Reservoir	Badami development	LAS 19045	61.6 acre ft per year (20,000,000 gal)	86,000,000	yes	drinking water source
Turkey Lake	south of Badami CPF			730,000	no	relatively shallow lake
Shaviovik Pit	Shaviovik River Delta, west of Badami CPF	LAS 14042	1125.27 acre ft per year (370,000,000 gal)	125,000,000	no	typically used in ice roads to Badami
Pt Thomson Old Mine Site	PTU development area			104,000,000	unknown	
Unnamed lake	PTU development area (Sec. 22&23, south of airstrip)			923,000	no	used for Yukon Gold and Sourdough ice roads

Note: Estimated water source volumes are based on surface area, known or estimated depth, and typical bathymetric profiles.

3.13.4 Communications

A communication tower and associated equipment will be installed on the Point Thomson CPF Pad. The existing communication system at Badami will act as a repeater system enabling the exchange of voice and data signals between Point Thomson and Prudhoe Bay, existing systems on the North Slope (e.g., Alaska Clean Seas), and the outside world. Power and communications cables will be buried in the gravel roads to the airstrip and to the outlying production well pads for operation and control of the airstrip and the production well pad facilities and gathering pipelines.

The private microwave connection will carry voice and data signals into the facility. The tower will be approximately 300 ft (91 m) tall, and will be the facility's tallest structure. A separate communication building will, for reasons of radio frequency (RF) efficiency, house all RF equipment. This building will be located near the foot of the main microwave tower.

The buried fiber-optic cable will carry multiple channels of voice, data, distributed control system signals, and basic process control system signals to/from the West, East, and Central Well Pads, and the CPF Pad. Supervisory Control and Data Acquisition System Ultra High Frequency radio will provide supervisory control and data acquisition to the pipeline remote terminal units. Plant radio systems will provide a voice communication system in the plant and pad areas. Spill response radio will provide additional secure communication along and adjacent to the pipeline.

3.13.4.1 Airstrip Facilities

Navigation and communication equipment will be located at the Point Thomson airstrip. This equipment will include:

- Non-directional beacon,
- Distance measuring equipment,
- Pulsed light approach slope indicator,
- Meteorological automatic radio,
- Universal communication,
- Runway lighting, and
- Global positioning system approach.

3.13.5 Storage/Tanks

Table 3-6 illustrates the tanks and storage areas that are required for the project. The tanks and associated instrumentation will be heat traced and insulated to avoid damage during freezing weather conditions.

Table 3-6 Proposed Tanks and Storage Areas

Location/Purpose	Size	Notes
CPF Pad:		
Potable Water	200 barrel (bbl)	Located inside the utility module building
Fire fighting-potable water	12,000 bbl	Located outdoors
Cold Storage area (chemical, lube oil, etc., drums and containers)	50 ft by 150 ft (15 m by 46 m)	Located outdoors, lined with high-density polyethylene attached to a 1-ft (30-cm) high retention curb
Diesel fuel	25,000 bbl	Located outdoors within a 200 ft by 200 ft (61 m) diked area, volume within dike is 1.25 times tank volume
Drag Reducing Agent tank	800 bbl	Located outdoors, insulated and heated
Central Well Pad:		
Methanol	2000 bbl	Located outdoors
Diesel fuel	200 bbl	Located outdoors
Corrosion inhibitor	100 bbl	Located outdoors
G&I system storage pit	15,000 bbl (115 ft by 265 ft [35 m by 81 m])	Open lined pit/diked area
East and West Well Pads:		
Methanol	2000 bbl	Located outdoors, each pad

Diesel fuel is required at the beginning of the project for drilling the first three wells and supplying the diesel driven generators. Later, with the power plant in operation, the tank will be used to store fuel to supply vehicles as well as the emergency generators. A 25,000 barrel (bbl) tank will be installed which provides sufficient fuel for approximately 4.5 months drilling activity using two rigs. The diesel tank will be designed to applicable American Petroleum Institute Code and will be located within a lined containment area. The tank will have a cathodic protection system, a leakage detection system, and an instrumentation and controls system adequate to safeguard the tank storage, loading and dispensing operations.

Methanol is required for hydrate and freeze protection during start-up and shut-down of the wells, the production and injection pad piping, the gathering lines from the East and West Well Pads, and the injection lines from the CPF Pad to the CWP. A methanol storage tank with a capacity of 2,000 bbl or more will be located on the CPF Pad.

Provision will also be made for the storage of other several other chemicals including drag reducing agent, corrosion inhibitor, various drum chemicals, etc. as required to support ongoing operations.

This page intentionally left blank

3.14 OPERATIONS AND MAINTENANCE

Point Thomson will have a full time onsite operations, maintenance, and support staff sized to handle normal activities. At this time, normal onsite staffing, including all support (catering, housekeeping, security, etc.) is projected to be approximately 25 positions (50 full time employees). Normal staffing will be supplemented with temporary staffing for special work activities including major equipment maintenance and well work. It is currently assumed that management, administrative, and engineering support for the operations will be based in Anchorage, Alaska.

Normal transportation of personnel and light equipment to and from the site will be via charter aircraft. Up to three helicopter trips per week and one or two daily flights by other aircraft may be required to support operations activities. During the short summer open water season, bulk materials and supplies will be delivered by barge. Winter ice roads connecting Point Thomson to Prudhoe Bay may be constructed when justified by special activities (rig mobilization, major construction, etc.).

Before construction, drilling, or operations activities commence, a comprehensive Safety, Health, and Environmental management program will be developed and implemented in compliance with ExxonMobil's Operations Integrity Management System. Components of this program will include employee health and safety programs, environmental awareness training, polar bear training, first aid training, medical evacuation training, and other emergency response/ contingency plan training. Personnel responsible for sales pipeline operations and maintenance will meet all Alaska Department of Transportation training and testing requirements. All employees and contractors are required to immediately report to local supervisors any conditions they observe that might represent a hazard to human safety or to the environment so that prompt action can be taken to resolve these conditions.

These management systems will also help to ensure that all construction, drilling, operations, and maintenance activities are conducted in full compliance with all relevant federal, State, and local rules, regulations and permit conditions.

Automated leak detection equipment will be installed on the condensate sales pipeline. Ground based surveys and aerial patrols will also be conducted periodically along the pipeline right-of-way (ROW). Pipeline block valves and pressure relief systems will be periodically inspected in accordance with regulatory and industry standards. Infield pipelines and facilities will also be visually inspected for any leaks during routine daily operations and maintenance activities. A corrosion-monitoring program will be implemented utilizing corrosion coupons, ultrasonic testing, and instrumented pigging as appropriate to ensure pipeline and facility integrity. Specifics of these programs will be detailed in pipeline ROW applications and spill control plans.

This page intentionally left blank

3.15 TERMINATION

The expected life of the Point Thomson gas field is approximately 30 years. This includes the possibility of shifting the project to a gas sales venture once a means for getting the gas to market is realized. In addition, the actual service life of the project will depend on several factors. Once the project is constructed, infield drilling or possible satellite development could extend the service life of the production facilities and pipeline system. Likewise, since the pipeline system will be operated as a common carrier, Point Thomson Owners or other entities could continue to use the pipeline for other, future purposes after the Point Thomson reservoir has been depleted.

ExxonMobil will decide when to abandon the project based on the need for continued use of the facilities. At the time the project is no longer needed, ExxonMobil would either begin abandonment procedures according to the permit conditions and regulations in force at that time, or enter into negotiations to transfer ownership of the project to another entity.

Actual detailed abandonment procedures will not be determined at this time, but will be developed as a project modification at the time ExxonMobil or any future owner or operator decides to terminate the project. Just as project construction is subject to numerous overlapping local, State, and federal authorities, abandonment will be subject to multiple agency reviews and approvals.

Permits issued by the Alaska Department of Natural Resources and United States Army Corp of Engineers typically contain provisions requiring abandonment and restoration of the area be completed according to the satisfaction of the agency, and will contain clauses requiring approval of abandonment procedures. The discretion allowed in identification of termination and abandonment procedures allows for full consideration of the environmental impacts of removal options, and allows evaluation of any benefits from leaving certain facilities or structures in place at the time of abandonment.

This page intentionally left blank

4.0 AFFECTED ENVIRONMENT

4.1 METEOROLOGY

The climate of the Point Thomson area is Arctic Marine, characterized by extremely low winter temperatures and short, cool summers. Winds are persistent throughout the year, with blizzards occurring frequently during the winter. The sun remains below the horizon in the area from late November through mid-January.

Meteorological data for the area are limited; there are historical data collected at Barter Island, located about 60 miles (mi) (97 kilometers [km]) to the east. These data include daily measurements of temperature, wind speed and direction (velocity), precipitation, and other parameters for 1949 through 1988. The Alaska North Slope Eastern Region (ANSER) monitoring station at Badami, about 15 mi (24 km) west of the project area, has collected background climatic data including temperature and wind velocity since first quarter 1999, as well as precipitation since fourth quarter 1999. Temporary stations located at Flaxman Island (summer 1997 and 1998) and on the mainland south of Flaxman Island (summer 1999) recorded temperature and wind velocity.

4.1.1 Temperature

From year to year, the average monthly temperature, especially in winter, can vary widely. For example, at Barter Island, the average January temperature was 4.5 degrees Fahrenheit (°F) (-16.5 degrees Celsius [°C]) in 1981 and -21.8°F (-6°C) in 1983. The recorded minimum temperature at Barter Island was -59°F (-51°C) in February 1950 and the maximum was 78°F (26°C) in July of 1978 (USFWS 1987). In summer, variations are less pronounced, but more important because the accumulation of days above freezing (thaw index) greatly influences the depth of thaw in the soil and the rate of melting of ice on the water bodies. Table 4-1 compares temperatures recorded at Barter Island and Badami. The table shows that the mean temperature ranges and mean annual temperatures are comparable between the locations.

Table 4-1 Mean Annual and Mean Temperature Ranges Near Point Thomson

LOCATION	MEAN ANNUAL TEMPERATURE °C	MEAN TEMPERATURE RANGE °C	PERIOD OF MEASUREMENT
Barter Island	-12.3	-45.4 to 26.3	1949-1988
Badami	-12.7	-42.2 to 22.3	1999-2000[1]

[1]July to June
Sources: USFWS 1987, ANSER 2000

4.1.2 Precipitation

Precipitation in the Point Thomson area is light, but frequent, occurring as drizzle in summer and as light snow in the winter months. Although rain accounts for most of the annual precipitation along the coast, snow begins falling in September and usually remains on the ground from October through June (BLM 1979). Table 4-2 summarizes the precipitation data for the Barter Island and Badami stations.

Table 4-2 Precipitation Data Summary Barter Island And Badami

LOCATION	MINIMUM MONTHLY PRECIPITATION (INCHES [IN.])	MAXIMUM MONTHLY PRECIPITATION (IN.)	AVERAGE ANNUAL PRECIPITATION (IN.)	PERIOD OF MEASUREMENT
Barter Island	0.19 (April)	1.1 (Aug.)	6.19	1949-1988
Badami	0.28 (March)	1.5 (Dec.)[2]	NA	1999-2000[1]

[1]October to June
[2]No measurement taken in summer
Sources: USFWS 1987, ANSER 2000
NA – not available

The Barter Island data exhibits an average summer precipitation of 0.52 inch (in) (1.32 centimeters [cm]) in June, 1.01 in (2.57 cm) in July and 1.1 in (2.8 cm) in August. Rainfall rarely exceeds 0.5 in (1.27 cm) in any one day. A 10.8 in (27.4 cm) average annual snow depth recorded at Barter Island (USACE 1984) is representative of the area.

On the North Slope, relative humidity is generally high during the summer, reaching 80 to 95 percent (%) along the coast (LGL et al. 1998). Relative humidity in the winter months drops to about 60 %. On average, foggy conditions occur 76 days per year at Barter Island; ice fog forms when ambient temperatures drop below -20.4°F (-29° C) (USACE 1984).

4.1.3 Winds

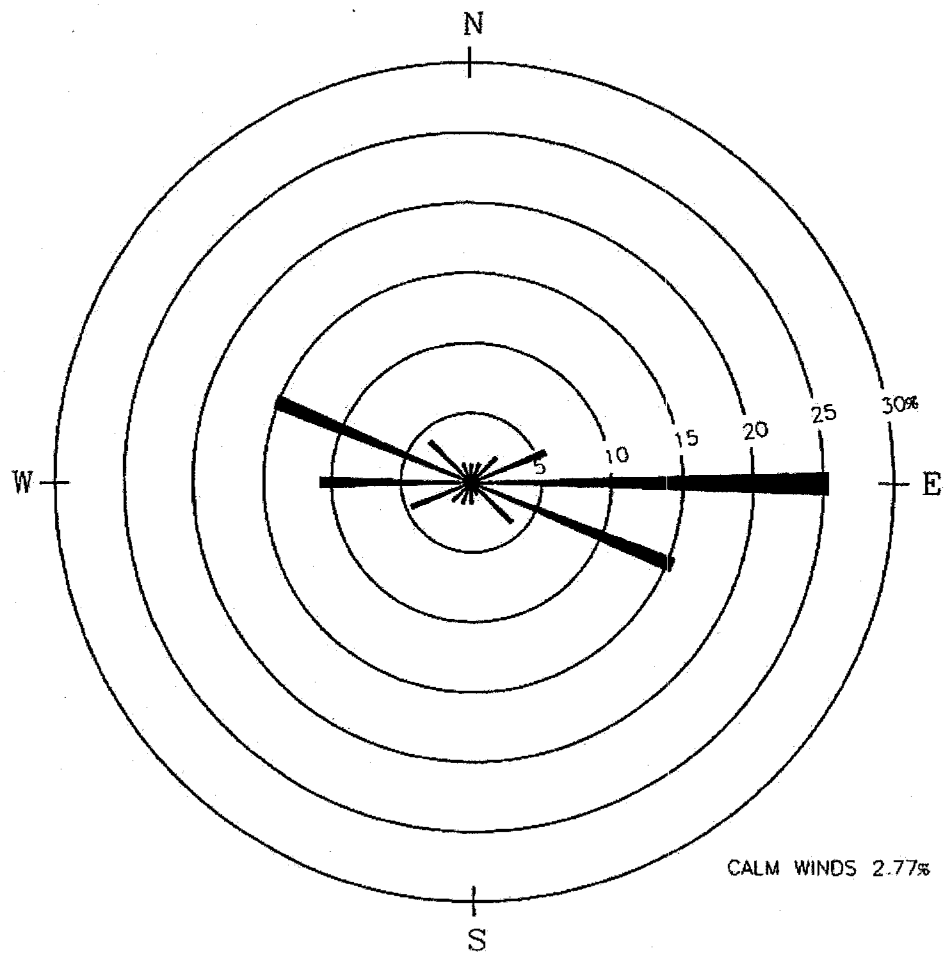
Winds on the arctic coast are persistent and tend to parallel the coastline. Easterlies occur about twice as frequently (60%) as westerlies (30%); the remaining time (10%) winds are calm or light and variable. Figure 4-1 provides a wind rose for Barter Island. Prevailing easterly winds consistently average 13.4 miles per hour (mph) (22 kilometers per hour [km/hr]) at Barter Island (usually East North East to North East). From January to April, the prevailing direction is westerly (WCC 1981). The windiest month usually is January (mean 15 mph [24 km/hr]) and the calmest is July (mean 10.7 mph [17 km/hr]). The peak gust (westerly) recorded at Barter Island was 75 mph (121 km/hr) in January 1980 (USFWS 1987). Sea breezes occur during about 25% of the summer and extend to at least 12.5 mi (20 km) offshore (MMS 1996). Persistence of the wind from either direction varies from 1 to 14 days with typical events lasting 2 to 5 days (Colonell and Niederoda 1990). Winds exceeding 31 mph (50 km/hr) occur about 2 to 8 % of the time.

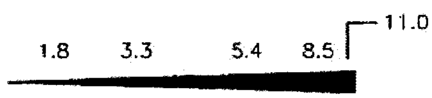
The Point Thomson area meteorological station data (summers 1997-1999) indicate that locally, east winds are prevalent during the summer and more than 90% of the wind speeds are less than 20 mph (32 km/hr). Maximum observed wind speeds of 31.1 mph (50 km/hr) were recorded during an easterly storm in late August 1999.

4.1.4 Air Quality

The ANSER monitoring station also measured several air quality parameters including concentrations of nitrogen oxide, nitrogen dioxide, sulfur dioxide, ozone, and particulate matter. Table 4-3 provides a summary of these parameters as recorded by this study. All concentrations shown in the table are well below the Alaska and National Ambient Air Quality Standards.

Figure 4-1 Wind Rose for Complete Year (1988) at Barter Island, Alaska





WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE OF EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE - WIND IS BLOWING FROM THE NORTH 1 3 PERCENT OF THE TIME.

FIGURE 1
WINDROSE
STATION NO: 27401
BARTER ISLAND, AK
PERIOD: 1988

BEE-LINE
SOFTWARE

Table 4-3 Air Quality Parameters Measured At Badami July 1999-June 2000

PARAMETER	AVERAGE ANNUAL CONCENTRATION	ANNUAL MEAN 24-HOUR CONCENTRATION	HIGHEST REPORTED 24-HOUR CONCENTRATION
Nitrogen oxide ($\mu g/m^3$)	3.6	NA	NA
Nitrogen Dioxide ($\mu g/m^3$)	3.3	NA	NA
Sulfur Dioxide ($\mu g/m^3$)	3.5	NA	NA
Ozone ($\mu g/m^3$)	46.1	NA	NA
Particulate matter ($\mu g/m^3$)	NA	2.2	25.7[1]

[1]Recorded during nearby construction activities
NA – Not Available
$\mu g/m^3$-micrograms per cubic meter
Source ANSER 2000

4.2 GEOMORPHOLOGY

The proposed Point Thomson Gas Cycling project is located in the Arctic Coastal Plain (ACP) physiographic unit (Wahrhaftig 1965). The plain rises gradually from the Arctic Ocean and extends southward to the base of the Arctic foothills along the northern edge of the Brooks Range. The coastal plain consists of perennially frozen marine, fluvial, aeolian, and lacustrine sediments underlain by Cretaceous and early Tertiary sedimentary rocks. This is a poorly drained, treeless, periglacial environment with a thick permafrost layer.

The proposed Point Thomson Gas Cycling Project infrastructure is located on the ancient Canning River alluvial fan. This fan can be divided into a coastal zone and an inland zone (LGL et al 1998). The coastal zone has been modified by coastal processes throughout a period when sea levels were higher than present. The division between the coastal zone and the inland zone is located approximately 2 to 3 mi (3 to 5 km) south of the coastline at an approximate elevation of 25 to 30 feet (ft) (7 to 9 meters [m]). Wind-oriented lakes dominate the landscape in the Canning River coastal zone and in the area west of the ancient Canning River alluvial fan, which starts at the southern limit to Mikkelsen Bay. Thaw lake basins originate in areas of restricted drainage where shallow ponds form during the warmer summer surface temperatures. The warmer temperatures cause the underlying ground ice to thaw resulting in subsidence. Most of these ponds and lakes are less than 4 ft (1.2 m) deep (BPXA 1995).

Thaw lakes are relatively uncommon on the Canning River inland fan zone as compared to the coastal zone. Small beaded tundra streams and drainages that cross the alluvial fan indicate that ground ice is present, but the lack of thaw lakes suggests that the dominant soil type is coarser than the soils in the coastal zone to the north (LGL et al 1998). Ground ice is present in a layer above the permafrost to the base of the active layer. The ground ice is generally in the form of wedge-ice that occurs the perimeters of polygons. Outwash material is found within the Canning River inland zone. A recent geotechnical investigation delineated sandy gravel and gravely sand outwash deposits with traces of silt (DM&A 2001). These deposits are proposed to be the material source for the construction of roads, airstrip, and pads for various facilities

4.2.1 Permafrost

Permafrost is defined as the thermal condition of soil or rock in which temperatures below 32 °F (0°C) persist over at least two consecutive winters and the intervening summer; moisture in the form of water and ground ice may or may not be present. Earth materials in this condition may be described as perennially frozen, irrespective of their water and ice content.

Although mean annual air temperature is basic in determining permafrost distribution, the mean annual ground temperature is the key that determines presence or absence of permafrost. Ground temperatures depend on the climatic history of an area, thermal properties of the earth materials, depth below the ground surface, season, moisture content of surficial soils, vegetative cover, solar gain during the summer, and thickness of insulating snow layers in the winter. In the project area, typical ground temperatures at a depth of 25 ft (7.6 m) range from 10°F to 20°F (-12 °C to -6.1 °C) (LGL et al. 1998).

Even in the coldest parts of Alaska, there exists a thin layer of soil known as the active layer. This layer thaws every summer and insulates the permafrost from the ground surface. The thickness of the active layer on the North Slope varies in thickness locally from 0.5 to 5 ft (15 cm to 1.5 m) or more adjacent to significant streams, and can change when the surface is disturbed. The thickness of the active layer in the project area ranges from less than 1 ft to 5 ft (30 cm to 1.5 m) and averages about 2 ft (60 cm) (LGL et al. 1998).

The amount of ice present in the surficial permafrost deposits can vary from none to nearly 100% by volume. The proportion of ice to mineral or organic material depends initially on the water present in the material before freezing, but during the freezing process (and during annual temperature cycles) the ice and soil may become segregated. The segregated ice may take the form of irregular masses or lenses. Ice lenses range in thickness from less than 1 in (2.54 cm) to several ft, commonly forming vertically oriented wedges that thin downward and may be tens of ft deep and several ft wide at the top (LGL et al 1998).

The amount of ice present and the soil type determines the thaw settlement behavior of a soil. Coarsely grained soils (sand and gravel) generally contain less ice by volume and experience less thaw settlement than silty-sands and silt that may typically contain considerable amounts of ice. During a recent geotechnical exploration program of the Point Thomson area, however, areas were encountered where considerable ice was found in coarsely grained soils (DM&A 1997).

4.2.2 Mainland Shore

Studies have shown the mainland shoreline in the Point Thomson area to be relatively stable (Kinnetic Laboratories, Inc. 1983). This stability is primarily due to the sheltering effect of the offshore barrier islands. Spits and bluffs tend to be more dynamic than the low mainland shore. The numerous low-lying sand and gravel spits located along the mainland shoreline also provide protection by dissipating wave and ice forces. These spits are formed and altered by continuous littoral sediment transport and overwash processes. Although high erosion rates of the bluffs along the mainland shoreline and the seaward side of Flaxman Island have been reported, historical maps indicate that little change in the shape of the coastline has occurred. In areas where extensive bluff erosion has been observed, thermal erosion was determined to be the primary cause (Kinnetic Laboratories, Inc. 1983).

4.3 HYDROLOGY

The Staines and Canning Rivers border the eastern portion of the project area and the Shaviovik River is located about 5 mi (8 km) west of the proposed West Well Pad location. The headwaters of the Canning River are in the Brooks Range, approximately 110 mi (177 km) south of the coast. The Staines River forms an alluvial delta just east of the proposed project area. The Shaviovik River, from its headwaters in Juniper Creek to the coast, is about 100 mi (160 km) long. Most of the flow from the Shaviovik River appears to discharge into Foggy Island Bay, west of the Point Thomson project area. Drainage area and discharge effects on Lions Lagoon from the Canning and Staines Rivers are discussed in Section 4.4.2.4.

Several minor tundra streams are located within the project area. These tundra streams are generally small, meandering, and drain into larger streams or Lions Lagoon. For the most part, the tundra streams are confined to a single channel, although larger streams may have braided channels. Many tundra streams are beaded, meaning that they consist of a series of small ponds interconnected by short, narrow stream segments.

As summarized in Section 4.2, wind-oriented lakes dominate the landscape in coastal zone of the Point Thomson area. Soil in the area is generally poorly drained due to the shallow depth to permafrost and the low slope of the terrain. The shallow thaw lakes follow a cyclic pattern of formation and drainage. Thaw lakes originate from low-center polygons and tundra ponds by wind-driven thermokarst erosion during the warm season (Britton 1957; Carson and Hussey 1961; Billings and Peterson 1980). Thaw lakes go through a cycle of development, expansion, drainage, and revegetation until they are incorporated by a stream that provides constant drainage. In contrast to the coastal zone, these thaw lakes are relatively uncommon on the Canning River inland fan zone. Small beaded streams and drainages that cross the alluvial fan indicate that ground ice is present. Several of these lakes, in addition to former mine sites at Point Thomson and Badami could be used as water sources for the Point Thomson project (see Figure 3-19).

4.3.1 Snowmelt Floods

Mean annual precipitation is approximately 5 in (12.7 cm) per year with total snow accumulation estimated to be approximately 10 in (25.4 cm). During the long winter, a substantial portion of the precipitation is lost to sublimation. Due to the transport of snow by drifting, the actual amount available in a particular small drainage basin can vary widely depending on the ability of the local relief to trap snowdrifts.

During snowmelt, the initial runoff occurs as sheet flow over the frozen ground surface where infiltration is practically nonexistent. As breakup continues, the snowmelt runs over the frozen surface of small streams and ponds behind snowdrifts. As breakup progresses, these small drifts thaw or are overtopped, and the accumulated melt water is released to flow downstream until it again ponds behind another snowdrift or flows into an open water stream or river. This storage and release process results in an unsteady and non-uniform flow during breakup. Typically snowmelt floods occur every year.

Once the breakup crest has passed a particular point on a stream, the recession is rapid. Typically, the flow on a small stream two weeks after the breakup crest will be less than 1% of the peak flow, and the intermittent drainages will be dry within two weeks. During breakup, the bed and banks of small drainages tend to remain frozen, thereby limiting erosion.

Floods on small streams have historically occurred solely as a result of snowmelt, which responds to a rapid seasonal increase in temperature. As a result, snowmelt floods on a given stream tend to occur at about the same time each year. In 1998, nearly all of the streams crested on May 29 or 30. At peak stage (water surface elevation) many of the channels were between 10 to 50 % blocked by snow. The peak discharge appears to have occurred at a lower water surface elevation, although typically above bankfull (LGL et al. 1998).

Strudel scour occurs along the coast when snowmelt floods overflow onto sea ice and drain through holes in the ice. Due to limited number of holes in the ice, the velocity of the water flowing through them can be strong enough to scour the seabed. The size and shape of the scour is dependent upon a number of parameters, such as the water depth, overflow depth, and seabed soil type.

4.3.2 Rainfall Floods

Summer floods are not anticipated to occur on the smaller streams within the project area. Similar small streams in the region have not produced floods because of the relatively small watershed (drainage basin), the low intensity of the rainfall, and the large capacity of tundra and thaw lakes to absorb and retard runoff. However, summer floods resulting from unusually heavy precipitation in the Brooks Range occur on rivers such as the Canning, Staines and Shaviovik Rivers. These floods are not frequent, but may be larger than typical break-up floods (BPXA 1995; LGL et al. 1998).

4.4 OCEANOGRAPHY OF LIONS LAGOON

Lions Lagoon, is located offshore of the Point Thomson Gas Cycling Project and about 46 mi (74 km) east of Prudhoe Bay. Flaxman Island and a chain of barrier islands known as the Maguire Islands (including Challenge, Alaska, Duchess, and Northstar Islands) forms the lagoon. The Beaufort Sea lies seaward of these islands (see Figure 3-2). Lions Lagoon is approximately 3 to 4 mi (5 to 6 km) long, with water depths typically between 5 and 13 ft (1.5 to 4 m). Passes or gaps between the barrier islands serve to connect the lagoon waters with the Beaufort Sea, and thus waves, storm surges, and other regional oceanographic processes influence the lagoon waters.

4.4.1 Bathymetry

The barrier island complex serves to shelter or partially protect much of the lagoon from exposure to storm waves generated in the Beaufort Sea during the open-water periods. The Mary Sachs Entrance is a broad, 2-mi (3-km) pass between Northstar and Flaxman Islands (see Figure 3-2). The lagoon east of the Mary Sachs Entrance is quite shallow and protected by Flaxman Island, while west of the Mary Sachs Entrance the lagoon is deeper and wider, and open at the west end.

Water depth in the eastern part of the lagoon is quite shallow. Shoals are common near the mouth of the Staines River and western tributary of the Canning River and extend toward Point Brownlow. The pass between the east end of Flaxman Island and Point Brownlow is narrow (1,200 ft [66 m]) and relatively deep (26 ft [8 m]). Historical soundings obtained from the National Oceanic and AtmosphericAdministraion (NOAA) Chart No. 16045, revised in 1996, suggest the lagoon is asymmetrical, with deeper waters near the mainland shore and a gentle slope from the mid-channel north to Flaxman Island. Water depths within the lagoon gently increase towards the west to a depth of 8 ft (2.4 m) approximately mid-length of Flaxman Island and reach 11 ft (3.4 m) immediately northeast of Point Thomson.

Mary Sachs Entrance is a relatively deep pass, with a northeast/southwest-oriented channel that extends toward Point Thomson. Water depths within the channel are typically 9 to 11 ft (2.7 to 3.4 m) with the 10 ft (3 m) isobath approximately 2,400 ft (732 m) north of the mainland shore in the vicinity of Point Thomson. Mary Sachs Entrance provides a break in the protection offered by the barrier islands, exposing the shoreline adjacent to and east of Point Thomson to offshore storm events. The increased exposure to waves is evidenced by the well-developed spit and bar formation along the mainland shore.

The western portion of the lagoon is protected by the Maguire Islands. This portion of the lagoon widens from 1.5 mi (2.4 km) at Point Thomson to 3.5 mi (5.6 km) near Challenge Island. Water depths adjacent to the mainland between Point Thomson and Point Hobson are typically 7 to 10 ft (2 to 3 m) and gently increase to 16 ft (5 m) at the west end of the lagoon.

4.4.2 Physical Oceanography

Several oceanographic studies have been conducted in Lions Lagoon (Kinnetics 1983, Tekmarine 1983, and URS 1999). Understanding of the lagoon dynamics and relation to the adjacent Beaufort Sea is augmented substantially by extensive work done along the Beaufort Sea coast since 1976 and synthesized by Colonell and Niedoroda (1990). The hydrography (temperature, salinity, and water column structure) of summer Beaufort Sea coastal waters is determined by the recent wind velocity (direction and speed) and freshwater input. Circulation within the coastal environment is almost entirely wind driven. Easterly winds effectively lower sea level and initiate regional upwelling, while westerly winds raise sea level and initiate regional downwelling. Local salinity is a function wind direction and distance to the nearest source of freshwater. Local water temperature is a function of solar radiation and, to a lesser extent, distance to nearest freshwater source. Details regarding the oceanography of Lions Lagoon are provided in the following sections.

4.4.2.1 Tides and Storm Surges

As with other areas along the Beaufort Sea coast, astronomical tidal ranges are only about 8 in (20 cm); however, the range of sea level rise and fall due to major storms (storm surge) can be as much as 8 ft (2.4 m) at the shore. Storm surges result from the combined effects of wind and atmospheric pressure changes. Positive surges (water level increases) are associated with westerly winds, and negative surges (water level decreases) are associated with easterly winds.

A Kinnetics study (1983) observed a maximum positive surge of 2 ft (60 cm) in Lions Lagoon, associated with winds up to 35 knots (kts) (65 km/hr) during an ice covered period in October. Reimnitz and Maurer (1978) studied driftwood elevations left by a large gale-force westerly storm, in the Point Thomson region in 1970, that had flooded some low lying inland areas. They estimated the height of the surge in Lions Lagoon to be about 7 to 9 ft (2.1 m to 2.7 m) and projected this incident to have a recurrence interval of about 100 years. Storm surges in the Canadian Beaufort Seaare known to have positive surges of up to 6 ft (2 m) and negative surges of 3 ft (1 m).

4.4.2.2 Waves

Storm waves are generated by wind stress on the water surface. The wind velocity, the duration of the time the wind blows, and the fetch (the extent of open water across which the wind blows) influence wave height and period (Bascom 1980). Another important factor that limits wave height is water depth. As waves move into shallow waters, breakers form and dissipate the wave energy. Thus, storm waves in the shallow lagoon waters tend to be smaller than storm waves generated in the deeper Beaufort Sea waters north of the barrier island complex. Passes between the barrier islands will allow larger waves to enter the lagoon as evidenced by the shoreline near Point Thomson, which is an exposed portion of the lagoon shoreline immediately south of the Mary Sachs Entrance.

Using moored instruments, Kinnetics (1983) measured wave conditions in Lions Lagoon. During the study, waves were found to be relatively small in the lagoon due to a lack of significant strong wind events and the lingering presence of sea ice. The maximum wave heights were generally less than 2 to 3 ft (60 to 90 cm). Significant wave heights and periods (defined as the average of the highest one-third of the waves) were measured at just over 1 ft (30 cm), with significant periods of about 2.5 seconds. One storm event during August 1982 with winds over 20 kts (37 km/hr) produced waves up to 5 ft (1.5 m), significant wave heights of 2.75 ft (83 cm), and periods up to 3.5 seconds.

4.4.2.3 Currents

The nearshore Beaufort Sea has been intensively studied for more than two decades, so the oceanographic behavior of the region is well understood. As with most shallow seas, the wind governs the hydrodynamics (water movement) of the Beaufort Sea almost exclusively such that currents in shallow water are aligned generally with the wind direction. That is, east winds produce westward currents and west winds produce eastward currents.

Three forcing factors drive the circulation of the coastal ocean: wind stress, horizontal pressure gradients, and tides. Along the Beaufort Sea coast, astronomical tides are small (< 8 in [20 cm]) with associated weak currents (< 0.1 kt [5 centimeters per second (cm/sec)]), except in the narrow passes between barrier islands. Winds are typically parallel to the coast, with easterlies (i.e., winds from the east) prevailing about 60 % of the open-water season (July-September). During easterly wind conditions, water enters the lagoon at Mary Sachs Entrance and other passages between the barrier islands, and exits the lagoon via Challenge Entrance (URS 1999). For westerly winds this pattern is reversed, with water entering the lagoon via Challenge Entrance, and exiting through the other passages.

Currents were measured in the passes on each end of Flaxman Island during a 40-day period throughout August and early September 1997 (URS 1999). Typically, currents within the Mary Sachs Entrance were <0.58 kts (<30 cm/sec); however, at the peak of a severe easterly storm during late August, current speeds were nearly 0.97 kts (50 cm/sec). Tidal currents observed in the Mary Sachs Entrance were typically 0.014 to 0.19 kts (7 to 10 cm/sec). Active sediment transport was evident with the burial of the current mooring anchor.

Water movement through the narrow channel between Point Brownlow and the east end of Flaxman Island typically reached speeds in excess of 1.2 kts (60 cm/sec) with a maximum recorded value of 1.7 kts (90 cm/sec); however, the mooring was fouled prior to a late August 1997 storm event in which higher current speeds likely would have been observed (URS 1999).

4.4.2.4 River Input

The Canning and Staines rivers provide freshwater input to the Beaufort Sea in the vicinity of the Point Thomson area. The river outflow into coastal waters provides low saline waters along the coast. From its headwaters to the coast, the Canning River is about 117 mi (188 km) long and has a drainage area of about 2,256 square miles (mi^2) (5,900 km^2). The river has a braided, meandering channel, with low banks and broad floodplains consisting of gravel terraces. The discharge of the Canning River averages 1,125 cubic feet per second (cfs) (32,000 liters/sec) (AEIDC 1974). Large coastal rivers such as the Canning show no measurable discharge from January to early May (MMS 1996). By contrast the Staines River has an annual average flow of 14-cfs (AEIDC 1974). This river is 21 mi (34 km) long and has a drainage area of about 28 mi^2 (73 km^2).

4.4.2.5 Sea Ice

In late winter, first year sea ice in the Beaufort Sea generally is about 6.5 ft (2 m) thick. From the shore to a depth of about 7 ft (2.1 m) 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 ride-ups along the coast and on barrier islands. Occasionally, the floating ice sheet is driven up onto the shore a significant distance (>100 ft [30.5 m]) in a phenomenon known as *Ivu* by the Inupiaq inhabitants of the region.

Sea ice forms within Lions Lagoon in September or October, and typically first along shore where water is less saline. Initially the water is covered with brash and pancake ices, that gradually thicken into ice sheets. If storm surges occur during the early stages of freeze-up, the smooth sheet of ice can be broken into blocks, forming a chaotic pattern of ice fragments. As the sea ice develops, the ice fragments freeze into an ice sheet which grows to a thickness of about 7 ft (2.1m) by April or May. Ice blocks and ridges within the sheet may extend to 15 ft (4.6m) or more below the surface.

In spring, melting of the sea ice begins at the surface. During the initial stages of melting brine pockets isolated during freeze-up 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.

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 occasionally 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 ft (10m) 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.

4.4.3 Water Quality

4.4.3.1 Salinity and Temperature

Marine waters are generally cold (30 to 37°F [-1 to +3 °C]) 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 availability of sea ice.

Summer Conditions (Open Water)

The open water season typically occurs in late June to early July and, as warming continues into summer, the sea-ice melts, resulting in about 75 days of open water. After sea ice breakup, wind speed and direction become the key factors in determining the fate of freshwater advected along the coast. Wind speed and direction also influence water level variations that, in turn, play a key role in the exchange rates between brackish nearshore and offshore marine waters. Other agents controlling currents include the small (<1 ft [30 cm]) astronomical tide and occasionally large 3 to 7 ft (1 to 2 m) storm surges.

During and immediately after sea ice breakup, there is a freshwater (~3 to 6 ppt) surface layer up to 13 ft (4 m) thick that encompasses the lagoon and covers the marine (~30 ppt) waters. This two-layer or stratified water column is a short-term event, persisting on average for only 1 or 2 weeks. As the sea ice diminishes, winds mix the waters of Lions Lagoon, creating an unstratified (uniform) water column of brackish (~12 to 17 ppt) waters. As summer progresses, the water column typically remains unstratified, with salinity gradually increasing to marine (>30 ppt) conditions by mid-September (URS 1999). These unstratified marine conditions persist into freeze-up.

Wind history (speed and direction) is of prime importance in determining the fate of freshwater advected along the coast by currents during the open-water season. The prevailing summer winds along the Beaufort Sea coast are from the east, so the nearshore currents respond to this wind stress by flowing westward. This current regime transports river discharges westward along shore such that freshwater is mixed with the ambient nearshore waters.

The Canning River is the only significant source of freshwater to Lions Lagoon, east of Flaxman Island; however, once it reaches the Beaufort Sea, the freshwater becomes sufficiently mixed with seawater, resulting in brackish conditions. The pass east of Flaxman Island has a limited opening and thus restricts significant quantities of these well-mixed (brackish) Canning River waters from entering Lions Lagoon. The other freshwater source is the Staines River, located immediately south of Brownlow Point; this river discharges within Lions Lagoon. Freshwater input from the Staines River is small, yet produces a stratified water column adjacent to the river delta (URS 1999).

During west winds, the timing and rate of discharges from the Sagavanirktok and Shaviovik rivers influence the amount of freshwater available for distribution in the marine environment of Lions Lagoon. The Sagavanirktok River delta located approximately 40 mi (64 km) west of Point Thomson, discharges substantial volumes of freshwater into the nearshore environment. Additional freshwater input from the Shaviovik River mixes with brackish Sagavanirktok River plume near Bullen Point. The resulting brackish water tends hug the shoreline, with the difference between surface and bottom salinity decreasing towards Point Thomson.

Upwelling of marine bottom waters creates a stratified water column adjacent to Point Thomson. Under strong easterly winds, regional coastal upwelling draws cold, saline, bottom water into the lagoon through passes between the barrier islands. This results in a temporary stratified, two-layer water column consisting of brackish (~24 parts per thousand [ppt]) surface waters and a bottom layer of cold, saline (>30 ppt) waters (URS 1999). West winds serve to break down this stratification by transporting marine surface water shoreward and mixing it throughout the water column.

Winter Conditions (Ice-Covered)

During winter, the Beaufort Sea is covered by sea ice that begins to form in late September. Freeze-up of the waters is completed by the end of October, with ice growing to a maximum thickness of 7.5 ft (2.3 m) by April (MMS 1996). Ice cover persists on average for 290 days until spring warming results in river breakup, and subsequent sea ice melting near the river and stream deltas. Temperature and salinity profiles collected under the sea ice within the Beaufort Sea exhibit uniform cold, 29°F (-1.5°C), saline (32.4 ppt) marine waters. Under ice observations in the Beaufort Sea indicate very low current speeds aligned with bathymetry, which results in an easterly or westerly flow. The average current speed observed during ice-covered conditions is less than 3 cm/sec (0.06 kts) (Berry and Colonell 1986).

While the current meters employed during under-ice studies are generally insensitive to speeds below 2 cm/sec (0.04 kts), the data do not indicate stagnant conditions. Heavy brine formed by the thickening sea ice could produce a stratified water column in stagnant or near-stagnant conditions; however, low current speeds (e.g., less than 2 cm/sec) are sufficient to disperse any such brine through the water column and minimize or eliminate resulting under-ice vertical stratification. The typical water column structure observed under sea ice in the Beaufort Sea is uniform, with no temperature, salinity, or density stratification (Berry and Colonell 1986).

4.4.3.2 Dissolved Oxygen

During the open-water season, dissolved oxygen levels in Lions Lagoon are usually high, typically above 10 milligrams per liter (mg/L) (URS 1998). 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 of 7.4 to 13.2 mg/L were measured in Foggy Island Bay, which is immediately west of Lions Lagoon (MW 1997and 1998).

4.4.3.3 Turbidity and Suspended Sediment

Suspended sediment is introduced naturally to the marine environment through river runoff and coastal erosion (MMS 1996) and is re-suspended during summer by wind and wave action. Satellite imagery and suspended particulate matter data suggest that turbid waters are generally confined to depths less than 16 ft (5 m) and are shoreward of the barrier islands. Storms, wind and wave action, and coastal erosion increase turbidity in shallow waters periodically during the open-water season. Turbid conditions persist in areas where the sea floor consists primarily of silts and clays as opposed to areas having a predominantly sand bottom.

During the 1998 open-water season, the average total suspended solids (TSS) value was 43.3 mg/L, with a maximum concentration of 79 mg/L from water samples collected near Point Thomson (URS 1998). In-situ turbidity measurements collected during the 1998 open-water season ranged between 1 and 173 nephelometric turbidity units (NTU). There was no correlation between TSS and turbidity values from samples collected within Lions Lagoon (URS 1998).

In winter the presence of ice cover eliminates external effects that cause turbidity (MMS 1996). However, occasional under-ice water movement can stir bottom sediments into the water column. Under-ice TSS values collected in the western portion of Foggy Island Bay ranged from 2.5 to 76.5 mg/L (MW 1997and 1998). Field-measured turbidity for February and March under-ice conditions ranged from 1 to 35.6 NTU, and laboratory-measured turbidity ranged from 0 to 24 NTU (MW 1997and 1998).

4.4.3.4 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 trace metals concentrations are low in the Beaufort Sea (MMS 1996). Open-water concentrations for arsenic, chromium, lead, and mercury were below detection limits for samples collected near Point Thomson (URS 1998). Barium concentrations were determined to range from 0.015 to 0.020 mg/L (URS 1998).

4.4.3.5 Hydrocarbons

Background water hydrocarbon concentrations in the Beaufort Sea tend to be low, generally less than 1 part per billion and appear to be biogenic. Sediment aliphatic and aromatic hydrocarbon levels are relatively high in comparison with other undeveloped outer continental shelf areas. The hydrocarbon composition differs from most other areas because they are largely fossil-derived. The hydrocarbon sources primarily are on the onshore coal and shale outcrops and natural petroleum seeps that are drained by rivers into the Beaufort Sea (Steinhauer and Boehm 1992). The aliphatic hydrocarbons range from 5 to 41 ppt dry weight. Most of these are higher molecular weight alkanes (n-C21 to n-C34) which are characterized by odd-carbon dominance, indicating a biogenic source from terrestrial plant materials. The presence of lower molecular weight alkanes (0.3 to 1.2 parts per million) also suggests widespread presence of naturally occurring petroleum hydrocarbons in the sediments (MMS 1996).

This page intentionally left blank

4.5 MARINE BENTHOS

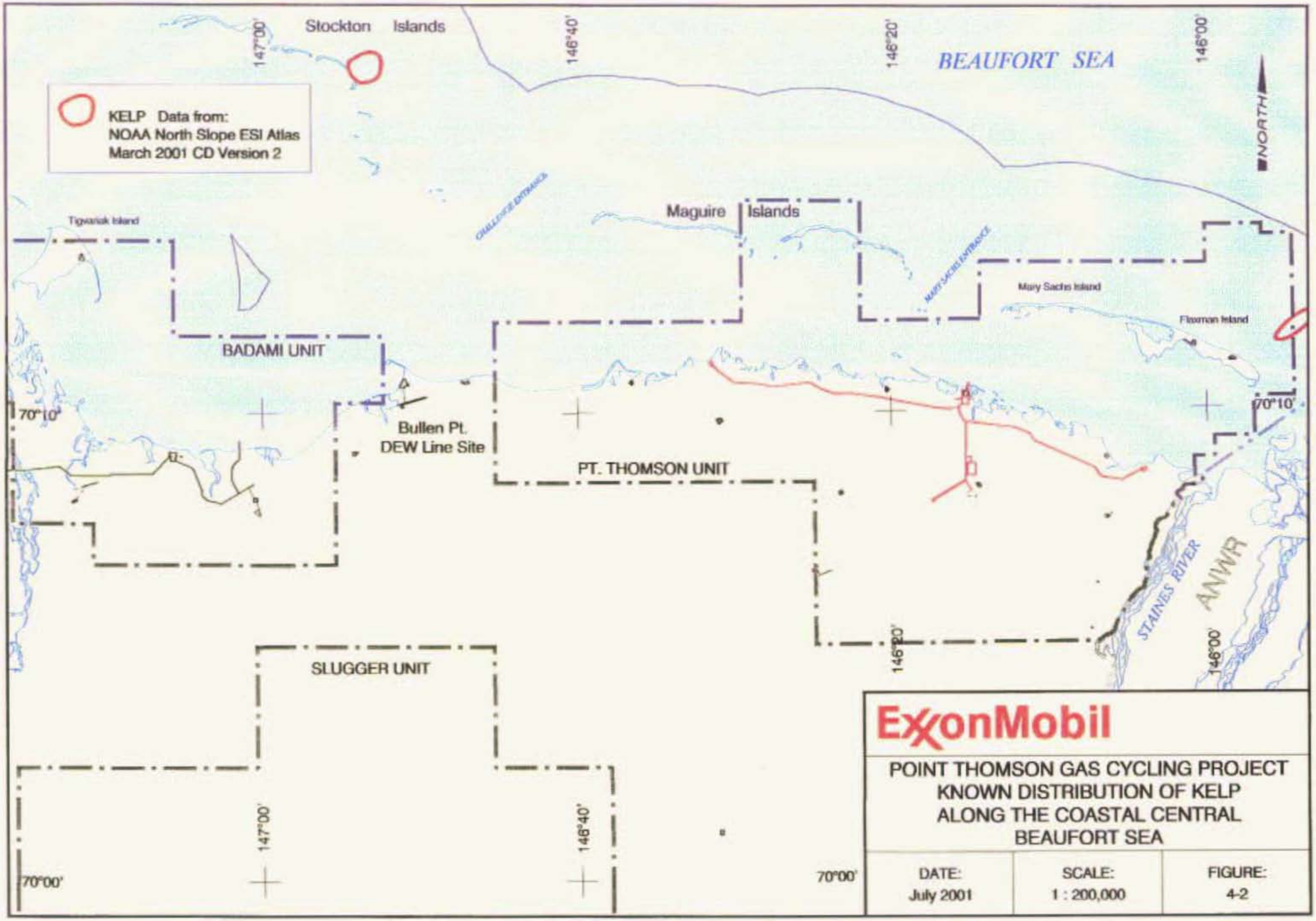
Most of the nearshore seabed of the Alaskan Beaufort Sea consists of a soft-bottom featureless plain comprised of mud or sand. The benthic communities associated with soft-bottom benthic habitat include microalgae, bacteria, and invertebrates. Benthic invertebrates typically are classified as either 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 Final Environmental Impact Statements for Sales 97, 109, 124, and 144 (MMS 1987a, 1987b, 1990, and 1996, respectively) and by Thorsteinson (1983).

Epibenthos is defined as benthic invertebrates that reside on or near the surface of the substrate. In general, epibenthic species diversity and abundance increase as water depth increases. The proportion of longer-lived sessile or sedentary species also increases as compared to the more motile and opportunistic species found closer to shore in shallower waters. The presence of the shore-fast ice in the nearshore zone (waters <6 ft (1.8 m) deep) prevents most species from over-wintering in this zone. Therefore, the nearshore benthic community is dominated by motile, opportunistic species that can re-colonize the area after the ice melts in the spring (Broad 1977, Broad et al. 1978, Feder et al. 1976, Grider et al. 1977 and 1978, and Chin et al. 1979). The most abundant groups in this zone include epibenthic amphipods, mysids, and isopods.

Infaunal organisms live within the substrate and, as a result, often are sedentary. As mentioned above, relatively few species are found in nearshore waters with depths less than 2 m (6.6 ft). Any polychaetes and clams found in this zone protect themselves from the harsh and variable substrate conditions by burrowing into the sediment. Other infaunal organisms such as oligochaete worms and clams increase in abundance toward the deeper edge of this zone, reflecting the greater substrate stability found further offshore (LGL et al. 1998). Although shore-fast ice can occur in the shallower end of the inshore zone, the diversity and biomass of infauna increase and species composition changes in the inshore environment where water depths range from 2 to 10 m (6.6 to 33 ft). This zone can support a greater diversity of benthic organisms and up to about 10 times the biomass of the nearshore zone. Polychaetes represent 70 to 80 % of the total infauna at water depths ranging from 15 to 30 ft (4.5 to 9 m) (Carey 1978).

Although there are no studies that have examined the benthic community specifically in Lions Lagoon, information from studies in similar Beaufort Sea habitats can be extrapolated (Carey and Ruff 1977). Based on the results of this study, the benthic community of the lagoon is likely to be composed primarily of infaunal invertebrates (e.g., polychaetes, clams, and various crustaceans) and epifaunal invertebrates (e.g., amphipods, isopods, and mysids). Since depths within Lions Lagoon do not exceed 16 to 20 ft (5 to 6 m), low benthos density and diversity is expected, as is characteristic within the nearshore zone of other areas along the Beaufort Sea coast. Boulder/cobble substrate needed to support boulder patch communities (i.e. large material/boulders) has not been observed at the proposed dock area or elsewhere in Lions Lagoon. However two distinct areas with kelp habitat have been found seaward of the barrier islands (Figure 4-2).

This page intentionally left blank



ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
KNOWN DISTRIBUTION OF KELP
ALONG THE COASTAL CENTRAL
BEAUFORT SEA

DATE:	SCALE:	FIGURE:
July 2001	1 : 200,000	4-2

fig4_2.dgn

4.6 VEGETATION AND WETLANDS

The proposed Point Thomson Gas Cycling project is located on the ancient Canning River alluvial fan. The physical environment controls most plant growth and establishment. Geomorphic processes are responsible for initiating open habitats for colonization and succession. Wind-oriented lakes dominate the Canning River coastal zone and the area west of the alluvial fan which starts at the southern limit to Mikkelsen Bay. The shallow thaw-lakes of the northern coastal plain follow a cyclic pattern of formation and drainage. Thaw-lakes originate from low-center polygons and tundra ponds by wind-driven thermokarst erosion during the warm season (Britton 1957; Carson and Hussey 1961; Billings and Peterson 1980). Lakes grow and coalesce until they are captured by a stream and drain out. Following drainage the wet basins are colonized, within a few years, by pioneer graminoid plant and moss species (Ovendon 1986). The floristic composition of the basins changes gradually over time while the ice-wedge polygonization in the permafrost of the underlying sediments re-asserts itself near the surface. One result of this reassertion is the appearance of low center polygons, which is followed by erosion of the polygon rims and the beginning of a new cycle. The time dimension of this cyclic change is variable and essentially unknown. It has been estimated at between 1500 and 2500 years (Billings and Peterson 1980). Initial plant invaders and successional sequences vary within and between regions due to localized aspects of the physical environment. For instance, the degree of drainage varies considerably between individual basins and even within a single basin. Thaw lakes are relatively uncommon on the Canning River inland fan zone where the dominant soil types are more coarsely graded.

The project area has been described as lowland loess with wet minerotrophic tundra (Carter 1988; Walker and Everett 1991). Calcareous loess (pH 6.0 to 8.4) downwind of the Canning River favors the development of minerotrophic plant communities (Walker and Everett 1991). Three gradients associated with loess deposition contribute to the regional soil patterns:

- a gradient of mineral material added to the peat soils downwind of the Canning River
- a gradient of soil particle sizes associated with distance from the loess source
- a pH gradient associated with the carbonate rich aeolian material

The soils in this region have a relatively high silt content, high pH, and lower organic material content when compared with acidic regions of the coastal plain (Tedrow 1977; Gersper et al. 1980). As a consequence of the lowered organic content of the soil, water retention increases downwind from the river. The higher mineral content increases bulk density in the soils which in turn decreases the insulating capacity of the soil and generally results in a greater summer depth of thaw. Loess deposition also influences soil nutrient availability directly by mineral additions and indirectly by altering the cation exchange capacity, which is dependent upon the content of organic material due to the relatively low clay content of these alkaline tundra soils (Bilgin 1975 and Walker and Everett 1991). Phosphorus availability may be particularly affected by pH values in the soil since at low pH (<6) it forms insoluble compounds with iron, aluminum and manganese. At higher pH values (>7) phosphates react with calcium and calcium carbonates to form insoluble calcium phosphates (Schlesinger 1991). These patterns are particularly important because phosphorus has been shown to be the primary limiting nutrient in Prudhoe Bay tundra. It was the only primary nutrient to have significant effects on the recovery of oil-damaged wet tundra and abandoned mesic to dry silt-loam road surfaces (McKendrick and Mitchell 1978 and

McKendrick 1987). The high deposition of loess downwind from the Canning River acts to maintain the vegetation in an early successional state (Walker and Everett 1991). Loess may also have important effects on other ecosystem processes and components, such as production and mineralization rates, invertebrate populations, shorebirds and mammals (Walker and Everett 1991).

A vegetation survey was conducted in the Point Thomson area in 1998 (Noel and Funk 1999). The boundary of the surveyed area runs along the coast from Point Hobson to the western edge of the Staines River, including Point Thomson and Flaxman Island (Figure 4-3). The majority of the southern boundary extends approximately 1 to 2 mi (2 to 3 km) inland. Exceptions are a corridor along the Staines River that extends approximately 7.5 mi (12 km) inland, and the Point Thomson area, where the boundary extends to the southwest up to 3 mi (5 km). A total of 32,990 acres (13,356 hectares [ha]) was mapped. An additional 11-mi (18-km) gap (9091 acres [3681 ha]) between the western edge of the area mapped for Point Thomson and the eastern edge of the Badami map was recently completed. The final vegetation map for the Point Thomson project area (Figure 4-3), which also includes part of the Badami area previously mapped (BPXA 1995), encompasses a total of 52,759 acres (21,287 ha).

Seventy-seven species of vascular plants and 17 non-vascular plants were identified during collection of ground reference data for the Point Thomson vegetation map. No threatened or endangered plant species are known to occur in the proposed project area. Seven species of rare vascular plants occur on the North Slope and may be found within or near the proposed project area (Murray and Lipkin 1987 and 1997). For example, *Mertensia drummondii* is considered a species of concern (formerly a candidate species) under the Endangered Species Act (ESA) and could be present in localized areas of active dunes near the mouths of streams and rivers. This small (12-16 cm tall) vascular plant has been found in areas of moderately active sand dunes on the Meade River at Atkusuk and the Kogusukruk River near Umiat (Murray and Lipkin 1987). *Potentilla stipularis* occurs in sandy substrates, such as sandy meadows and riverbank silts. *Pleuropogon sabinei* is an aquatic grass that rarely occurs between the *Arctophila* and *Carex* zones in lakes and ponds. *Draba adamsii* has been found near Barrow in eroding turfy polygons near the ocean or streams. *Poa hertzii* is a grass known from sites on the Meade River and within ANWR where it occurs on dry sands in active floodplains. *Erigeron muirii* may occur on some drier soils such as ridges along rivers but it has generally been reported at more inland sites near the foothills. *Aster pygmaeus* is known from sites east of the National Petroleum Reserve-Alaska (NPRA) and is found growing on mudflats and saline soils. However, none of these rare plant species were found during collection of ground reference data for the vegetation map.

The project area is mostly covered by water (35.3 %), including subtidal bays and inlets, rivers, streams, lakes and ponds (Table 4-4 and Figure 4-3). Predominant vegetation types are Moist Sedge, Dwarf Shrub/Wet Sedge tundra complexes (30.3 %) and Moist Sedge, Dwarf Shrub Tundra (22.7 %). Moist Sedge, Dwarf Shrub/Wet Sedge tundra complexes are typically found in high- and low-center polygon areas and in weakly developed strangmoor (reticulated tundra). *Salix* spp., *Dryas integrifolia*, mesic *Carex* spp., and a number of forbs dominate the polygon rims or high centers (Table 4-5).

Other vegetation types include Wet Sedge Tundra (2.6 %) and Dry Dwarf Shrub Lichen Tundra, including crustose and fruticose lichens (2.1%), with the remaining vegetation types each account for less than 2% of the study area (Table 4-4). Salt marsh areas cover 2.9% of the study area. Human disturbances (gravel roads and pads and associated washouts) cover 0.2 % of the study area and are confined to exploratory pads constructed in the Point Thomson area.

Most of the vegetation types in the study area are considered to be wetlands (Table 4-5). Exceptions are the well-drained dwarf shrub, crustose and fruticose lichen communities associated with pingos and some high-center polygons, respectively, and partially vegetated sand dunes. Some riparian areas also are likely to be upland due to their gravel substrate and infrequent inundation. Tundra disturbed by gravel fill also may be converted to upland depending on the thickness of the fill.

Table 4-4 Area and Percent of Area Covered by Vegetation Types in the Point Thomson Study Area, Alaska

VEGETATION TYPE[1]	LEVEL C CODES	TOTAL AREA	
		ACRES	PERCENT
Water (bays, lagoons, inlets, subtidal rivers, tidal rivers, streams, lakes, and ponds)	Ia	18,624.4	35.3
Salt Marsh		1511.6	2.9
Wet Graminoid Tundra (wet saline tundra, saltmarsh)	IIIb	*545.4*	*1.0*
Wet Barren/Wet Graminoid Tundra Complex (barren/saline tundra complex, saltmarsh)	IXh	*286.4*	*0.5*
Dry Barren/Forb, Graminoid Complex (saline coastal barrens)	IXi	*679.8*	*1.3*
Aquatic Graminoid Tundra	IIb	228.3	0.4
Water/Tundra Complex	IId	167.4	0.3
Wet Sedge Tundra	IIIa	1383.4	2.6
Wet Sedge Tundra/Water Complex	IIIc	538.0	1.0
Moist Sedge, Dwarf Shrub Tundra/ Wet Sedge Tundra Complex		15,990.5	30.3
Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex (wet patterned ground complex)	IIId	*7010.5*	*13.3*
Wet Graminoid, Dwarf Shrub Tundra/Barren Complex (frost-scar tundra complex)	IIIe	*347.4*	*0.7*
Moist Sedge, Dwarf Shrub/Wet Graminoid Tundra Complex (moist patterned ground complex)	IVa	*8632.6*	*16.4*
Moist Sedge, Dwarf Shrub Tundra		11,961.4	22.7
Moist Sedge, Dwarf Shrub Tundra	Va	*9076.3*	*17.2*
Moist Graminoid, Dwarf Shrub Tundra/ Barren Complex (frost-scar tundra complex)	Ve	*2885.1*	*5.5*
Moist Tussock Sedge, Dwarf Shrub Tundra	Vb	2.3	<0.1
Dry Dwarf Shrub, Crustose Lichens	Vc	689.0	1.3
Dry Dwarf Shrub, Fruticose Lichens	Vd	422.5	0.8
Dry Barren/Dwarf Shrub, Forb Grass Complex	IXb	250.6	0.5
Dry Barren/Forb Complex	IXc	21.5	<0.1
Dry Barren/Grass Complex	IXe	6.1	<0.1
Dry Barren/Dwarf Shrub, Grass Complex	IXf	4.7	<0.1
River Gravels/Beaches	Xa	308.8	0.6
Bare Peat, Wet Mud		565.6	1.1
Wet Mud	XIa	*532.4*	*1.0*
Bare Peat	XIc	*32.2*	*0.1*
Gravel Roads and Pads (and washouts)		84.1	0.2
Barren Gravel Outcrops	Xc	*4.8*	*<0.1*
Gravel Roads and Pads	Xe	*79.3*	*0.2*

Table 4-5 Vegetation and Wetland Types that Occur in the Point Thomson Area, Alaska

VEGETATION TYPE	LEVEL C TYPES[1]	WETLAND TYPE[2]	DESCRIPTION/DOMINANT PLANT SPECIES
Water	Bays, lagoons, inlets, subtidal rivers (Ia)	Estuarine subtidal (E1UBL).	Low energy brackish water.
	Rivers and streams (Ia)	Riverine, permanently and tidally influenced (R1UBV, R2UBH, R3UBH).	Includes tidally influenced rivers upstream from ocean derived salinity.
	Lakes/Ponds (Ia)	Lacustrine (L1UBH, L2UBH) and Palustrine (PUBH) waterbodies.	
Salt Marsh	Wet Graminoid Tundra (IIIb)	Estuarine emergent intertidal (E2EM1N, E2EM1P).	Regularly and irregularly flooded salt marsh. Species present are comparable to those described above.
	Wet Barren/Wet Graminoid Tundra Complex (IXh)	Estuarine intertidal, regularly flooded mud flats (E2USN, E2USP) with emergent intertidal (E2EM1P).	Regularly and irregularly flooded salt marsh with large patches of unvegetated, exposed intertidal sediments. Species include Puccinellia phryganodes, Carex subspathacea, C. ursina, Dupontia fisheri, Stellaria humifusa, Cochlearia officinalis.
	Dry Barren/Forb Graminoid Complex (IXi)	Unknown (original vegetation salt-killed); possibly was saturated scrub shrub emergent wetlands (PSS/EM1B).	Coastal vegetation Intermittently flooded by saltwater resulting in death of original vegetation. New colonizers include Puccinellia spp., Carex ursina, Stellaria humifusa, and Cochlearia officinalis.
Aquatic Graminoid Tundra	Aquatic Graminoid Tundra (IIb)	Lacustrine (L2EM2H) and Palustrine (PEM1H) permanently flooded emergent marshes.	Arctophila fulva occurs in deep water areas, whereas Carex aquatilis, Eriophorum angustifolium and E. scheuchzeri occur in shallow water areas.
Water/Tundra Complex	Water/Tundra Complex (IId)	Lacustrine(L2UB/EM2H) and Palustrine (PUB/EM2H, PUB/EM1H) complexes of open water and emergent vegetation.	Dominated by open water interspersed with patches of emergent Aquatic Graminoid Tundra (see above). Moist microsites are dominated by species found in Wet Sedge Tundra and Moist Sedge, Dwarf Shrub Tundra (see above).
Wet Sedge Tundra	Wet Sedge Tundra (IIIa)	Palustrine PEM1B, PEM1E saturated wet sedge meadows. Some wet sedge meadows also may be permanently or semi-permanently flooded (PEM1H, PEM1F).	Carex aquatilis, C. rotundata, C. saxatilis, and Eriophorum spp. Dupontia fisheri is frequently codominant along the coast.
Wet Sedge Tundra/Water Complex	Wet Sedge Tundra/Water Complex (IIIc)	Lacustrine (L2EM2/UBH) and Palustrine (PEM1/UBH) complexes of emergent vegetation and open water.	Similar to above except that vegetation is dominant and emergent vegetation is not typically found in the open water areas. Wet Sedge Tundra is the dominant community type (see above).

Table 4-5 (Cont.) Vegetation and Wetland Types that Occur in the Point Thomson Area, Alaska

VEGETATION TYPE	LEVEL C TYPES[1]	WETLAND TYPE[2]	DESCRIPTION/DOMINANT PLANT SPECIES
Moist Sedge, Dwarf Shrub Tundra/ Wet Sedge Tundra Complex	Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex (IIId)	Complexes of palustrine scrub shrub, wet sedge meadows (PSS/EM1B) and saturated wet sedge meadows (PEM1B, PEM1E). Some wet sedge meadows also may be permanently or semi-permanently flooded (PEM1H, PEM1F).	Patterned ground dominated by Moist Sedge, Dwarf Shrub Tundra (see above) on low-center polygon rims and high-center polygon centers. Wet Sedge Tundra (see above) occurs in the basins of the low-center polygons and in the troughs of the high-center polygons. Frost-scarred barren areas also are associated with this complex.
	Wet Graminoid, Dwarf Shrub Tundra/Barren Complex (IIIe)	see above	see above
	Moist Sedge, Dwarf Shrub/Wet Graminoid Tundra Complex (IVa)	see above	see above
Moist Sedge, Dwarf Shrub Tundra	Moist Sedge, Dwarf Shrub Tundra (Va)	Palustrine saturated scrub shrub emergent wetlands (PSS/EM1B).	High-center polygons comprising Salix pulchra, S. arctica, S. reticulata, Dryas integrifolia, Carex misandra, C. bigelowii, and C. atrofusca. Frost-scarred barren areas also are associated with this type.
	Moist Graminoid, Dwarf Shrub Tundra/Barren Complex (Ve)	see above	see above
Moist Tussock Sedge, Dwarf Shrub Tundra	Moist Tussock Sedge, Dwarf Shrub Tundra (Vb)	Palustrine saturated emergent and scrub shrub wetlands (PEM/SS1B).	Dominated by tussock cottongrass (Eriophorum vaginatum) with other sedges including E. angustifolium, Carex bigelowii, and C. misandra. Common shrubs include Dryas integrifolia, Salix reticulata, and S. planifolia sp. Pulchra). Dominant forbs include Cassiope tetragona, and Polygonum viviparum. These communities occur between lake-basins and on the sides of pingos, in better-drained soils.
Dry Dwarf Shrub, Crustose Lichens	Dry Dwarf Shrub, Crustose Lichens (Vc)	Upland	Well drained sites (commonly pingos) consisting of Dryas integrifolia, Salix rotundifolia, S. phlebophylla, Carex rupestris, and a diversity of legumes and other forbs. Exposed mineral soil is covered with crustose lichens.

Table 4-5 (Cont.) Vegetation and Wetland Types that Occur in the Point Thomson Area, Alaska

VEGETATION TYPE	LEVEL C TYPES[1]	WETLAND TYPE[2]	DESCRIPTION/DOMINANT PLANT SPECIES
Dry Dwarf Shrub, Fruticose Lichens	Dry Dwarf Shrub, Fruticose Lichens (Vd)	Upland and palustrine emergent moist/wet sedge meadows (PEM1B, PEM1E). Some wet sedge meadows also may be permanently or semi-permanently flooded (PEM1H, PEM1F).	Well-drained high-center polygons with narrow, well-developed polygon troughs. Vegetation on the high centers is similar to Dry Dwarf Shrub (see above), with the addition of Cassiope tetragona and Vaccinium vitis-idaea and mesic forbs (e.g., Saxifraga punctata and Pyrola grandiflora). Exposed peaty soil covered with fruticose lichens.
Dry Barren/Dwarf Shrub, Forb Grass Complex	Dry Barren/Dwarf Shrub, Forb Grass Complex (IXb)	Upland and palustrine, temporarily flooded riparian open shrub (PSS/EM1A)	Diverse assemblage of shrubs, grasses, and forbs on a moderately well-drained gravel substrate. Species include Salix rotundifolia, S. phlebophylla, S. reticulata, Dryas integrifolia, Deschampsia caespitosa, Alopecurus alpinus, Poa glauca, Astragalus alpinus, Epilobium latifolium, and Artemisia arctica.
Dry Barren/ Forb Complex	Dry Barren/ Forb Complex (IXc)	Palustrine partially vegetated emergent persistent well drained (PEM1/USD)	Seasonally flooded, well drained areas on river floodplains that are partially vegetated with Epilobium latifolium, Artemisia arctica, and Wilhelmsia physodes.
Dry Barren/Grass Complex	Dry Barren/Grass Complex (IXe)	Upland	Coastal sand dunes partially vegetated with Elymus arenarius.
Dry Barren/Dwarf Shrub, Grass Complex	Dry Barren/Dwarf Shrub, Grass Complex (IXf)	Upland	Partially vegetated sand dunes. Species include Salix ovalifolia, Artemisia borealis, A. glomerata, Deschampsia caespitosa, Trisetum spicatum.
River Gravels	River Gravels (Xa)	Riverine, seasonally flooded areas (R2USC, R3USC).	
Bare Peat, Wet Mud	Wet Mud (XIa)	Exposed Lacustrine (L2USD) and Palustrine (PUSD) peat and sediments.	Drained lake basins.
	Bare Peat (XIc)	see above	see above
Gravel Roads and Pads (and washouts) (Xe, Xc)	Barren Gravel Outcrops (Xc)	Upland/Unknown	Wetland status of gravel washouts on tundra depends on thickness of gravel fill.
	Gravel Roads and Pads (Xe)	see above	see above

[1] Taken from Noel and Funk (1999) with recent revisions and based on Level C (in parentheses) of *A hierarchical tundra vegetation classification especially designed for mapping in northern Alaska* (Walker 1983).

[2] Study area was not specifically classified and mapped into wetland types, but rather vegetation types were reclassified into wetland types, based on USFWS National Wetland Inventory (NWI) nomenclature (Cowardin et al 1979).

Figure 4-3 is a map located in a pocket at the end of the report.

This page intentionally left blank

4.7 FISH

4.7.1 Fish of the Beaufort Sea

Forty-five species of fish reported to live in the Alaskan Beaufort Sea are listed in Table 4-6. These fish can be classified in terms of three principal life histories: freshwater, diadromous, or marine. As per Gallaway and Fechhelm (2000), the term diadromous is used to describe the ciscoes, whitefish and Dolly Varden char that migrate between freshwater and coastal habitats on an annual basis. The terms "anadromous" and "amphidromous" are more descriptive of the migration pattern, but the generic term diadromous is used here simply to identify those species that migrate through the nearshore lagoon during seasonal movements to and from freshwater and coastal habitats. By definition, most freshwater species spend their entire lives in rivers and lakes of the North Slope and generally avoid saline waters, although some species like Arctic grayling (*Thymallus arcticus*) and round whitefish (*Prosopium cylindraceum*) may move down river and enter low-salinity estuarine waters during early summer. Diadromous species, such as Dolly Varden char (*Salvelinus malma*), arctic cisco (*Coregonus autumnalis*), broad whitefish (*C. nasus*) and least cisco (*C. sardinella*) migrate back and forth each summer between upriver over-wintering areas and feeding grounds in Beaufort Sea coastal waters. Most marine species inhabit deeper offshore waters and are rarely reported in the North Slope coastal zone. Notable exceptions are Arctic cod (*Boreogadus saida),* fourhorn sculpin (*Myoxocephalus quadricornis*) and Arctic flounder (*Pleuronectes glacialis*), which specifically migrate into shallow, low-salinity coastal waters and estuaries during summer.

4.7.2 Diadromous and Freshwater Fish

The distribution of diadromous fish in the Beaufort Sea is primarily from two major population centers—the Mackenzie River system of Canada in the east and the Colville River and ACP systems of Alaska in the west (Craig 1984). Most of the major river systems along the 373-mi (600-km) coastline between the Mackenzie and Colville rivers originate in the Brooks Range and are termed "mountain streams" (Craig and McCart 1975). They are shallow throughout their courses and provide little over-wintering habitat except for that associated with warm-water perennial springs (Craig 1989), or rehabilitated mine sites. Dolly Varden char and Arctic grayling are the two principal species that inhabit these mountain streams, although lakes associated with these drainages may contain lake trout (*S. namaycush*) and grayling. Ninespine stickleback (*Pungitius pungitius*) are also prevalent in drainages within the western portion of the "mountain stream" range. While small runs of pink salmon (*Oncorhynchus gorbuscha*) occur in the Sagavanirktok and Colville rivers, and spawning populations of chum salmon (*O. keta*) inhabit the Colville and Mackenzie rivers (Craig and Haldorson 1986; Moulton 2001), the remaining salmon species consist of individuals from southern populations (e.g., Bering Sea) and are considered incidental visitors to the Beaufort Sea (Craig and Haldorson 1986).

Arctic cisco in the Alaskan Beaufort Sea originate from spawning grounds in the Mackenzie River system of Canada (Gallaway et al. 1983, 1989). Fry emerge by spring break-up in late May to early June and are swept downstream to coastal waters, where they begin feeding in the brackish waters near the Mackenzie Delta. Young-of-the-year are transported away from the Mackenzie region by wind-generated currents. In years with predominant easterly winds, some young-of-the-year are transported westward to Alaska by wind-driven coastal currents (Gallaway et al. 1983, Fechhelm and Fissel 1988, Moulton 1989, Fechhelm and Griffiths 1990, Schmidt et al. 1991, Underwood et al. 1995, and Colonell and Gallaway 1997). They arrive in the Prudhoe Bay area from mid-August to mid-September. In summers with strong and persistent east winds, enhanced westward transport can carry fish to Alaska's Colville River where they take up winter residence. They return to the Colville River every fall for overwintering until the onset of sexual maturity beginning at about age 7, at which point they migrate back to the Mackenzie River to spawn (Gallaway et al. 1983). The rearing Arctic cisco constitute one of the most abundant diadromous species found in the Alaskan Beaufort Sea, so much so that they support a very small commercial fishery in the Colville River and a subsistence fishery at the village of Nuiqsut (George and Kovalsky 1986; George and Nageak 1986; Moulton et al. 1990, 1992, and 1993; Moulton and Field 1988, 1991, and 1994; and Moulton 1994, 1995, 1996, and 1997).

Table 4-6 Species Taken in Nearshore and Offshore Waters of the Western and Central Beaufort Sea

Clupeidae	**Liparidae**
Pacific herring (*Clupea pallas)*	Leatherfin lumpsucker (*Eumicrotremus derjugini*)
Salmonidae	Snailfish (*Liparis sp.*)
Arctic cisco *(Coregonus autumnalis)*	**Agonidae**
Bering cisco (*Coregonus laurettae*)	Arctic alligatorfish (*Aspidophoroides olriki*)
Broad whitefish (*Coregonus nasus*)	**Stichaeidae**
Humpback whitefish (*Coregonus pidschian)*	Slender eelblenny (*Lumpenus fabricii*)
Least cisco (*Coregonus sardinella*)	Stout eelblenny (*Lumpenus medius*)
Pink salmon *(Oncorhynchus gorbuscha*)	Fourline snakeblenny (*Eumesogrammus praecisus*)
Round whitefish (*Prosopium cylindraceum*)	**Pholidae**
Dolly Varden (*Salvelinus malma*)	Rock gunnel (*Pholis gunnellus*)
Arctic grayling (*Thymallus arcticus*)	Anarhichadidae
Osmeridae	Wolf-eel (*Anarrhichtys ocellatus*)
Capeline (*Mallorus villosus*)	**Ammodytidae**
Rainbow smelt (*Osmerus mordax*)	Pacific sandlance (*Ammodytes hexapterus*)
Gadidae	**Gasterosteidae**
Polar cod (*Arctigadus glacialis*)	Threespine stickleback (*Gasterosteus aculeatus*)
Arctic cod (*Boreogadus saida*)	Ninespine stickleback (*Pungitius pungitius*)
Saffron cod (*Eleginus navaga*)	**Pleuronectidae**
Burbot (*Lota lota*)	Arctic flounder (*Liopsetta glacialis*)
Zoarcidae	Starry flounder (*Platichthys stellatus*)
Fish doctor *(Gymnelis viridis)*	Alaska plaice (*Pleuronectes quadrituberculatus*)
Saddles eelpout *(Lycodes mucosus)*	**Hexagrammidae**
Canadian eelpout *(Lycodes polaris)*	Kelp greenling (*Hexagrammos decagrammus*)
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*)	
Great sculpin (*Myoxocephalus polycanthocephalus*)	
Fourhorn sculpin (*Myoxocephalus quadricornis*)	
Ribbed sculpin (*Triglops pingeli*)	

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

4.7.3 Freshwater Habitat

The proposed Point Thomson Gas Cycling Project area is located in the "mountain stream" zone of the North Slope. The principal freshwater habitat consists of the Staines and Canning Rivers immediately to the east and the Shaviovik and Kavik Rivers situated about 31 mi (50 km) to the west. Both systems support populations of Dolly Varden (Inupiaq name Aqalupiaq), grayling (Inupiaq name Sulukpaugaq), and ninespine stickleback, with the Canning River also containing round whitefish, burbot, and slimy sculpin. The coastal tundra ponds and lakes between the Staines and Shaviovik rivers have the potential to contain populations of ninespine stickleback (Ward and Craig 1974). Seven tundra-origin streams between the Staines River and East Badami Creek contain ninespine stickleback (WCC and ABR 1983).

The Staines and Canning river system is considered important summer feeding habitat for Dolly Varden char. Juvenile Dolly Varden char remain within their natal streams for several years prior to their first seaward migration (Craig 1977a, 1977b and 1989). There is also a component of the population that consists of non-diadromous males that remain within their natal rivers for their entire life (Craig 1977a and 1977b). Fish age 2 and younger and non-diadromous males would therefore reside and feed in these riverine environments throughout the summer.

Rivers are the obligatory migratory routes for diadromous Dolly Varden char and ninespine stickleback in spring and late summer. Arctic grayling and round whitefish may also move down river in early summer to brackish-water estuaries and coastal areas while the nearshore region is still relatively fresh from the high runoff associated with breakup (Moulton and Fawcett 1984).

Over-wintering space is limited in North Slope rivers, particularly for Dolly Varden char, which require higher dissolved oxygen levels than arctic grayling. Craig (1989) postulated that the small amount of over-wintering habitat available to diadromous fish could be the most important factor limiting population size and causing cyclical fluctuations in species abundance. Dolly Varden char spawn in the fall and require perennial warm-water springs for successful wintering and reproduction. These springs provide fish with open-water habitat throughout the winter and prevent eggs from freezing (Craig 1984). Craig and McCart (1974) identified numerous Dolly Varden over-wintering areas in the Canning River, and to a more limited extent in the Shaviovik and Kavik rivers. However, the authors note that:

> "...this report concerns only those areas known to be important. Additional spawning and over-wintering sites will undoubtedly be located in the future."

Freshwater species may enter deep-water lakes and isolated river channels during winter. There are two major independent streams that empty into Mikkelsen Bay east of the Shaviovik/Kavik River. Ward and Craig (1974) identified them merely as First Unnamed Stream East of Kavik River and Second Unnamed Stream East of Kavik River. More recently, Hemming (1996) referred to these to drainages as No Name River and East Badami Creek, respectively. This report adheres to the latter nomenclature. Hemming (1996) described No Name River as:

> "...a 42-mi (67-km) coastal system that drains a 147 square mi (380 km^2) tundra area. The river mouth is located 1.6 mi (2.5 km) east of the Shaviovik River. No Name River is a single channel system with extensive gravel bars. Vegetated terraces are found on both sides of the active channel. The active channel is 173 to 330 ft (70 to 100 m) wide in the lower part of the drainage in late summer. Water depth does not exceed 6.5 ft (2 m)"

and East Badami Creek as:

> "...a 15.5 mi (25 km) long single channel system. The active channel is 33 to 50 ft (10 to 15 m) wide in late summer. East Badami Creek has a gravel bar deposit on the inside of meander bends with tundra vegetation occurring on the cutbank side. Cutbanks are less than 6.6 ft (2 m). Water depth does not exceed 6.6 ft and substrate materials are composed of gravel."

Fyke net surveys reported high numbers of ninespine stickleback in both East Badami Creek and No Name River, with catch rates ranging from 243 to 1,525 fish/day (Hemming 1996). A few juvenile Dolly Varden were collected in East Badami Creek ($N = 3$) and No Name River ($N = 9$) and a single grayling and a single round whitefish were reported for No Name River.

Visual surveys of six additional streams between East Badami Creek and the Staines River, ranging in length between 9 and 20 mi (15 and 32 km), found ninespine stickleback in all, and fourhorn sculpin in the estuarine portion of one (WCC and ABR 1983). Sampling results from East Badami Creek and No Name River (Hemming 1996) indicate that juvenile Dolly Varden, and possibly other diadromous species, may enter these streams to feed during early summer when stream flow is high.

Ward and Craig (1974) surveyed some of the larger lakes along the North Slope. Of these, nine were located between the Staines and Kavik Rivers and within 25 mi (40 km) of the coast. Numerous small tundra ponds and drainage streams characterize much of the coastal area between the East Badami Creek and the Staines River. These streams all support ninespine stickleback during summer, but most are shallow and freeze solid during winter; however the occasional deep pool might serve as a limited over-wintering area for a few ninespine stickleback (WCC and ABR 1983). These ponds and streams may be exploited to a greater degree during the open-water summer season. Ninespine stickleback and juvenile Dolly Varden char move up and down the coast in large numbers during summer and could enter and feed in any inland water body that is connected to the sea. Arctic grayling, broad whitefish and least cisco have also been reported to move between North Slope rivers during the summer (Hemming 1993, Moulton; and George 2000). It is probable that fish utilize the smaller tundra ponds and streams between Mikkelsen Bay and the Staines River in a similar manner.

4.7.4 Coastal Habitat

The prominent coastal feature in the Point Thomson area is Lions Lagoon. As in previous nearshore studies conducted in nearshore areas located to the west (Griffiths and Gallaway 1982; Critchlow 1983; Griffiths et al. 1983; WCC 1983; Moulton et al. 1986; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993, 1994a, and 1994b; Reub et al. 1991; and Griffiths et al. 1995, 1996, and 1997), the lagoon exhibits highly variable temperature and salinity through the summer, with lowest salinity and highest temperature early in the summer (LGL 2000b). The water becomes more marine as summer progresses, river flows decrease and offshore water is transported into the lagoon. In early to mid-July 1999, salinity was near 5 parts per thousand (ppt) in the study region (LGL 2000b). Salinity remained low at stations east of Point Thomson, gradually increasing to near 20 ppt by early August and 30 ppt by mid August. In contrast, stations at or west of Point Thomson had salinity increases to 20-25 ppt in mid-July, with salinity generally remaining high for the remainder of the summer. Water temperatures demonstrated the expected inverse trend, with the eastern stations tending to be warmer than the western stations, with temperatures decreasing during summer. In early to mid July, water temperatures ranged to 45 to 46°F (7 to 8°C), decreasing to 37 to 39°F (3 to 4°C) by mid-August (LGL 2000b).

This barrier-island lagoon system is a major migratory pathway for diadromous species, including Dolly Varden char from the Staines/Canning and Shaviovik/Kavik drainages as well as other North Slope river systems. Other abundant diadromous species using the lagoon include Arctic cisco and least cisco, with broad whitefish and humpback whitefish present in lower numbers (LGL 2000b). Sampling in the lagoon during 1999 also revealed some use by Arctic grayling and round whitefish (LGL 2000b). Ninespine stickleback are tolerant of high salinity (Fechhelm et al. 1996) and are found throughout Lions Lagoon regardless of water quality.

4.7.4.1 Arctic Cisco

Despite the inability of the mountain streams between the Colville and Mackenzie rivers to support spawning populations of adult Arctic cisco (Inupiaq name Tipuk), nearly all summer studies conducted along that portion of the coast have caught substantial numbers of these fish (Craig and Mann 1974; Griffiths et al. 1975 and 1977; West and Wiswar 1985; Wiswar and West 1987; Griffiths 1983; Fruge et al. 1989; and Underwood et al. 1995). This coast-wide distribution implies extensive summer dispersal from major over-wintering areas in the Colville and Mackenzie rivers. Lions Lagoon is no exception, although the abundance of adult Arctic cisco tends to fluctuate throughout the summer as schools of fish pulse through the area. During 1999, Arctic cisco were the most abundant fish caught by fyke nets in the lagoon (LGL 2000b).

Data collected over years of study in the Prudhoe Bay region suggest that the mountain rivers east of the Sagavanirktok River do not provide over-wintering areas for large numbers of juvenile Arctic cisco including young-of-the-year (YOY) that are transported westward along the coast (Griffiths and Gallaway 1982; Critchlow 1983; Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Moulton et al. 1986; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993, 1994a and 1994b; Reub et al. 1991; and Griffiths et al. 1995, 1996, and 1997). As a general rule, if there is no recruitment of YOY to the Colville/Sagavanirktok region, there is no appreciable recruitment of that year class (i.e. age cohort) in following summers (Fechhelm and Griffiths 1990). These year-class gaps eventually manifest themselves in the commercial and Native subsistence fisheries of the Colville River (Moulton et al. 1990, 1992 and 1993; Moulton and Field 1988, 1991 and 1994; and Moulton 1994 and 1995).

The unknown entity in this hypothesis has always been the Canning River. It is the third largest drainage on the Alaskan North Slope, which implies some over-wintering capability. However, no major studies have been conducted in the lower delta. Underwood et al. (1995) reported taking substantial numbers of small Arctic cisco (4 to 5 in [100 to 120 millimeters (mm)] in length; approximate size for one-year old fish) at Simpson Cove, located 19 mi (30 km) east of the Canning River, in July of 1988 and 1990. Whether these young fish came from the Sagavanirktok River (81 mi [130 km] west), the Mackenzie River (223.7 mi [360 km] east), or possibly the nearby Canning River is unknown. Results from sampling in 1999 suggested that wintering capacity in the Point Thomson/Canning River area is very limited (LGL 2000b). Few age 1 and age 2 Arctic cisco were caught early in the open-water period. Catches did not increase until after a period of sustained easterly winds, which suggested that the fish moved into the region from areas to the east. Recruitment of these year classes (1997 and 1998) was strong in the Prudhoe Bay region, so if suitable wintering areas were present in the Point Thomson region, the early season catches should have been much higher.

4.7.4.2 *Least Cisco*

The only source population of least cisco in the region is from the Colville River. Adult least cisco regularly reach the Sagavanirktok Delta during summer (Griffiths and Gallaway 1982; Critchlow 1983; Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Moulton et al. 1986; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993, and 1994a, 1994b; Reub et al. 1991; and Griffiths et al. 1995, 1996, and 1997). They have also been reported to be extremely abundant in Mikkelsen Bay, 93 mi (150 km) east of the Colville River and 25 mi (40 km) west of Lions Lagoon (LGL and WCC 1996). Underwood et al. (1995) reported substantial numbers of least cisco at Simpson Cove in the summer of 1990 but not in 1988, 1989, and 1991. During 1999, least cisco were fourth in abundance of all species caught in Lions Lagoon. The vast majority of these least cisco were in excess of 10 in (250 mm), which indicates the least cisco reaching this far east were almost all mature adults. A total of 23 tagged least cisco were caught, with all the recoveries coming from fish that had been released in the Prudhoe Bay region from 1990 to 1993. Since least cisco caught in Prudhoe Bay are considered to originate exclusively from the Colville River (LGL 2000b), the capture of these tagged fish is additional evidence that least cisco found in the Point Thomson region are also likely to be from the Colville River.

Juvenile least cisco are not expected in the Lions Lagoon area. Juveniles (<7 in [180 mm]) from the Colville River disperse as far east as the eastern end of Simpson Lagoon, approximately 50 mi (80 km), in only one of every two years (Fechhelm et al. 1994). It is doubtful that the dispersal range of these small fish would extend another 56 to 62 mi (90 to 100 km) eastward to Lions Lagoon. Catches of small least cisco were low in Mikkelsen Bay during the summer of 1995, despite the fact that large catches were reported in the Prudhoe Bay/Sagavanirktok Delta area (Griffiths et al. 1997). Juvenile least cisco were essentially absent from Lions Lagoon in 1999 (LGL 2000b).

4.7.4.3 *Broad Whitefish*

The potential source populations of broad whitefish (Inupiaq name Kausilik) in this portion of the coastal Alaskan Beaufort Sea region include the Sagavanirktok and Colville rivers. Of the four diadromous species of major interest over the years, broad whitefish have been monitored because they are believed to be the least tolerant of high salinity, and therefore would be sensitive to coastal development. Young fish (age 2 and younger) from the Sagavanirktok and Colville river populations tend to remain near the low-salinity waters of the delta throughout much of the open-water season (Griffiths and Gallaway 1982; Critchlow 1983; Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Moulton et al. 1986; Moulton and Fawcett 1984; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993, 1994a, and 1994b; Reub et al. 1991; and Griffiths et al. 1995, 1996, and 1997). Few young fish were found in Mikkelsen Bay in 1995 (Fechhelm et al. 1996) or in Lions Lagoon in 1999 (LGL 2000b). In 2000, only three broad whitefish of the 491 caught were less than 280 mm.

Older broad whitefish (age 3 and older) disperse farther from their natal rivers than do juveniles, regularly moving between the Sagavanirktok and Colville rivers (Moulton et al. 1986; Cannon et al. 1987; Moulton and Field 1994) through Simpson Lagoon. Adult broad whitefish were also abundant in Mikkelsen Bay in 1995 (Fechhelm et al. 1996) and were caught in Lions Lagoon in 1999. Broad whitefish caught in Lions Lagoon were primarily between 280-480 mm in length.

Fish of this size are consistent with broad whitefish ranging from ages 4 to 15 from the Saganvanirktok River (LGL 2000b). Broad whitefish catches reported for the eastern Alaskan Beaufort Sea have been nominal to nil (Griffiths 1983, West and Wiswar 1985, Wiswar and West 1987, Fruge et al. 1989, and Underwood et al. 1995).

4.7.4.4 Humpback Whitefish

Humpback whitefish (Inupiaq name Qaalriq) in the Alaskan Beaufort Sea are considered to originate from the Colville River. Humpback whitefish were rare in fish monitoring studies in and around Prudhoe Bay from 1981 to 1995 (Griffiths and Gallaway 1982; Critchlow 1983; Griffiths 1983; Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Moulton and Fawcett 1984; Fawcett et al. 1986; West and Wiswar 1985; Moulton et al. 1986; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993, 1994a, and 1994b; Reub et al. 1991; and Griffiths et al. 1995, 1996, and 1997), although they had been relatively abundant in limited monitoring efforts prior to the construction of the West Dock causeway, located on the northwest corner of Prudhoe Bay (Furniss 1974). Humpback whitefish catches in Prudhoe Bay increased following construction of a breach in West Dock in winter 1995-1996, leading to speculation that the prior lack of humpback whitefish on the east side of West Dock reflected a restriction of the eastward dispersal from the Colville River (Fechhelm 1999). During sampling in Lions Lagoon in 1999, the mean catch rate of humpback whitefish (0.65 fish per day) exceeded that observed during Prudhoe Bay studies in any year between 1985 and 1995 (maximum = 0.42 fish per day), although the 1999 catch rate was considerably lower than either 1996 or 1997 at Prudhoe Bay (4.1 and 6.2 fish per day). Evidence that humpback whitefish caught in Lions Lagoon are not likely to be from Mackenzie River stocks is provided by results of sampling to the east of the Canning River. Humpback whitefish were not caught in sampling along the Arctic National Wildlife Refuge (ANWR) coast (Camden Bay, Kaktovik/Jago Lagoon, Beaufort Lagoon and Pokok Bay) in 1988 and 1989 (Fruge et al. 1989; andPalmer and Dugan 1990).

4.7.4.5 Marine Species

Fourhorn sculpin, Arctic flounder, and Arctic cod are regularly taken in nearshore coastal waters in virtually all areas of the Beaufort Sea during summer (Craig and Haldorson 1981; Griffiths and Gallaway 1982; Critchlow 1983; Griffiths 1983; Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Moulton and Fawcett 1984; Fawcett et al. 1986; West and Wiswar 1985; Moulton et al. 1986; Cannon et al. 1987; Wiswar and West 1987; Fruge et al. 1989; Dugan and Palmer 1990; Glass et al. 1990; LGL 1990, 1991, 1992, 1993, 1994a, and 1994b; Reub et al. 1991; Griffiths et al. 1995, 1996 and 1997; Underwood et al. 1995; and Fechhelm et al. 1996). They were also abundant in Lions Lagoon in 1999 (LGL 2000b). Fourhorn sculpin was second in abundance behind Arctic cisco. Saffron cod were more abundant that Arctic cod and Arctic flounder, but all were consistently caught in the lagoon.

This page intentionally left blank

4.8 BIRDS

The Point Thomson area, located between the Badami development and the Staines River, has been the site of bird research periodically since the early 1980s. Wright and Fancy (1980) and WCC and ABR (1983) conducted limited ground-based studies of birds in the Point Thomson area. Additional research on bird populations and habitats was conducted to the east of the Point Thomson area in ANWR during the 1002 Area studies conducted from 1984 to 1986 (Garner and Reynolds 1986) and along the Canning River (Martin and Moitoret 1981). More recently, bird studies were conducted inland from Point Thomson at the Yukon Gold exploratory ice pad (TERA 1993) and in the Badami area (TERA 1994). In recent years, LGL (Noel et al. 1999a, 2000), TERA (1999 and 2000), and the United States Fish and Wildlife Service (USFWS) (Petersen et al. 1999; Flint et al. 2001) have conducted aerial surveys for waterfowl, eiders, and ducks in the nearshore and tundra habitats of the Point Thomson area. Local residents (primarily Iñupiaq Eskimos from Kaktovik) hunt birds in the Point Thomson region as an essential element of their subsistence lifestyle.

Johnson and Herter (1989) estimated that approximately 10 million birds of over 240 species occur in the Beaufort Sea region. Nearly all bird use on the ACP of Alaska is concentrated in the summer months (May–September) when snow-free nesting habitats, forage, and open water are available. Only a few species remain in the area during the winter, when food resources are scarce. In the Point Thomson area, WCC and ABR (1983) recorded 57 species of birds using tundra and nearshore habitats (Table 4-7).

Birds occurring in the region can be divided into three major species groups: waterfowl, tundra-nesting birds, and predatory birds. General abundance, distribution, and habitat use are addressed below for the species in each group, based largely on information from baseline studies at Point Thomson and elsewhere on the North Slope (Spindler 1976, Martin and Moitoret 1981, WCC and ABR 1983, Gardner et al. 1986, Garner and Reynolds 1986, Moitoret et al. 1996, Johnson and Herter 1989, Murphy and Anderson 1993, TERA 1993, Noel et al. 1999a and 2000, and Johnson et al. 2000). Most of these studies focused on study areas affected by current or future oil development, but they also include studies conducted in ANWR since the late 1970s.

4.8.1 Waterfowl & Other Waterbirds

The Point Thomson region supports 23 species of waterfowl (tundra swan, geese, eiders, and other ducks) and other waterbirds (loons, grebes, and seabirds) including seven species that breed in the area (Table 4-7).

4.8.1.1 Tundra Swan

Tundra swans are common breeders on the ACP and have been recorded breeding in the Point Thomson area (Johnson and Herter 1989; Byrne et al. 1994; Johnson et al. 1999). Tundra swans have served as indicators of regional ecosystem health since they are sensitive to human disturbance and often nest at the same location year after year (King 1973 and Ritchie et al. 1990). Therefore, changes in their activities and distribution can provide a measure of the effects

Table 4-7 Common and Scientific Names, Status, and Relative Abundance of Birds Occurring on the Arctic Coastal Plain of Alaska and those Species Recorded in the Point Thomson Region, Alaska

COMMON NAME	SCIENTIFIC NAME	INUPIAQ NAME	STATUS[A]	RELATIVE ABUNDANCE[B]
Short-tailed Shearwater	*Puffinus tenuirostris*	--	Visitant+	Uncommon
Red-throated Loon	*Gavia stellata*	qaqsrauq	Breeder*	Common
Pacific Loon	*Gavia pacifica*	malbi	Breeder*	Common
Common Loon	*Gavia immer*	taasifiq	Visitant+	Casual
Yellow-billed Loon	*Gavia adamsii*	tuullik	Migrant+	Uncommon
Horned Grebe	*Podiceps auritus*		Visitant	Casual
Red-necked Grebe	*Podiceps grisegena*	aqpaqsruayuuq, sublitchauraq	Breeder	Uncommon
Greater White-fronted Goose	*Anser albifrons*	niblivik	Breeder+	Common
Emperor Goose	*Chen canagica*	mitilugruaq	Visitant	Accidental
Snow Goose	*Chen caerulescens*	kafuq	Breeder+	Uncommon
Canada Goose	*Branta canadensis*	iqsrabutilik	Breeder*	Common
Brant	*Branta bernicla*	niblinbaq	Breeder*	Common
Tundra Swan	*Cygnus columbianus*	qugruk	Breeder+	Common
American Wigeon	*Anas americana*	kurugabnaq	breeder+	Uncommon
Mallard	*Anas platyrhynchos*	kurugaqtaq	Visitant+	Rare
Northern Shoveler	*Anas clypeata*	alluutaq, qaqjutuuq	Breeder+	Uncommon
Northern Pintail	*Anas acuta*	kurugaq	Breeder+	Common
Green-winged Teal	*Anas crecca*	qaiffiq	Breeder	Uncommon
Canvasback	*Aythya valisineria*		Visitant	Casual
Greater Scaup	*Aythya marila*	qaqjuqpalik	breeder+	Uncommon
Lesser Scaup	*Aythya affinis*	qaqjutuuq	Breeder?	Casual
Steller's Eider	*Polysticta stelleri*	igniqauqtuq	Visitant	Casual
Spectacled Eider	*Somateria fischeri*	qavaasuk	Breeder*	Uncommon
King Eider	*Somateria spectabilis*	qifalik	Breeder*	common
Common Eider	*Somateria mollissima*	amauligruaq	Breeder*	Uncommon
Surf Scoter	*Melanitta perspicillata*	avixuqtuq	Visitant+	Rare
White-winged Scoter	*Melanitta fusca*	killalik	Visitant+	Rare
Black Scoter	*Melanitta nigra*	tuungaagrupiaq	Visitant+	Rare
Long-tailed Duck	*Clangula hyemalis*	aaqhaaliq	Breeder*	Common
Common Goldeneye	*Bucephala clangula*		Visitant	Casual
Red-breasted Merganser	*Mergus serrator*	paisugruk, aqpaqsruayuuq	Breeder+	Uncommon
Bald Eagle	*Haliaeetus leucocephalus*	tifmiaqpak	Visitant	Casual
Northern Harrier	*Circus cyaneus*	papiktuuq	Visitant+	Uncommon
Sharp-shinned Hawk	*Accipiter striatus*		Visitant+	Rare
Rough-legged Hawk	*Buteo lagopus*	qixbiq	Visitant+	Rare
Golden Eagle	*Aquila chrysaetos*	tifmiaqpak	Visitant+	Uncommon
Gyrfalcon	*Falco rusticolus*	aatqarruaq	Visitant	Rare
Peregrine Falcon	*Falco peregrinus*	kirgavik	Visitant+	Rare
Willow Ptarmigan	*Lagopus lagopus*	aqargiq, nasaullik	Resident*	Uncommon
Rock Ptarmigan	*Lagopus mutus*	niksaaktufiq	Resident*	Common
Sandhill Crane	*Grus canadensis*	tatirgaq	Breeder+	Rare
Black-bellied Plover	*Pluvialis squatarola*	tullivak	Breeder*	Common
American Golden-Plover	*Pluvialis dominicus*	tullik	Breeder*	Common
Semipalmated Plover	*Charadrius semipalmatus*	kurraquraq	Breeder+	Rare

Table 4-7 (Cont.)

COMMON NAME	SCIENTIFIC NAME	INUPIAQ NAME	STATUS[A]	RELATIVE ABUNDANCE[B]
Killdeer	*Charadrius vociferus*	taligvak	Visitant	Casual
Lesser Yellowlegs	*Tringa flavipes*	uviñfuayuuq	Visitant	Casual
Wandering Tattler	*Heteroscelus incanus*	sixixisuqtuq	Visitant	Casual
Upland Sandpiper	*Bartramia longicauda*		Visitant	Casual
Whimbrel	*Numenius phaeopus*	sigguktuvak	Visitant+	Rare
Hudsonian Godwit	*Limosa haemastica*		Visitant	Casual
Bar-tailed Godwit	*Limosa lapponica*	turraaturaq	Breeder+	Uncommon
Ruddy Turnstone	*Arenaria interpres*	tullignaq	Breeder*	Uncommon
Black Turnstone	*Arenaria melanocephala*		Visitant	Casual
Red Knot	*Calidris cauntus*		Migrant+	Casual
Sanderling	*Calidris alba*	kimmitquixaq	Migrant+	Rare
Semipalmated Sandpiper	*Calidris pusilla*	livalivaq	Breeder*	Abundant
Western Sandpiper	*Calidris mauri*		Migrant+	Rare
Red-necked Stint	*Calidris ruficollis*		Visitant	Casual
Least Sandpiper	*Calidris minutilla*	livalivauraq	Migrant+	Casual
White-rumped Sandpiper	*Calidris fuscicollis*		Breeder*	Uncommon
Baird's Sandpiper	*Calidris bairdii*	puviaqtuuyaaq	Breeder*	Common
Pectoral Sandpiper	*Calidris melanotos*	puviaqtuuq	Breeder*	Abundant
Sharp-tailed Sandpiper	*Calidris acuminata*		Visitant	Casual
Dunlin	*Calidris alpina*	qayuuttavak	Breeder*	Common
Stilt Sandpiper	*Calidris himantopus*		Breeder+	Uncommon
Buff-breasted Sandpiper	*Tryngites subruficollis*	satqagiixaq	Breeder*	Uncommon
Ruff	*Philomachus pugnax*		Visitant	Casual
Short-billed Dowitcher	*Limnodromus griseus*		Visitant	Casual
Long-billed Dowitcher	*Limnodromus scolopaceus*	kilyaktalik	Breeder*	Common
Common Snipe	*Gallinago gallinago*	saavbaq, aiviqiaq	Breeder+	Uncommon
Red-necked Phalarope	*Phalaropus lobatus*	qayyiubun	Breeder*	Abundant
Red Phalarope	*Phalaropus fulicaria*	auksruaq	Breeder*	Common
Pomarine Jaeger	*Stercorarius pomarinus*	isuffabluk	Migrant+	Common
Parasitic Jaeger	*Stercorarius parasiticus*	migiaqsaayuk	Breeder+	Common
Long-tailed Jaeger	*Stercorarius longicaudus*	isuffaq	Breeder+	Uncommon
Ringed-billed Gull	*Larus delawarensis*		Visitant	Accidental
Herring Gull	*Larus argentatus*	nauyavvaaq	Visitant+	Casual
Slaty-backed Gull	*Larus schistisagus*		Visitant	Casual
Glaucous-winged Gull	*Larus glaucescens*		Visitant	Casual
Glaucous Gull	*Larus hyperboreus*	nauyavasrugruk	Breeder*	Common
Sabine's Gull	*Xema sabini*	iqirgagiaq	Breeder+	Common
Ross's Gull	*Rhodostethia rosea*	qagmaqluaq	Migrant	Rare
Ivory Gull	*Pagophila eburnea*	igirraq	Migrant	Casual
Arctic Tern	*Sterna paradisaea*	mitqutaixaq	Breeder+	Common
Black Guillemot	*Cephus grylle*		Breeder+	Uncommon
Snowy Owl	*Nyctea scandiaca*	ukpik	Breeder+	Uncommon
Northern Hawk Owl	*Surnia ulula*	niaquqtuabruk	Visitant	Casual
Short-eared Owl	*Asio flammeus*	nipaixuktaq	Breeder+	Uncommon
Common Raven	*Corvus corax*	tulugaq	Resident+	Uncommon
Northern Flicker	*Colaptes auratus*		Visitant	Casual
Common Raven	*Corvus corax*	tulugaq	Resident+	Uncommon
Horned Lark	*Eremophila alpestris*	nagrulik	Visitant+	Casual

Table 4-7 (Cont.)

COMMON NAME	SCIENTIFIC NAME	INUPIAQ NAME	STATUS[A]	RELATIVE ABUNDANCE[B]
Tree Swallow	*Tachycineta bicolor*	tulugabnauraq	Visitant+	Casual
Bank Swallow	*Riparia riparia*	tulugabnaq	Visitant	Casual
Cliff Swallow	*Petrochelidon pyrrhonota*	tulugagnauraq	Visitant	Casual
Barn Swallow	*Hirundo rustica*		Visitant	Accidental
Arctic Warbler	*Phylloscopus borealis*	sufaqpaluktufiq	Visitant	Rare
Bluethroat	*Luscinia svecica*		Visitant	Rare
Northern Wheatear	*Oenanthe oenanthe*	tifmiaqpauraq	Visitant	Casual
American Robin	*Turdus migratorius*	kuyapigaqturuq	Visitant	Casual
Varied Thrush	*Ixoreus naevius*	sifutlulluuq	Visitant	Casual
Yellow Wagtail	*Motacilla flava*	piibaq, misiqqaaqauraq	Breeder+	Common
American Pipit	*Anthus rubescens*	piibavik, putukiuxuk	Visitant	Rare
European Starling	*Sturnus vulgaris*		Visitant	Accidental
Orange-crowned Warbler	*Vermivora celata*		Visitant	Casual
Yellow Warbler	*Dendroica petechia*		Visitant	Casual
Black-and-white Warbler	*Mniotilta varia*		Visitant	Accidental
American Redstart	*Setophaga ruticilla*		Visitant	Accidental
Northern Waterthrush	*Seiurus noveboracensis*		Visitant	Accidental
Wilson's Warbler	*Wilsonia pusilla*		Visitant	Casual
American Tree Sparrow	*Spizella arborea*	misapsaq	Breeder	Uncommon
Savannah Sparrow	*Passerculus sandwichensis*	ukpisiuyuk	Breeder+	Common
Fox Sparrow	*Passerella iliaca*	ikxibvik	Visitant	Casual
Lincoln's Sparrow	*Melospiza lincolnii*		Visitant	Casual
White-throated Sparrow	*Zonotrichia albicollis*		Visitant	Casual
Harris's Sparrow	*Zonotrichia querula*		Visitant	Accidental
White-crowned Sparrow	*Zonotrichia leucophrys*	nufaktuabruk	Breeder+	Rare
Golden-crowned Sparrow	*Zonotrichia atricapilla*	qiaranatuuq	Visitant	Casual
Dark-eyed Junco	*Junco hyemalis*	kayatavaurak	Visitant	Casual
Lapland Longspur	*Calcarius lapponicus*	qupaxuk, putukiuxuk	Breeder*	Abundant
Smith's Longspur	*Calcarius pictus*	qalbuusiqsuuq	Visitant	Casual
Snow Bunting	*Plectrophenax nivalis*	amauxxigaaluk	Breeder*	Uncommon
Rusty Blackbird	*Euphagus carolinus*	tulukkatun ittuq	Visitant	Casual
Common Redpoll	*Carduelis flammea*	saksakiq	Breeder+	Uncommon
Hoary Redpoll	*Carduelis hornemanni*	saksakiq	Breeder	Uncommon

[a] Status (Kessel and Gibson 1978): resident — present throughout the year; known to breed
migrant — a seasonal transient between wintering and breeding ranges
breeder — a species known to breed; ? indicates probable or possible breeding
visitant — a nonbreeding species; also, in fall, one not directly en route between breeding and wintering ranges

[b] Abundance abundant — species occurs repeatedly in appropriate habitats, with available habitat heavily used
common - occurs in all or nearly all appropriate habitats, but some areas of presumed suitable habitats are occupied sparsely or not at all
uncommon — species occurs regularly, but uses little of the suitable habitat, not observed regularly even in appropriate habitats
rare — species within its normal range, occurring regularly but in very small numbers
casual —beyond normal range, but not so far that irregular observations are likely over a period of years; usually occurs in small numbers
accidental — a species so far from its normal range that further observations are unlikely; usually occurs singly

Sources: Kessel and Gibson (1978); Wright and Fancy (1980); Martin and Moitoret (1981); WCC and ABR (1983); Johnson and Herter (1989); TERA (1993); Hohenberger et al. (1994); Noel et al. (1999, 2000); Nickles et al. (1987) Field et al. (1988). Common and scientific names follow AOU (1983 and supplements 35–40), and Inupiaq names follow Webster and Zibell (1970), MacLean (1980), Norton et al. (1993), and Kaplan (1996 personal communication). Status: * = confirmed as breeder in Point Thomson study area; + = observed in Point Thomson region but not confirmed as breeding.

of development projects. On the North Slope, tundra swans nest at higher densities on major river deltas (Colville, Sagavanirktok, and Canning Rivers) than across the rest of the coastal plain. The Point Thomson region supports moderate numbers of tundra swans compared to other areas in northern Alaska (Rothe and Hawkins 1982 and Ritchie and King 2000).

Tundra swans inhabit the Point Thomson area from May through September (WCC and ABR 1983). Although the first swans arrive while the tundra is largely snow-covered (mid-May), most arrive 1 to 2 weeks later (Hawkins 1986 and Ritchie and King 2000). As snow melts, pairs move to breeding territories to nest by early June. After eggs hatch in early July, family groups remain together, but often range widely to find food (Johnson and Herter 1989). Before the young fly in mid- to late-September, adults become flightless (molt) for about 3 weeks. During this flightless period, swan broods are sensitive to disturbance. In the Colville delta area, non-breeding swans form large staging flocks (>100 birds), and have been found along river channels (East Channel of the Colville River and lower reaches of the Miluveach and Kachemach Rivers); data are lacking concerning non-breeding swan use of the Staines Canning River area. Fall staging on the coastal plain usually takes place during early to mid-September (Rothe et al. 1983, Smith et al. 1994 and Monda et al. 1994) and fall migration peaks in late September and early October (Johnson and Herter 1989).

Few surveys of nesting tundra swans have been conducted in the Point Thomson region, but nesting density (0.05 nests per square mile [nests/mi^2]) (0.08 nests per square kilometer [nests/km^2]) (Byrne et al. 1994) appears to be lower than has been recorded to the west (0.02–0.10 nests/mi^2 [0.03-0.17 nests/km^2] in the Kuparuk Oil Field, 0.08–0.21 nests/mi^2 [0.13-0.34 nests/km^2] on the Colville River delta, 0.23 birds/mi^2 [0.37 birds/km^2] on the Sagavanirktok River delta [Ritchie and King 2000]). Few swan nests have been found in the Point Thomson area. During ground searches in the Point Thomson area, WCC and ABR (1983) found two nests of tundra swans, both associated with lakes and ponds habitat types. Other swans were seen in June in wet strangmoor habitats (WCC and ABR 1983). During aerial surveys in 1994, Byrne et al. (1994) found that most nesting swans in the region were located between the Sagavanirktok River delta and Mikkelsen Bay and saw only seven swans (and no nests) between Mikkelsen Bay and the Staines River. On the Canning River delta (east of the Point Thomson area), the most common nesting habitat was graminoid-marsh (dominated by *Arctophila fulva* and *Carex aquatilis*), and nests were usually <0.6 mi (<0.97 km) from lakes (Monda et al. 1994).

No surveys have been conducted in the Point Thomson area specifically for brood-rearing swans, but LGL et al. (1999) reported densities of 0.28 swans/mi^2 (0.45 swans/km^2) during aerial surveys of tundra transects in the Point Thomson region. WCC and ABR (1983) recorded no tundra swans during the molting/brood-rearing period (25 July–15 August), but did observe small numbers of swans during staging (19 birds; 23–31 August) and fall migration (42 birds; 12–17 September) in the Point Thomson area. During aerial surveys, WCC and ABR (1983) also noted one staging area for tundra swans in a large lake near the coast southwest of Bullen Point (flocks of 20 and 28 swans with young noted during two aerial surveys). On the Canning River delta, brood-rearing swans occurred primarily in graminoid-marsh, graminoid-shrub-water sedge, and aquatic-marsh habitats (Monda et al. 1994). Other studies on the coastal plain have shown that tundra swans occur frequently in habitats supporting the emergent grass *Arctophila fulva*, which is a primary food for adults and young (Bergman et al. 1977; Derksen et al. 1981). Brood-rearing tundra swans prefer aquatic habitats because they provide food and escape cover, especially for the young.

4.8.1.2 Geese

Four species of geese (greater white-fronted goose, Canada goose, brant, and snow goose) regularly nest on the ACP and have been recorded in the Point Thomson region (Johnson and Herter 1989 and WCC and ABR 1983) (see Table 4-7). The distribution of each species differs across the coastal plain and is influenced by their nesting habits. Greater white-fronted and Canada geese nest in isolated pairs on the tundra or on small islands in lakes and ponds. In contrast, brant and snow geese nest primarily in colonies at traditional sites, ranging from a few to several hundred pairs.

The greater white-fronted goose is the most common goose on the ACP, becoming less common east of Prudhoe Bay (Johnson and Herter 1989). Greater white-fronted geese are present on the coastal plain from approximately mid-May to mid-September. They arrive when open tundra appears and begin nesting within 1 to 2 weeks, usually by late May (Rothe et al. 1983 and Johnson and Herter 1989). Eggs hatch in late June and early July. Before the young can fly, adults (breeding and nonbreeding) molt and are flightless for 2 to 3 weeks. During brood-rearing, family groups form large flocks near deep lakes that provide protection from predators. Once adults and young can fly, they form large staging flocks before the migration, which begins in mid-August and ends about mid-September (Johnson and Herter 1989).

Greater white-fronted geese may breed in low numbers in the Point Thomson region, but were not recorded as nesting by WCC and ABR (1983) or Wright and Fancy (1980). Small numbers of greater white-fronted geese were seen during spring arrival and nesting, but they were most numerous during the staging period, suggesting that the area is more important for staging than nesting (WCC and ABR 1983). This conclusion is supported to some extent by the relatively large density (15.0 birds/mi^2 [24 birds/km^2]) of geese seen during aerial surveys in August and September (LGL et al. 1999).

The Canada goose has a patchy distribution across the ACP, with highest densities in the Prudhoe Bay area (Johnson and Herter 1989). Breeding phenology is similar to that described previously for the greater white-fronted goose. In the Point Thomson region, Canada geese are the primary nesting goose species (Wright and Fancy 1980 and WCC and ABR 1983) and have been commonly observed during the breeding season (WCC and ABR 1983). Eight Canada goose nests were located during ground searches in the Point Thomson area in 1983, all in lake and pond habitat type (WCC and ABR 1983). Wright and Fancy (1980) found two Canada goose nests, one in each of their plots (drilling site south of Point Gordon/control site south of Point Sweeny).

The estimated nesting density (3.9 nests/mi^2 [6.3 nests/km^2]) WCC and ABR 1983) in the Point Thomson area was the highest recorded for study sites from Point Thomson to the Prudhoe Bay area (Table 4-8). During aerial surveys of tundra transects during staging in August–September 1998, LGL et al. (1999) reported densities of 4.2 birds/mi^2 (6.8 birds/km^2). Brant nest in low numbers across most of the coastal plain, with larger nesting colonies found on major river deltas, such as those of the Colville, Kuparuk, and Sagavanirktok Rivers (Johnson and Herter 1989 and Sedinger and Stickney 2000). Brant occur in the Point Thomson region from late May through late August (WCC and ABR 1983). They arrive on the coastal plain in early June and move to nesting colonies soon afterwards (Kiera 1979 and Rothe et al. 1983). Hatching begins in late June or early July and brant form large brood-rearing flocks shortly thereafter. Brant depart the coastal plain soon after the young can fly, usually by mid-August.

Table 4-8 Nesting Density (Nests/mi^2) of Birds in the Point Thomson Region and Adjacent Areas on the Arctic Coastal Plain, Alaska

SPECIES	POINT THOMSON (1983)	YUKON GOLD (1993)	CANNING RIVER DELTA (1979–1980)	BADAMI (1994)	KADLER-OSHILIK (1994)	SAGAVAN-IRKTOK RIVER DELTA (1981)	POINT MCINTYRE REFERENCE AREA (1981–1992)
Red-throated Loon				0.8			0.3
Pacific Loon					2.6		3.9
Greater White-fronted Goose					0.8		2.8
Canada Goose	3.9				3.4		0.3
Northern Pintail							0.3
Spectacled Eider					0.8		0.5
King Eider			2.1	1.8	1.8	4.4	3.4
Common Eider	3.9						
Long-tailed Duck	3.9	0.8	2.1	0.8	3.4	4.4	3.4
Willow Ptarmigan							0.3
Rock Ptarmigan			3.9	0.8			0.8
Black-bellied Plover				0.8	1.8	4.4	1.6
American Golden-Plover		2.6	3.9	7.0	4.4	8.5	7.0
Sanderling							0.3
Semipalmated Sandpiper		6.0	25.9	41.4	23.3	30.3	32.4
Western Sandpiper							0.3
White-rumped Sandpiper							1.6
Baird's Sandpiper	50.5			2.6		8.5	1.8
Pectoral Sandpiper	27.2	18.9	31.9	23.3	31.1	4.4	22.5
Dunlin			8.0	8.5	10.4		19.4
Stilt Sandpiper				3.4	3.4		1.8
Buff-breasted Sandpiper			6.0			4.4	2.3
Long-billed Dowitcher	7.8		-	1.8			1.0
Red-necked Phalarope		1.8	14.0	2.6	8.5	4.4	2.3
Red Phalarope	7.8	3.4	47.7	6.0	19.9	13.0	17.6
Parasitic Jaeger							0.3
Lapland Longspur	62.2	38.1	71.5	90.7	64.8	47.4	38.3
Total Density	167.1	73.3	216.9	192.9	180.3	134.2	166.3
Waterfowl	11.7	0.8	4.2	3.4	12.7	8.8	14.8
Shorebird	93.2	32.6	137.3	97.4	102.8	78.0	111.9
Passerine	62.2	38.1	71.5	90.7	64.8	47.4	38.3
Other Birds	0	0	3.9	0.8	0	0	1.3
Number of Species	8	7	11	15	15	11	26
Source	WCC and ABR (1983)	TERA (1993)	Martin and Moitoret (1981)	TERA (1994) in BP (1995)	TERA (1994) in BP (1995)	Troy (1988)	TERA (1993)

Note: Methods varied among studies but all involved nest searches within transects or plots; for multiple-year studies, average densities are presented.

In the central Beaufort Sea region, brant nest primarily at two large colonies between the Staines and Colville Rivers, one on islands in the East Channel of the Colville River and one on Howe Island in the Sagavanirktok River delta (Sedinger and Stickney 2000). In addition, smaller colonies and single nests are found at scattered locations across the coastal plain in this area. In the Point Thomson area, brant have been found nesting (1 nest) on an island in the Staines River delta (Ritchie et al. 1991). Small numbers of brant have been recorded nesting at locations immediately west of the study area on the Shaviovik and Kadleroshilik River deltas and on Tigvariak Island (Ritchie et al. 1990 and 1991; Stickney et al. 1992 and 1993). Nesting habitats of brant have been described for the Colville River delta and include salt-killed tundra, aquatic sedge with deep polygons, brackish water, salt marsh, nonpatterned wet meadow, and wet sedge-willow meadow (Johnson et al. 1999).

No brood-rearing brant have been recorded in the Point Thomson area, but small flocks have been seen on deltas of the Kadleroshilik and Shaviovik Rivers and on Tigvariak Island to the west (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993; Noel and Johnson 1997; Noel et al. 1999c). WCC and ABR (1983) reported small numbers (407 birds) of brant in the Point Thomson area during the molting/brood-rearing period (mid July–mid August). Brood-rearing (and molting) flocks have a strong affinity for coastal and salt-affected habitats because brant feed primarily on *Puccinellia phryganodes* and *Carex subspathacea*, which are found only in saline habitats (Kiera 1979). This habitat type is somewhat limited in the Point Thomson area, but small acreages (<2% of total mapped acreage) of this type can be found near Point Thomson and at scattered locations between the Staines River and Mikkelsen Bay (see Section 4.6). The distance of these habitats from known breeding colonies limits their availability for brood-rearing flocks, although they may be used by birds during staging and migration. Large numbers of brant have been recorded moving westward through the Point Thomson area during the staging and fall migration periods, 5959 and 2526 birds, respectively (WCC and ABR 1983). It is not known if any of these birds used salt-marsh habitats in the Point Thomson area. Small numbers of brant (0.36 birds/mi^2 [0.58 birds/km^2]) were recorded during aerial surveys of lagoon transects in the Point Thomson area during August–September 1998 (LGL et al. 1999).

Snow Geese nest in several colonies and in scattered pairs across the ACP; generally west of the Sagavanirktok River delta (Derksen et al. 1981, Simpson et al. 1982, Johnson 2000, and Ritchie et al. 2000). Three small colonies (~50 to ≥400 nests) have been recorded in the Sagavanirktok, Ikpikpuk, and Kukpowruk River deltas (Ritchie and Burgess 1993; Noel et al. 1998; Johnson 2000; Ritchie et al. 2000; Ritchie 2001). No breeding colonies have been reported in the Point Thomson region (Wright and Fancy 1980 and WCC and ABR 1983), but WCC and ABR (1983) did report sighting of four snow geese during spring arrival (early June). The nesting colony closest to Point Thomson is at Howe Island, on the Sagavanirktok River delta, which has supported limited numbers of nesting snow geese in recent years, due to disruption of nesting by predator/scavengers (Noel et al. 1999c and Noel and Johnson 2001a and 2001b).

Snow geese arrive in coastal nesting areas in late May or early June and young hatch during late June, although breeding phenology can be affected by late snow-melt in nesting areas. Brood-rearing snow geese have been seen in most years immediately west of the Point Thomson area in the vicinity of the Shaviovik River delta and Tigvariak Island (Noel and Johnson 1997 and Noel et al. 1999c). During autumn migration, large numbers (150,000–450,000) of snow geese stage in the eastern coastal plain of ANWR for short periods in early-mid September (Robertson et al. 1997). LGL et al. (1999) did not record any snow geese during aerial surveys of tundra and lagoon transects in the Point Thomson area in August–early September 1998, and WCC and ABR (1983) did not record snow geese during staging or fall migration in the Point Thomson area.

4.8.1.3 Ducks

Ducks on the ACP of Alaska can be separated into three general groups: Arctic breeders (e.g., eiders and long-tailed duck [oldsquaw]); breeders on the edge of their range (e.g., green-winged teal, northern pintail, greater scaup, northern shoveler, American wigeon, and red-breasted merganser); and non-breeders (e.g., scoters and common goldeneye).

Of the 13 species of ducks recorded in the Point Thomson region, four are confirmed breeders: the long-tailed duck, and spectacled, king, and common eiders (Tables 4-7 and 4-8) (Wright and Fancy 1980, WCC and ABR 1983, and TERA 1993). Spectacled eiders are discussed in Section 4.11 Threatened and Endangered Species. King eiders were the most abundant eider seen during aerial surveys for eiders in the Point Thomson region (Byrne et al. 1994 and TERA 1999 and 2000). Northern pintails are common in the Point Thomson area and probably nest in the area, but no nests were found by Wright and Fancy (1980), WCC and ABR (1983), or TERA (1993). Other duck species could potentially be abundant in the Point Thomson region during years when they are displaced by drought from the prairie regions of North America (Derksen and Eldridge 1980). Common eiders nest primarily on the coast and on offshore barrier islands, but breeding pairs also have been recorded at inland sites in the Point Thomson area (TERA 1999 and 2000), suggesting some nesting may occur there. Common eiders regularly nested on the barrier islands between Mikkelsen Bay and the Staines River, with a yearly average of 130 nests total found among the barrier islands searched (Moitoret 1998 and Noel et al. 1999c and 2001). Of the seven major barrier islands in the Point Thomson region, Pole, Alaska, Northstar, and Duchess islands supported the most nesting common eiders (Moitoret 1998 and Noel et al. 1999c).

Like most waterbirds, ducks (including eiders) occur in the Point Thomson region between May and September, when tundra ponds are ice-free. Ducks arrive on the tundra in mid- to late May, begin nesting within 1 to 2 weeks, and depart by late August (Rothe et al. 1983 and North et al. 1984). Male king eiders and long-tailed ducks leave the breeding grounds by mid-June after females commence incubation (Rothe et al. 1983). Duck broods first appear in early to mid-July, and most young can fly by late August (Rothe et al. 1983 and North et al. 1984). Eider broods probably remain in the area longer than other duck species, because their larger size requires more time for young to fledge (become capable of flight).

Information on nesting habitats of ducks in the Point Thomson region is relatively sparse, but WCC and ABR (1983) found breeding pairs in moist and wet tundra habitats and lakes without emergent vegetation. During brood rearing, ducks on the coastal plain primarily use aquatic habitats, particularly those with emergent vegetation. Brood-rearing long-tailed ducks use aquatic sedge and grass marshes, small lakes, and river channels; while molting groups occur more often on large, deep open lakes, tapped lakes, and coastal lagoons. Northern pintails generally use aquatic sedge and grass marshes, flooded tundra, brackish ponds, and salt marshes during brood rearing. In general, all aquatic habitats in the Point Thomson region likely receive some use by ducks for nesting, brood rearing, and foraging.

Aerial surveys for long-tailed ducks have been flown in the Point Thomson region sporadically since 1977 and allow calculations of relative abundance (densities; birds/mi^2 [birds/km^2]) and distribution during the molting (mid-July to 19 August) and post-molting periods (20 August to 20 September) (Noel et al. 1999a and 2000, Petersen et al. 1999, and Flint et al. 2001). During the molting and post-molting periods, long-tailed ducks are abundant along the mainland and in the lagoon system between the Staines River and Mikkelsen Bay, but are less commonly found on the inland tundra (Figures 4-4A and 4-4B). Relative abundance of long-tailed ducks varies among locations along the mainland shore and in the barrier island system of Lions Lagoon. Shorelines immediately east of Point Thomson to a point near Point Gordon received the greatest use during both the molting and post-molting periods (mean = 509 birds/mi^2 [820 birds/km^2]) and 223 birds/mi^2 [360 birds/km^2]), respectively, as calculated from raw data in Noel et al. 1999a and 2000 and Flint et al. 2001), while the shorelines to the east and west of this area were used less. Within Lions Lagoon, the densities of long-tailed ducks varied both from east to west and between the molting and post-molting periods. During the molting period, the density of long-tailed ducks increased from west to east, reaching its highest mean density in the lagoon south of Flaxman Island to Brownlow Point (mean = 102 birds/mi^2 [160 birds/km^2]); calculated from data *in* Noel et al. 1999a and 2000 and Flint et al. 2001). This same general west-east trend also was apparent during post-molting, but the peak abundance shifted westward in the lagoon to the Alaska Island to Flaxman Island area, and the mean density increased three-fold (283 birds/mi^2 [450 birds/km^2]); calculated from data *in* Noel et al. 1999a and 2000 and Flint et al. 2001). Aerial surveys flown at the northern edge of the lagoon in 1999 showed a somewhat similar pattern of distribution and relative abundance, but the post-molting peak abundance had shifted even farther west. Of all the surveys flown, the highest mean densities of long-tailed ducks during both the molting and post-molting periods were recorded on and immediately adjacent to the barrier islands (Noel et al. 1999a and 2000 and Flint et al. 2001). As shown on Figure 4-4A, during molting, the Flaxman Island to Brownlow Point area supported densities (mean = 1001 birds/mi^2 [1600 birds/km^2]); as calculated from data *in* Noel et al. 1999a and 2000 and Flint et al. 2001) about twice those found in transects farther west (means ranged from 356 birds/mi^2 [570 birds/km^2]) to 588 birds/mi^2 [950 birds/km^2]); as calculated from data *in* Noel et al. 1999a and 2000 and Flint et al. 2001). In contrast, offshore (north of the barrier islands) transects had few long-tailed ducks during either the molting or post-molting period (Figure 4-4A and 4-4B).

4.8.1.4 Loons

Three species of loons—yellow-billed, Pacific, and red-throated—breed on the ACP of Alaska. Common loons and two species of grebes are casual visitors or irregular breeders, respectively (see Table 4-7).

Yellow-billed loons are uncommon breeders on most of the ACP and are common breeders only near the Alaktak and Chipp Rivers (Sjolander and Agren 1976 and Johnson and Herter 1989). No nests of yellow-billed loons have been documented in the Point Thomson area, but WCC and ABR (1983) indicated several loons during fall staging (1 bird) and migration (7 birds). Wright and Fancy (1980) also recorded yellow-billed loons at their two study plots near Point Gordon and Point Sweeny. Yellow-billed loons have also been observed on the Canning River delta to the east of Point Thomson (Martin and Moitoret 1981). Low densities (mean density = 0.05 birds/mi^2 [0.08 birds/km^2]) of yellow-billed loons were recorded during aerial transects along the barrier islands of Lions Lagoon in August–September 1998 and 1999 (LGL et al. 1999 and Noel et al. 2000).

Pacific loons are common breeders across the entire coastal plain (Johnson and Herter 1989). They were the most abundant loons observed in the Point Thomson region in 1982 and have been recorded as breeding in the area (WCC and ABR 1983). Pacific loons occur in the project area from early May through September. Pacific loons arrive on the coastal plain in late May as open water appears in river channels and on tundra lakes and ponds; they move to nesting lakes as ice disappears in early to mid-June. After the young hatch in mid-July, they tend to remain in the nesting lake, or move to adjacent lakes. The time required for juveniles to fledge varies among loon species, with the larger yellow-billed and Pacific loons requiring more time than the smaller red-throated loon. Fall migration of loons peaks during early September along the Beaufort Sea (Johnson and Herter 1989), but family groups (adults with young) do not depart until the young can fly, which may be as late as mid-September.

The Pacific loon was the most abundant loon species recorded during aerial surveys in August–September 1998 on tundra transects and second-most abundant on the barrier islands transects in the Point Thomson area (mean density = 0.39 birds/mi^2 [0.63 birds/km^2]) and 0.02 birds/mi^2, [0.03 birds/km^2]) respectively) (LGL et al. 1999). In 1999, Noel et al. (2000) found that Pacific loons predominated in the lagoon system of the Point Thomson area during August–September surveys.

Limited information on habitat use by Pacific loons in the Point Thomson area indicates use of lakes and ponds with and without emergent vegetation, and also wet low-centered polygons (probably in standing water) (WCC and ABR 1983). On the Colville River delta, Pacific loons nested on islands and shorelines of all types of waterbodies and also in terrestrial habitats bordering lakes, such as aquatic sedge, salt marsh, salt-killed tundra, nonpatterned wet meadow, and wet sedge–willow meadow (Johnson et al. 1999b). Broods were observed in the same aquatic habitats where nests were found. Pacific loons feed primarily on aquatic invertebrates available in their breeding lakes (Bergman and Derksen 1977, North 1986, and Kertell 1994) and nearshore marine waters (Andres 1993).

The red-throated loon is a common breeder on the ACP, including the Point Thomson region (Johnson and Herter 1989 and Johnson et al. 1999a). Red-throated loons were less abundant than Pacific loons during all periods of the breeding season in the Point Thomson area (WCC and ABR 1983). Two red-throated loon nests were found in the Point Thomson area, both in the lake and pond habitat type (WCC and ABR 1983).

The breeding cycle and habitat use of red-throated loons differs from that of other loons. Red-throated loons arrive on the coastal plain later than the other species, usually not until early June when open water appears in tundra ponds. The timing of breeding events, however, is similar to that of yellow-billed and Pacific loons. Red-throated loons nest on smaller (often <3 acres [1.2 ha]), shallower ponds than do the other species (Johnson and Herter 1989 and Dickson 1994; McIntyre 1994). On the Colville River delta, habitats used by red-throated loons for nesting and brood-rearing include brackish water, salt-killed tundra, deep open lakes, shallow lakes, aquatic sedge, nonpatterned wet meadow, and wet sedge–willow meadow (Burgess et al. 2000 and Johnson et al. 2000). In other locations on the coastal plain, red-throated loons use both sedge and grass marshes, but they also use basin wetland complexes, especially during brood rearing (Bergman et al. 1977 and Derksen et al. 1981).

In contrast to the other loons, who do most of their feeding in their nesting lakes, red-throated loons fly to nearshore marine waters to hunt fish for their young (Bergman and Derksen 1977).

This behavior may account for the relatively greater abundance of red-throated loons compared to pacific loons in the barrier islands and lagoons in the Point Thomson area during August–September (0.21 birds/mi^2 [0.34 birds/km^2] and 0.10 birds/mi^2 [0.16 birds/km^2], respectively) (LGL et al. 1999). Nesting lakes are not used for feeding, probably because few fish survive when these shallow lakes freeze to the bottom in winter.

4.8.2 Tundra-Nesting Birds

Tundra-nesting birds of the Point Thomson region include shorebirds, ptarmigan, and songbirds (see Table 4-7). These bird species nest primarily in terrestrial habitats, rather than in association with aquatic habitats.

4.8.2.1 Shorebirds

Shorebirds are present on the Point Thomson region from May to September. They begin to arrive in late May, and most are present by mid-June. Nesting usually begins 7 to 10 days after arrival. The young hatch during late June to mid-July, and fledge 3 to 4 weeks later. After the breeding season, many shorebirds move to the coast to feed in shoreline habitats before beginning migration in August (Rothe et al. 1983, Andres 1989 and 1994, and Smith and Connors 1993).

Of the 21 species of shorebirds recorded in the Point Thomson region, 10 are confirmed breeders, based on nests or broods (see Table 4-7). Ground-based studies of shorebirds have been limited in the Point Thomson region but do include surveys for breeding shorebirds (WCC and ABR 1983), and a study at the Yukon Gold ice pad about 6 mi (10 km) south of Point Thomson (TERA 1993). Martin and Moitoret (1981) also conducted a shorebird study on the Canning River delta, east of the Point Thomson area. WCC and ABR (1983) found that the most common nesting shorebirds in the Point Thomson region were the Baird's sandpiper, pectoral sandpiper, red phalarope, and long-billed dowitcher. Both the diversity and density of shorebirds on the Point Thomson region during the breeding season were less than those found elsewhere on the ACP (Table 4-8).

Shorebirds breeding on the Point Thomson region use many habitats for nesting and brood-rearing. Plovers nested on the drier upland habitats, and phalaropes and other sandpiper species nested in wetter tundra habitats, including wet sedge meadows, wet nonpatterned tundra, and aquatic sedge and grass marshes (WCC and ABR 1983). During brood rearing, shorebirds move to tundra and aquatic habitats adjacent to the nest sites. After the young fledge, many shorebirds form large feeding flocks, often of mixed species, that tend to congregate in coastal habitats (Smith and Connors 1993). Large movements of shorebirds to coastal habitats were not seen in the Point Thomson area, although use of coastal marshes has been observed (WCC and ABR 1983). Shorebirds with broods were seen using lakes with and without emergent vegetation, wet strangmoor, and coastal marshes. These habitats, along with the others used for breeding activities, are the primary source of food (insects and other small invertebrates) for the birds (Andres 1989 and Johnson and Herter 1989). The coastal shift in habitat use by shorebirds continued during the staging and fall migration periods in the Point Thomson area (WCC and ABR 1983).

4.8.2.2 Ptarmigan

Rock and willow ptarmigan are widespread on the ACP, particularly inland from the coast (Johnson and Herter 1989). Although both species were seen in the Point Thomson area, only rock ptarmigan were confirmed as breeding (Wright and Fancy 1980 and WCC and ABR 1983) (see Table 4-7). Most rock ptarmigan were seen in the moist non-patterned habitats in the area (WCC and ABR 1983). A few ptarmigan of either species may overwinter in the Point Thomson region, but most winter in the foothills of the Brooks Range (Johnson and Herter 1989).

4.8.2.3 Songbirds

Songbirds occur on the ACP only during summer; with the exception of two redpoll species. Most songbirds winter in temperate and tropical regions of the Americas or southern Asia. Of the eight species recorded in the Point Thomson area, only four are confirmed breeders (Tables 4-7 and 4-8). The other species occur in the region during migration or as summer vagrants. Overall, nest densities of songbirds in the Point Thomson area are near the lower end of nesting densities reported for other locations on the ACP. The most abundant breeding species in the Point Thomson region is the Lapland longspur (see Table 4-8). Lapland longspurs were found nesting in most habitat types in the Point Thomson area, but the majority of nests were found in moist habitats (WCC and ABR 1983), wet sedge meadows, and *Dryas* tundra (Wright and Fancy 1980). In the Prudhoe Bay area, the highest densities of Lapland longspur nests occur in polygonized wet and moist meadows (Troy 1988).

4.8.3 Predatory Birds

Predatory birds recorded in the Point Thomson region include raptors (seven species), gulls (three species), jaegers (three species), arctic tern, and common raven (see Table 4-7). Except for the common raven, which is a year-round resident, all of these species winter farther south (Johnson and Herter 1989).

4.8.3.1 Raptors

None of the raptors (eagles, hawks, falcons, and owls) that occur on the ACP is a regular breeder in the Point Thomson region. Snowy and short-eared owls are locally common breeders on the coastal plain during years when small mammals are abundant (Johnson and Herter 1989). They probably nest in the project area during those times. Most raptors that breed regularly in northern Alaska are more common inland than on the outer coastal plain (Johnson and Herter 1989). Riparian bluffs in the foothills between the Canning and Sagavanirktok rivers offer fair to excellent breeding habitats for diurnal species including peregrine falcons, gyrfalcons, and rough-legged hawks. Many raptors seen near the coast are juveniles, failed breeders, or migrants. Immature golden eagles frequent the coastal plain in summer (Young et al. 1995). A few peregrine falcons and rough-legged hawks do nest in coastal areas and may be attracted to man-made structures for nesting (Ritchie 1991). Rough-legged hawks have nested on an airport tower at the Bullen Point Dewline site (R. J. Ritchie, ABR, Inc., pers. com.). Thus, although the Point Thomson area is used by raptors, it is not an important nesting area.

The Arctic peregrine falcon (*Falco peregrinus tundrius*) was removed from the threatened list by the USFWS on 5 October 1994 (59 FR 50796), and the species has now completed the 5-year monitoring period that follows delisting, when it was treated as a species of concern. Currently, the Arctic peregrine falcon receives no special considerations from regulatory agencies based on the Endangered Species Act, but still receives some protections under the Migratory Bird Treaty Act (16 U.S.C. 703-712). Peregrines generally have been considered as infrequent visitors to the coastal plain (Pitelka 1974 and Johnson and Herter 1989) and regular breeders inland (Cade 1960 and Pitelka 1974). However, recent surveys in the National Petroleum Reserve–Alaska suggest that individuals from the increasing population of peregrines have selected more marginal habitats including low mud bluffs on the ACP (Ritchie and Wildman 2000; Wildman and Ritchie 2000).

The largest concentrations of breeding Arctic peregrine falcons occur along rivers in the northern foothills of the Brooks Range, especially the central Colville River and its tributaries (Cade 1960 and White and Cade 1971), the Sagavanirktok River (Ambrose et al. 1988), and the transition zone between the foothills and coastal plain (Ritchie and Wildman 2000; Wildman and Ritchie 2000). In the Point Thomson region, Arctic peregrine falcons have been located nesting in foothill sections of all major rivers between the Sagavanirktok and Canning rivers (Wildman and Ritchie 2000); the nearest known nest sites occur on the lower Canning and Kavik rivers (Ambrose et al. 1988 and Wildman and Ritchie 2000) and Barter Island (Fran Mauer, USFWS, pers. comm.). Only a few Arctic peregrine falcon sightings have been reported in the Point Thomson area: one near Point Sweeny in 1980 (Wright and Fancy 1980) and one seen during late summer in 1983 (WCC and ABR 1983). Arctic peregrine falcon use of the area probably includes occasional hunting forays during summer by adults, movements of young birds after leaving the nest, and transient and migratory use.

4.8.3.2 Other Species

Other predatory birds that occur in the project area include gulls, jaegers, and the Arctic tern (see Table 4-7). Two species of gulls (glaucous and Sabine's) breed in the region (see Table 4-7); both are common to uncommon breeders on the ACP (Johnson and Herter 1989). Both species nest either as isolated pairs or in small colonies; small colonies of Sabine's gulls have been found on the Canning River delta (Martin and Moitoret 1981). Glaucous gulls also nest on the barrier islands offshore of the Point Thomson area (Noel et al. 1999b).

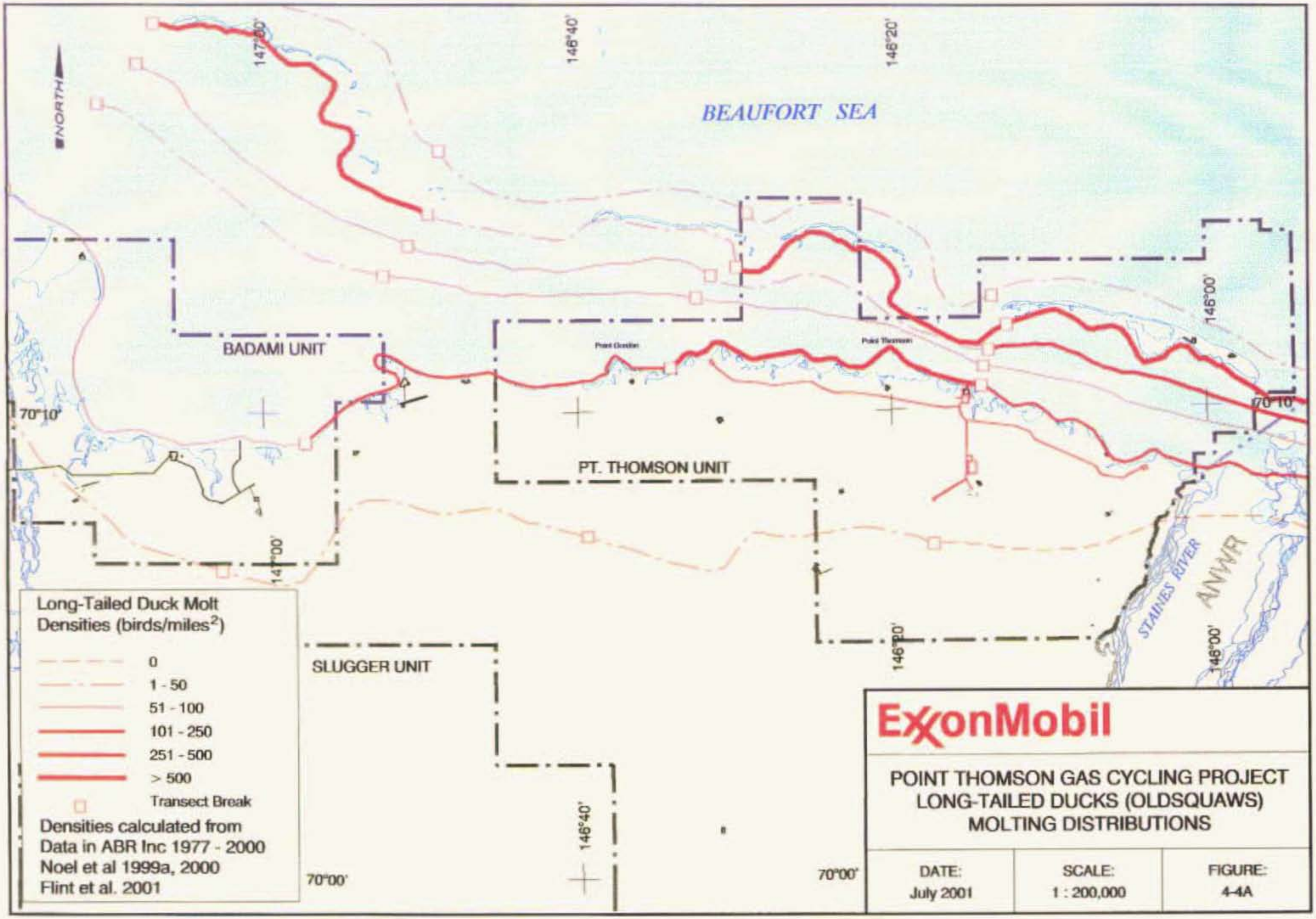
All three species of jaegers occur in the Point Thomson area (see Table 4-7), but only the parasitic jaeger is a regular breeder (see Table 4-8). Pomarine jaegers are common only during spring migration (early June) in the Point Thomson area (WCC and ABR 1983). Long-tailed jaegers were found nesting in the Kadleroshilik area (Nickles et al. 1987 and Fields et al. 1988) and may nest occasionally elsewhere in the Point Thomson region. Little is known about nesting habitats for jaegers in the Point Thomson area, but on the Colville River delta both parasitic and long-tailed jaegers nested primarily in wet sedge–willow meadows (Burgess et al. 2000; Johnson et al. 2000).

Arctic terns are common breeders across the coastal plain and have been found nesting on the barrier islands in the Point Thomson area (Johnson and Herter 1989; Noel et al. 1999b). WCC and ABR (1983) recorded arctic terns during most periods of the breeding season.

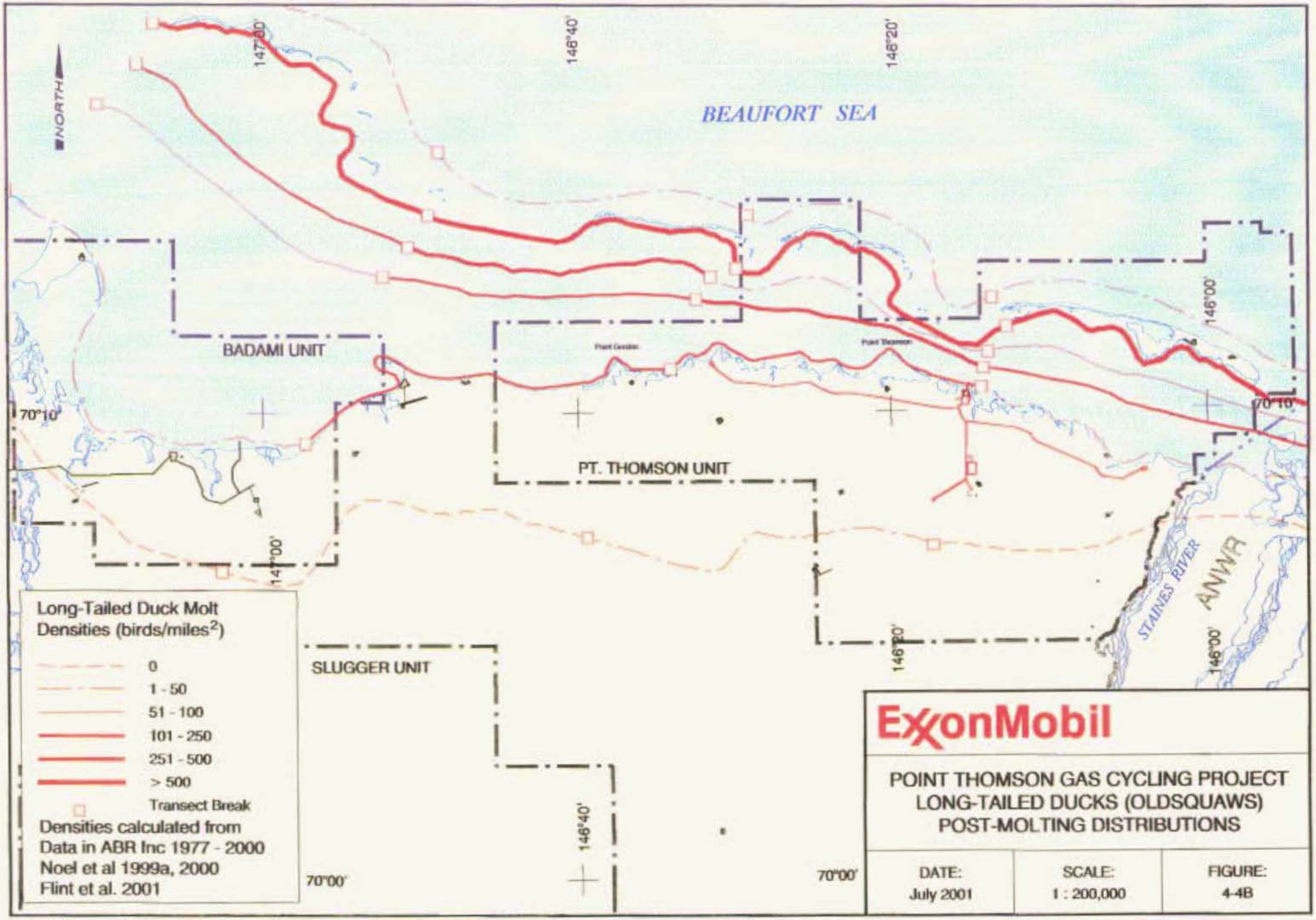
The breeding phenology for all of these birds is similar (May–September) to that described for other species, except that gulls arrive somewhat earlier on the coastal plain than the other species (Johnson and Herter 1989). Food habits differ among species, but all species range widely over the tundra in search of food. Glaucous gulls and jaegers eat small birds, small mammals, and the eggs and young of waterfowl, other waterbirds, and shorebirds. Parasitic and long-tailed jaegers prey on eggs of waterfowl (ducks, geese, and swans) and hunt shorebirds and other small birds (Johnson et al. 1999b, 2000). Sabine's gulls and arctic terns feed on aquatic invertebrates and small Fish in deep open lakes, deep ponds with emergent vegetation, and ponds in basin wetland complexes (Rothe et al. 1983). Gulls, jaegers, and terns occur throughout the Point Thomson area, given their broad habitat use and diverse prey.

Common ravens are uncommon residents on the ACP, where they closely associate with human habitations (Johnson and Herter 1989). Ravens occasionally nest near the coast, primarily on buildings and other structures, including oilfield facilities (Johnson and Herter 1989 and Ritchie 1991). Common ravens occur in the Point Thomson area, and one apparently active nest was found at the Bullen Point Dewline site in 1994 (Day et al. 1995). Small numbers of ravens use the Point Thomson area during summer (WCC and ABR 1983). Common ravens are the earliest breeding species on the coastal plain; nesting begins by early April and young fledge by mid-June (Johnson and Herter 1989). Ravens range widely across the tundra in search of food (bird eggs, small mammals, and carrion) and have been observed taking eggs of waterbirds (ducks or shorebirds) in the oil fields (ABR, unpublished data).

This page intentionally left blank


NORTH
147°00'
146°40'
146°20'
146°00'
BEAUFORT SEA
BADAMI UNIT
PT. THOMSON UNIT
SLUGGER UNIT
70°10'
70°00'
STAINES RIVER
ANWR
Long-Tailed Duck Molt
Densities (birds/miles^2)
0
1 - 50
51 - 100
101 - 250
251 - 500
> 500
Transect Break
Densities calculated from
Data in ABR Inc 1977 - 2000
Noel et al 1999a, 2000
Flint et al. 2001
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
LONG-TAILED DUCKS (OLDSQUAWS)
MOLTING DISTRIBUTIONS
DATE:
July 2001
SCALE:
1 : 200,000
FIGURE:
4-4A

ltdmd.dgn



NORTH
BEAUFORT SEA
147°00'
146°40'
146°20'
146°00'
70°10'
BADAMI UNIT
PT. THOMSON UNIT
SLUGGER UNIT
STAINES RIVER
ANWR
70°00'
Long-Tailed Duck Molt Densities (birds/miles²)
0
1 - 50
51 - 100
101 - 250
251 - 500
> 500
Transect Break
Densities calculated from Data in ABR Inc 1977 - 2000 Noel et al 1999a, 2000 Flint et al. 2001
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
LONG-TAILED DUCKS (OLDSQUAWS)
POST-MOLTING DISTRIBUTIONS
DATE: July 2001
SCALE: 1 : 200,000
FIGURE: 4-4B

ltdpmd.dgn

4.9 MARINE MAMMALS

The Beaufort Sea provides habitat for eight species of marine mammals. These include cetaceans (bowhead, gray, and beluga whales), pinnepeds (ringed, bearded, spotted seals, and walrus), and polar bear. Descriptions of marine mammals in the Beaufort Sea have also been presented in Final Environmental Impact Statements for Lease Sales 97, 109, 124, 144, and 170 (MMS 1987a, 1987b, 1990a, 1996a and 1997a, respectively).

4.9.1 Cetaceans

4.9.1.1 Bowhead Whales

The proposed Point Thomson Gas Cycling Project is located inside the barrier islands and south of the usual migration corridor used by bowhead whales (*Balaena mysticetus*). Figure 4-5 depicts this corridor with locations of Bowhead Whale sightings during 1980 to 1995. The Point Thomson Unit Development Area extends beyond the barrier islands; however, development beyond the Barrier Islands is not currently planned.

The western Arctic population of bowhead whales (Inupiaq name Agviq) was estimated to be 8,200 animals in 1993 (Zeh et al. 1995 and Hill et al. 1997). The population appears to be increasing at a rate of 3.2% per year, despite subsistence harvests of 14 to 74 bowheads per year from 1973 to 1993. (Suydam et al. 1995) The bowhead whale population in the western Arctic is currently classified as a strategic stock due to its listing as "Endangered" under the Endangered Species Act of 1973, therefore is designated as "depleted" under the Marine Mammal Protection Act of 1972 by the National Marine Fisheries Service (NMFS 2000). NMFS has issued a petition to designate bowhead whale critical habitat.

Western Arctic bowhead whales winter in the central and western Bering Sea, and spend the summer in the Canadian Beaufort Sea. Bowhead whales are the only baleen whales that spend their entire lives near the sea-ice and do not migrate to warmer waters to calve. Migration through the Alaskan Beaufort Sea takes place in spring and autumn (Moore and Reeves 1993). Spring migration takes place between April and June in a corridor centered at 71° 30' N latitude, and broadly occurring between latitudes 71° 20' N and 71° 45' N. This is located well offshore of Point Thomson (Figure 4-5). Bowheads first arrive in coastal areas of the Canadian Beaufort Sea and Amundsen Gulf in late May and early June (Moore and Reeves 1993). During fall migration, a few bowheads are expected to be offshore of the Point Thomson area in late August during some years; however, the primary fall migration of bowheads begins in early to mid-September and ends in late October (LGL and Greeneridge 1996, Green et al. 1997, and MMS 2001).

Information regarding sexual maturity and mating behavior for bowhead whales is not known with certainty. Most bowheads mate and calve from April through mid June, coinciding with the spring migration. Mating may start as early as January or February, when most of the population is in the Bering Sea, but has also been reported as late as September and early October (Koski et al. 1993). The gestation period is 13 to 14 months, and females give birth to single calves approximately every three to four years. Calving extends from late May to early August, primarily during spring migration (Nerini et al. 1984 and Koski et al. 1993). Newborn whales must begin swimming north with the migrating herd almost immediately (ADNR 1999).

Bowheads are filter feeders, filtering prey from the water through baleen fibers in their mouths. Bowheads apparently feed throughout the water column, including bottom and near-bottom feeding as well as surface feeding. Bowhead whales feed mainly in the eastern Beaufort Sea in the summer and Chukchi Sea in the fall (Wursig et al. 1984 and 1989 and Schnel and Saupe 1993). Food most commonly found in the stomachs of harvested bowhead whales includes copepods, euphausiids, mysids, and amphipods (Lowry and Frost 1984 and Lowry et al. 1993). Areas to the east of Barter Island often are used for feeding as the whales begin to migrate westward across the Beaufort Sea (Ljungblad et al. 1986 and Thomson and Richardson 1987). While this area is of periodic importance for feeding migrating whales late in the year, not all whales have been observed feeding (ADNR 1999). Bowheads continue to feed opportunistically where food is available as they migrate across the Alaskan Beaufort Sea (LGL et al. 1998 and ADNR 1999).

The auditory sensitivity of bowhead whales has not been specifically measured, but it is thought that they are specialized in low-frequency hearing, with some directional hearing capability (USACE 1999, Wursig and Clark 1983, and Richardson 1997). Bowheads produce vocalizations in the 50 to 400 hertz (Hz) band and their frequency ranges of optimum hearing are believed to overlap broadly with the low-frequency range of many industrial noises (USACE 1999). There is strong evidence that bowheads have very good hearing within these frequencies and could be disturbed by industrial noise sources. Sensitivity to noise is a subject of intense interest, research, and debate, as it affects subsistence whaling and oil and gas operations. The major sources of noise to which bowheads are exposed include aircraft and ship traffic, ice breaking, seismic exploration, marine construction, and offshore drilling. Studies indicate that bowhead behavior is often temporarily affected when exposed to close approaches by ships, seismic vessels, and aircraft. Reactions are less obvious when the noise source is fairly constant, such as with distant seismic or drilling work, but migrating bowheads sometimes adjust their course to divert around stationary sources of man-made noise (Hall et al. 1994, Richardson et al. 1995, and LGL and Greeneridge 1996).

Bowheads are very vocal and are believed use underwater sounds to navigate and communicate between widely separated individuals, mothers and calves, and for various other social functions (Clark et al. 1986, Clark et al. 1991, Ellison, et al. 1987, and Wursig and Clark 1993). Bowhead "songs" can be heard in the spring, but have not been reported in the late summer or fall. They are thought to be especially important during spring migration through areas of extensive ice (LGL et al. 1989 and ADNR 1999).

4.9.1.2 Beluga Whales

The beluga whale (*Delphinapterus leucas*) (Inupiaq name Qilalugaq) is a medium-sized cetacean belonging to the group known as odontocetes (toothed whales), also including sperm whales, killer whales, dolphins, and porpoises. Its closest relative is the narwhal (*Monodon monoceros*). The common name is derived, in part, from the Russian word for white. They are also called "white whales;" however, this is somewhat of a misnomer, since only older animals are actually white. Belugas range widely in Arctic and subarctic waters and are often the most important small cetacean to northern coastal peoples.

The beluga whale stocks in the Arctic and subarctic consist of several subpopulations. The most recent uncorrected aerial census of the Beaufort Sea stock estimates 19,629 individuals, a 95% confidence interval of 15,134 to 24, 125 (Harwood et al. 1996). The Beaufort Sea stock of beluga whales is not classified as a strategic stock and was estimated to be 39,258 individuals, using a sighting correction factor of 2x. (Hill et al. 1997).

Beluga whales migrate into the Beaufort Sea in April or May, although whales may pass Point Barrow as early as late March or as late as July. The spring migration takes place through offshore ice leads similar to those used by bowhead whales (Frost et al. 1988, Moore et al. 1993, and Richardson et al. 1995b). 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 and Harwood et al. 1996) or ranges into the Arctic Archipelago (LGL et al. 1998).

Belugas are rarely seen near the Point Thomson Development area during the summer. During autumn migration, small numbers of belugas are occasionally seen near the coast, east or west of the Point Thomson Unit Development area (Johnson 1979), but most migrate well offshore (Frost et al. 1988, Clarke et al. 1993, and Miller et al. 1997). Fall migration takes place between August and October, with the greatest movement being in September (Moore et al. 1993 and Clarke et al. 1993). Small numbers of beluga whales (up to a few hundred) could move into the waters offshore of the project area in the fall. Belugas are absent from the Alaskan Beaufort Sea from November through March (Seamen et al. 1986).

Beluga whales feed on a variety of fish and invertebrates and their diet varies by season and locale (Burns and Seaman 1985 and Hazard 1988). The Arctic cod (*Boreogadus saida*), is an important food for beluga whales in many parts of the Arctic. Winter foods of beluga whales are virtually unknown. However, in summer they feed on a variety of schooling and anadromous fish which are sequentially abundant in coastal zones. Most feeding is done over the continental shelf and in nearshore estuaries and river-mouths. In the shallow waters of Alaska, most feeding-dives are probably to depths of 20 to 100 ft (6 to 30 m) and last two to five minutes. Satellite tagged beluga whales in Canada were found to dive to depths of 2,000 ft (600 m) (ADF&G Wildlife Notebook Series, last modified 1/31/01).

The hearing of beluga whales is poor below 1 kilohertz (kHz) and their best sensitivity is in the 10 to 100 kHz band (Awbrey et al. 1998 and Johnson et al. 1989). Hearing is most sensitive above 20 kHz, consistent with their use of ultrasonic ecolocation calls. The hearing of belugas at low frequencies is not as sensitive as that of other whale species. Published studies of captive animals show thresholds of 125 decibels (dB) at <0.1kHz and about 100 dB at 1kHz (Awbrey et al. 1998 and Johnson et al. 1989). Recent data suggest that belugas' ability to hear low frequencies in the open sea may be slightly more sensitive than has been reported for captive animals. Beluga hearing thresholds improve greatly as the frequency of the sound increases (LGL et al. 1998).

The beluga's extensive vocal repertoire includes trills, whistles, clicks, bangs, chirps, and other sounds (Schevill and Lawrence 1949, Sjare and Smith 1986a, and Ouellet 1979). Beluga whistles have dominant frequencies at 2-6kHz, and other call types include sounds at mean frequencies ranging upward from 1 kHz (Sjare and Smith 1986a and 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. 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 (LGL et al. 1998).

At birth beluga whales are dark blue-gray in color. They measure approximately 5 ft (1.5 m) long and weigh 90 to 130 pounds (lbs) (41 to 59 kilograms [kg]). The color gradually lightens, and they are usually white by age 5 or 6. Adult males are from 11 to 15 ft (3.5 to 4.5 m) long and weigh 1,000 to 2,000 lbs (450 to 900 kg). Adult females are smaller, seldom exceeding 12 ft (3.7 m) in length. The size to which belugas grow varies in different parts of the range. Individuals more than 20 ft (6 m) long have occasionally been recorded, though not in Alaska.

Beluga calves are typically born between May-August, usually when the herds are near or in summer concentration areas. A single calf usually emerges tail first, and after birth it is guided to the surface and closely attended by its mother. Females become sexually mature at 4 to 5 years old, and males mature slightly later. Breeding takes place in March or April, and the total gestation period is approximately 14 ½ months. Adult females usually produce one calf every three years, which they nurse for about two years. Belugas can live to be nearly 40 years old. Polar bears and killer whales are natural predators of beluga whales.

4.9.1.3 Gray Whales

Gray whales (*Eschrichtius robustus*) (Inupiaq name Agvigluaq) have occasionally been identified in the waters of the Beaufort Sea near Point Barrow during the summer, but are unlikely to be present off of Point Thomson. The gray whale was removed from the endangered species list in 1994 (LGL et al. 1998).

Most summering gray whales congregate in the northern Bering Sea (particularly off St. Lawrence Island, in the Chirikov Basin) and in the Chukchi Sea. Few gray whales live or travel east of 155W in the Beaufort Sea (Clarke et al. 1989). A single gray whale was sighted by MMS on September 3, 1988 in Mickkelsen Bay near Tigvariak Island (Treacy 1989). No gray whales have been sighted by MMS or LGL in the proposed development area from 1979 to 1997 (LGL and Greeneridge 1996, Miller et al. 1997, and Richardson [ed.] 1997).

Gray whale summer feeding areas are in the Bering and Chukchi Seas. Gray whales generally avoid areas with significant ice. This suggests that individuals do not commonly travel through the Alaskan Beaufort Sea during summer. Few, if any, gray whales are expected to be in the Point Thomson area.

4.9.2 Pinnipeds

Pinnipeds are marine mammals such as bearded seals, ringed seals, spotted seals, and walrus. Their name "pinniped" can be broken down into *pinna*, a wing or fin; and *pedis*, a foot, describing their fin-like feet that enable them to easily maneuver through the water. The "ice seals" (ringed, bearded, and spotted seals) are usually observed in open water areas during the summer and into the fall. Spotted seals spend time on the beaches, offshore islands, and sand bars in bays, lagoons, and estuaries. Ringed seals may be found in areas of land-fast ice during the winter, while bearded seals occupy the active ice zone during winter and spring.

Seal surveys were conducted for the Liberty Island project area in spring 1985, 1986, and 1987, and resumed in 1997 (LGL et al. 1998, Frost et al. 1997, and LGL et al. 1997 and 1998), reported small numbers of ringed and bearded seals near the project area in the spring. Spotted seals were not observed during these aerial surveys. Boat-based marine mammal monitoring for an Ocean-Bottom Cable 3-D seismic survey from 25 July to 18 September 1996, in an area to the west of the proposed Point Thomson Gas Cycling Project area, documented the presence of all three seals, with 92% ringed seals, 7% bearded seals, and 1% spotted seals (Harris et al. 1997). BP Exploration-Alaska (BPXA)-sponsored aerial surveys conducted around Liberty Island (west of the proposed Point Thomson Area Cluster Development site) in May/June 1997 over land-fast ice, found ringed seals widely distributed throughout the Liberty area. No other seal species were encountered (LGL et al. 1998).

4.9.2.1 Bearded Seal

The bearded seal (*Erignathus barbatus*) (Inupiaq name Oogruk), the largest of the northern phocids, is found throughout the Bering, Beaufort, and Chukchi Seas. The population has been estimated at 300,000 (MMS 1996b), though current estimates may be unreliable (Small and DeMaster 1995). 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). They are most abundant in the northern Bering Sea in winter and spring and in the Chukchi Sea during summer and fall (Burns and Frost 1983; Kelly 1988).

The species is less common in the Beaufort Sea, where only a few over-winter. Bearded seals are an important subsistence resource for Alaskan coastal residents. They prefer open water habitats with broken, drifting pack ice, although shore-fast ice is also used (Burns and Frost 1983 and Kelly 1988). Bearded seals are primarily bottom feeders, preying on benthic organisms such as crabs, shrimp, and clams in habitats with water depths less than or 660 ft (201m). They have been found in deeper waters where they feed on organisms associated with sea-ice.

The seasonal movements of bearded seals are related to the advance and retreat of sea-ice and water depth. Some bearded seals overwinter in the Bering Sea. As the ice recedes in the spring, these seals migrate through the Bering Straight (mid-April to June), and summer either along the margin of the multi-year ice in the Chukchi Sea or in nearshore areas of the central and western Beaufort Sea. The observed seasonal decline in sightings during late summer and autumn aerial surveys (LGL and Greeneridge 1996, 1997) indicates that a portion of the Alaskan Beaufort Sea bearded seal population migrates to the Bering Sea during the winter months. 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 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.

Bearded seals breed in the spring. They depend on underwater communications with their potential mates, and emit distinctive calls, generally starting near 2.5-3 kHz and descending below 1kHz. These calls are believed to be important breeding behavior. Pupping takes place on top of the ice from late March through May, primarily in the Bering and Chukchi Seas, although some pupping takes place 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 (LGL et al. 1998 and MMS 2001).

There are no data on the hearing abilities of bearded seals, but they are probably comparable to other phocid seals (Richardson et al. 1995a). Bearded seals emit distinctive 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 important in breeding behavior (Ray et al. 1969 and Stirling et al. 1983). Calls are much less common in late summer/early autumn than during the spring mating season.

The number of bearded seals offshore of the Point Thomson area during the open water period is expected to be low. Only a few individuals were seen during boat-based marine mammal monitoring near the project site 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% 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 be found offshore of Point Thomson during open-water season, many may be young, non-productive animals. Bearded seals are not expected to enter the waters offshore of the development area at all during late autumn, winter, and early spring months when it is covered by fast-ice (LGL et al. 1998 and MMS 2001).

4.9.2.2 Ringed Seals

Ringed seals *(Phoca hispida)* (Inupiaq name Natchiq) are year round residents in the Beaufort Sea and are the most common seal offshore of the proposed development area. The worldwide population of ringed seals is estimated to be 6-7 million (Stirling and Calvert 1979), with the Alaskan portion being 1-1.5 million (Kelly 1988 and Small and Demaster 1995) in the Bering, Beaufort, and Chukchi Seas. Roughly 80,000 ringed seals can be found in the Beaufort Sea during the summer and 40,000 during the winter (Frost and Lowry 1981). During winter and spring, ringed seals spend much of their time on land-fast ice and offshore pack ice. They maintain breathing holes throughout the winter in ice up to 6 ft (1.8m) thick and dig multiple haul-out shelters and nursery lairs beneath the snow (Kelly 1988 and ADNR 1999).

In winter and spring, the ringed seal frequents land-fast ice and offshore pack ice; the highest densities of seals are usually found on stable land-fast ice. In areas with limited shore-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 that on shore-fast ice (Burns 1970, Stirling et al. 1982, and Finley et al. 1983).

Mating occurs in late April and May, primarily on land-fast ice. Females give birth to a single, white-coated pup in snow-dens on either land fast or drifting pack ice during late March or early April, and are nursed for 4 to 6 weeks. Quantitative surveys of ringed seals conducted during late winter and spring found ringed seal densities on the shore-fast ice between Oliktok Point and Flaxman Island ranging from 2.5 seals/mi^2 (0.97 seals/km^2) to 4.4 seals /mi^2 (1.69 seals/km^2) during the 1985-1987 period (Frost and Lowry 1988). BPXA-sponsored aerial surveys for ringed seals conducted around Liberty Island as well as in fast-ice areas north of the barrier islands in May to June 1997 found densities ranging from 1 seal/mi^2 (0.43 seals/km^2) (maximum survey density) to 1.2 seals/mi^2 (0.48 seals/km^2) (maximum daily density). North of the barrier islands, ringed seal densities were slightly higher, ranging from 1.3 to 1.5 seals/mi^2 (0.51 to 0.58 seals/km^2) (Miller et al. 1998).

Ringed seals are sensitive to underwater sounds in the 1 to 60 kHz band (Terhune and Ronald, 1975). Underwater audiograms have been obtained using behavioral methods for three species of phocid 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. There are few published data below 1 kHz, but a harbor seal's threshold deteriorated gradually to 97 dB 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 beluga whales (for which the threshold at 100 Hz is about 125 dB). No data are available on their reactions to underwater sounds due to the difficulty of observing these animals in water (USACE 1999).

Ringed seals produce clicks with fundamental frequency of 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. Ringed seals appear much less vocal in summer than during the breeding season in spring (Stirling et al. 1983).

The ringed seals molt in May and June. During this time they spend long periods hauled out on the ice basking in the sun. It is thought that warmer skin temperatures cause rapid hair growth. When hauled out on the ice, ringed seals are wary of predators. The amount of time spent on the ice increases as the molt season progresses. In summer, as the nearshore ice melts, most of the adult ringed seals are found along the edge of the ice pack, seaward of the proposed development area.

Ringed seals spend much of the summer and early fall in the water feeding. They eat a variety of invertebrates and fish. The particular species eaten depends on availability, depth of water, and distance from shore. In Alaskan waters, the important food species are Arctic cod, saffron cod, shrimp, and other crustaceans (ADNR 1999). In the eastern Beaufort Sea and Amundsen Gulf, ringed seals concentrate in offshore areas, often in large groups. The groupings appear to be associated with simultaneous populations of various prey species, such as crab and shrimp. Ringed seals offshore of the development area are likely to be individuals or small groups during the summer, as larger groups have not been reported during the summer in the central or western Beaufort Sea (LGL et al. 1998).

4.9.2.3 Spotted Seal

The spotted seal (*Phoca largha)* (Inupiaq name Qasigiaq*)* is found from the Beaufort Sea to the Sea of Japan and is most numerous in the Bering and Chukchi Seas (Quackenbush 1988). The population of spotted seals world-wide has been estimated between 335,000 and 450,000, and the size of the Bering Sea population, including animals in Russian waters, is estimated between 200,000 and 250,000 animals (Bigg 1981). A reliable estimate of the entire Alaskan stock of spotted seals is currently not available (Small and DeMaster 1995).

A few spotted seal haul outs have been documented in the central Beaufort Sea, primarily in the deltas of the Colville and Sagavanirktok Rivers. Historically, these sites have supported as many as 400 to 600 seals. However, since the 1980s, fewer than 10 seals have been seen at any one site (LGL et al. 1998). 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, and only a small portion may be visible at any one time (Frost et al. 1993 and ADNR 1999).

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. Pupping occurs in March or April in the Bering Sea wintering areas. A month later mating occurs, followed by molt (Seaman et al. 1981; Quackenbush 1988). In late April and early May, adult spotted seals are often seen on the ice in female-pup or male-female pairs (Frost et al. 1991). Subadults may be seen in larger groups of up to 200 animals. As the seasonal ice-cover recedes in summer, spotted seals disperse throughout the open waters of the Bering, Chukchi, and Beaufort seas. 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 number of seals 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%) of the local population may be hauled out at any one time (Frost et al. 1993). In summer, spotted seals are rarely seen on the pack ice, except when the ice is very near to shore. They are commonly seen in bays, lagoons, and estuaries. Spotted seals feed on invertebrates, such as shrimp and cephalopods either offshore or in the lower reaches of the rivers or the river deltas and on pelagic and demersal fish, including herring, capelin, sand lance, Arctic cod, saffron cod, and sculpins. Spotted seals migrate out of the Beaufort Sea in the fall (September to mid-October) as the shore-fast ice re-forms and pack ice advances southward. (ADNR 1999).

There are no data on hearing capabilities of spotted seals, but they are probably comparable to those of ringed and harbor seals. Calls of captive spotted seals (Beier and Wartzok 1979) are similar to harbor seals. Both species emit faint clicks near 12 kHz (Schevill et al. 1963 and 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).

4.9.2.4 Walrus

The walrus (*Odobenus rosmarus*) (Inupiaq name Aiviq) is the largest of the Alaskan pinnipeds (ADF&G Wildlife Notebook Series, last modified 1/31/01). The Alaskan Beaufort Sea is outside the principal range of the walrus. However, small numbers of walrus 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. Walrus feed on benthic organisms, primarily bivalves, and typically are found in waters less than or equal to 328 ft (100 m) deep.

There have been at least eight sightings of walrus between 146 W and 150 W in the Prudhoe Bay region during MMS and LGL surveys conducted from 1979 to 1997. All sightings were in waters less than or equal to 131 ft (40 m) deep. Walrus sightings are unusual in the area, which is well to the east of their primary summer range. There have been six sightings north of the barrier islands and two within Stefansson Sound. One sighting was in the lagoons during MMS aerial surveys and another sighting of a single juvenile walrus was made during 1996 boat-based marine mammal monitoring (Richardson [ed.] 1997) near the Liberty Island Development site. Walrus are expected to be rare in the waters offshore of Point Thomson.

4.9.3 Polar Bears

Polar bears (*Ursus maritimus*) (Inupiaq name Nanuq) have a circumpolar distribution throughout most ice-covered seas of the Northern Hemisphere, and are common within 200 mi (322 km) of the arctic coast of Alaska (Amstrup and DeMaster 1988). Within this range, polar bears are divided into five largely discrete populations. The range of the Southern Beaufort Sea population extends from the northwest Chukchi Sea to Cape Bathurst, Canada (Lentfer 1974 and Amstrup et al. 1986) and encompasses the area proposed for the Point Thomson Gas Cycling Project. This population was estimated at 1500-2000 bears in 1994, and has grown at a mean annual rate of 2.4% over the last 20 years (Amstrup 1995). Population density currently appears to be stabilizing or increasing slightly since it is believed to be approaching the carrying capacity of the environment (USFWS 1995).

In the proposed project area, polar bears are present near the coast during the ice-covered period and infrequently during the summer. Polar bear distribution is influenced greatly by prey abundance (particularly ringed seal) on seasonal ice (Smith 1980). As the ice-pack spreads southward in the fall, polar bears move with it, appearing along the Beaufort Sea coast from September to October (Lentfer 1972). Polar bears generally prefer areas of heavy offshore pack ice (Stirling 1988), and adult males usually remain there, rarely coming ashore (Amstrup and DeMaster 1988). During winter and spring, polar bears tend to concentrate in these areas of shore-fast ice with deep drifted snow along pressure ridges, at the floe edge, and on drifting ice with at least 7 to 8 in (18 to 20 cm) of ice cover (Stirling et al. 1975 and 1981). The greatest densities occur 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. Polar bears are typically on land only during the winter denning season. In addition to denning females, females with cubs and subadult males occasionally come ashore. Females with young cubs may hunt in fast-ice areas.

The breeding season is from April through June when both males and females are active on the sea-ice. During the breeding season in late March through May, males actively seek out females by following their tracks on the sea-ice. Bears are polygamous, and the male remains with a receptive female a relatively short time and then seeks another female. Gestation lasts about eight months. Pregnant females enter dens in October or November and give birth in December or January to between one and three cubs. Bears (mother and cubs) emerge from their dens in late March or April when cubs weigh about 15 lbs (6.8 kg), and move out onto the pack ice (Lentfer and Hentsel 1980 and Amstrup and Gardener 1994).

They make short trips to and from the open den for several days as the cubs become acclimated to outside temperatures. They then start traveling on the drifting sea-ice. Females can breed again at about the same time they separate from their young, so normally they can produce litters every third year. Cubs usually stay with their mothers until they are 1½ to 2½ years old, although some may remain into their third or fourth year (Stirling et al. 1975). Adult males and non-pregnant females are active all year using dens only as temporary shelter during severe weather.

Between 1981 and 2001, 49% of polar bear dens found in coastal Alaska and neighboring Canada were on land, barrier islands, or fast-ice (Amstrup, unpublished data). Figure 4-6 shows the known polar bear den sites in the Point Thomson area. The two onshore den sites located within the Point Thomson Unit immediately west of the proposed facilities were active dens in 2001. The other locations have been used historically over the period 1988-1999.

Bears excavate maternity dens in compacted snowdrifts adjacent to bluffs, barrier islands, and other areas of topographic relief (Amstrup and DeMaster 1988). Denning females often use stable sea-ice on the shoreward side of the barrier islands. Flaxman, Pingok, Cross, Cottle, Thetis and other barrier islands in the Beaufort Sea are known to support maternity dens.

Most terrestrial dens are located within a few mi of the coast, although dens as much as 30 mi (48 km) inland have been reported (USFWS 1995). A total of 10 maternal dens have been documented between 1981 and winter of 2000/2001 in the coastal areas between the Canning and the Shaviovik Rivers. Seven of these dens were located on Flaxman Island, one in the Canning River Delta, two along the coast west of Point Thomson, and one on land fast ice offshore of Point Thomson. Flaxman Island would be the only predictable denning area in this region (Ampstrup, unpublished data). The number of polar bears denning in the project area within a particular year cannot be estimated with confidence. However, the proportion of bears denning on land in the Beaufort Sea region appears to be increasing, probably because of hunting restrictions beginning in the early 1970s (Stirling and Andriashek 1992 and Amstrup and Gardner 1994).

Polar bears occasionally congregate on the barrier islands in the fall and winter because of available food such as bowhead carcasses and favorable environmental conditions. In November 1996, a congregation of 28 bears was observed near a carcass on Cross Island, and another 11 were observed within a 2 mi (3.2 km) radius of a carcass on Barter Island (Kalxdorff 1998).

Polar bears are extremely curious and opportunistic hunters, and they have been known to approach facilities in search of food. The main food of polar bears in the Alaskan Beaufort Sea is the ice-inhabiting ringed seal. Bears capture seals by waiting for them at breathing holes and at the edge of leads or cracks in the ice. They also stalk seals resting on top of the ice and catch young seals by breaking into pupping chambers in snow on top of the ice in the spring. Bears prey to a lesser extent on bearded seals, walrus, and beluga whales. They also feed on carrion, including whale, walrus, and seal carcasses they find along the coast. They occasionally eat small mammals, bird eggs, and vegetation when other food is not available. A keen sense of smell, extremely sharp claws, patience, strength, speed, and the camouflaging white coat aid in procuring food (ADF&G Wildlife Notebook Series, Jan 31, 2001).

Cubs weigh between 1 and 2 lbs (0.5-0.9 kg) at birth. An extremely large adult male may weigh 1,500 lbs (680 kg). Most mature males weigh between 600 and 1,200 lbs (273-545 kg), and are between 8 and 10 ft (2 to 3 m) in length. Mature females weigh 400 to 700 lbs (182 to 318 kg). Bears in the wild have been recorded as old as 32 years but most typically do not live beyond 25 years (ADF&G 2001).

Polar bears live in areas under the jurisdiction of five nations--Russia, Norway, Denmark, Canada, and the United States--and also on the high seas where jurisdiction is not clearly defined. Representatives of the five polar bear nations prepared an international agreement on conservation of polar bears in November 1973. The pact was ratified in 1976. It allows bears to be taken only in areas where they have been taken by traditional means in the past and prohibits the use of aircraft and large motorized vessels. The agreement has created a high seas polar bear sanctuary but does not prohibit hunting from the ground using traditional methods.

In Alaska prior to the late 1940s, nearly all polar bear hunting was by Eskimos with dog teams. Sport hunting, sometimes with the use of aircraft, started in the late 1940s and continued through 1972. In 1972, the state of Alaska prohibited the use of aircraft in polar bear hunting. With the passage of the Statehood Act, Alaska began a polar bear management program. State regulations required sealing of skins, provided a preference for subsistence hunters, and protected cubs and females with cubs (ADF&G 2001).

The federal Marine Mammal Protection Act (MMPA) of 1972 transferred management authority from the State to the federal government and placed a moratorium on hunting of marine mammals by people other than Alaskan Natives. This resulted in a reduced total harvest, but an increase in the proportion of female bears and cubs. The MMPA includes provisions that allow for waiver of the moratorium or transfer of management authority back to states. At intervals since 1972, the State of Alaska has made efforts at regaining polar bear management. State management could allow a resumption of sport hunting and produce increased economic opportunities in coastal rural communities. For a variety of reasons, efforts to regain State management have been discontinued. Polar bear meat, other than that of males in the rut, is quite palatable when boiled. It is a favored subsistence food in some areas.

The stocks of polar bear in Alaska are shared with other nations. In 1988, the North Slope Borough Department of Wildlife Management (representing Alaskan Natives) and the Inuvialuit Game Council (representing Canadians) signed an agreement to provide for coordinated management of the Beaufort Sea polar bear stock (ADF&G 2001)

This page intentionally left blank

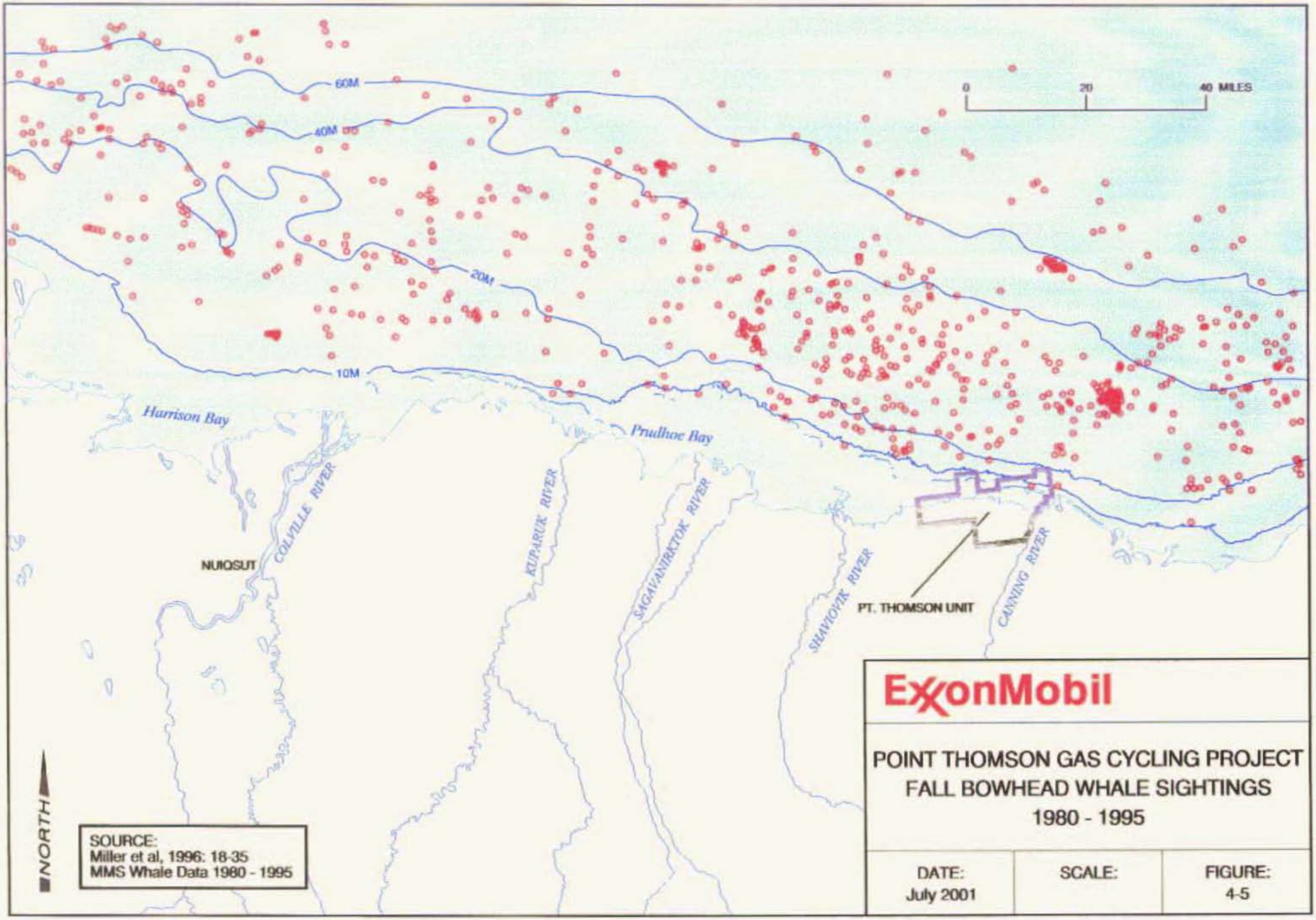

60M
40M
20M
10M
0
20
40 MILES
Harrison Bay
Prudhoe Bay
COLVILLE RIVER
KUPARUK RIVER
SAGAVANIRKTOK RIVER
SHAVIOVIK RIVER
CANNING RIVER
NUIQSUT
PT. THOMSON UNIT
NORTH
SOURCE:
Miller et al, 1996: 18-35
MMS Whale Data 1980 - 1995
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
FALL BOWHEAD WHALE SIGHTINGS
1980 - 1995
DATE:
July 2001
SCALE:
FIGURE:
4-5

fig4_5.dgn

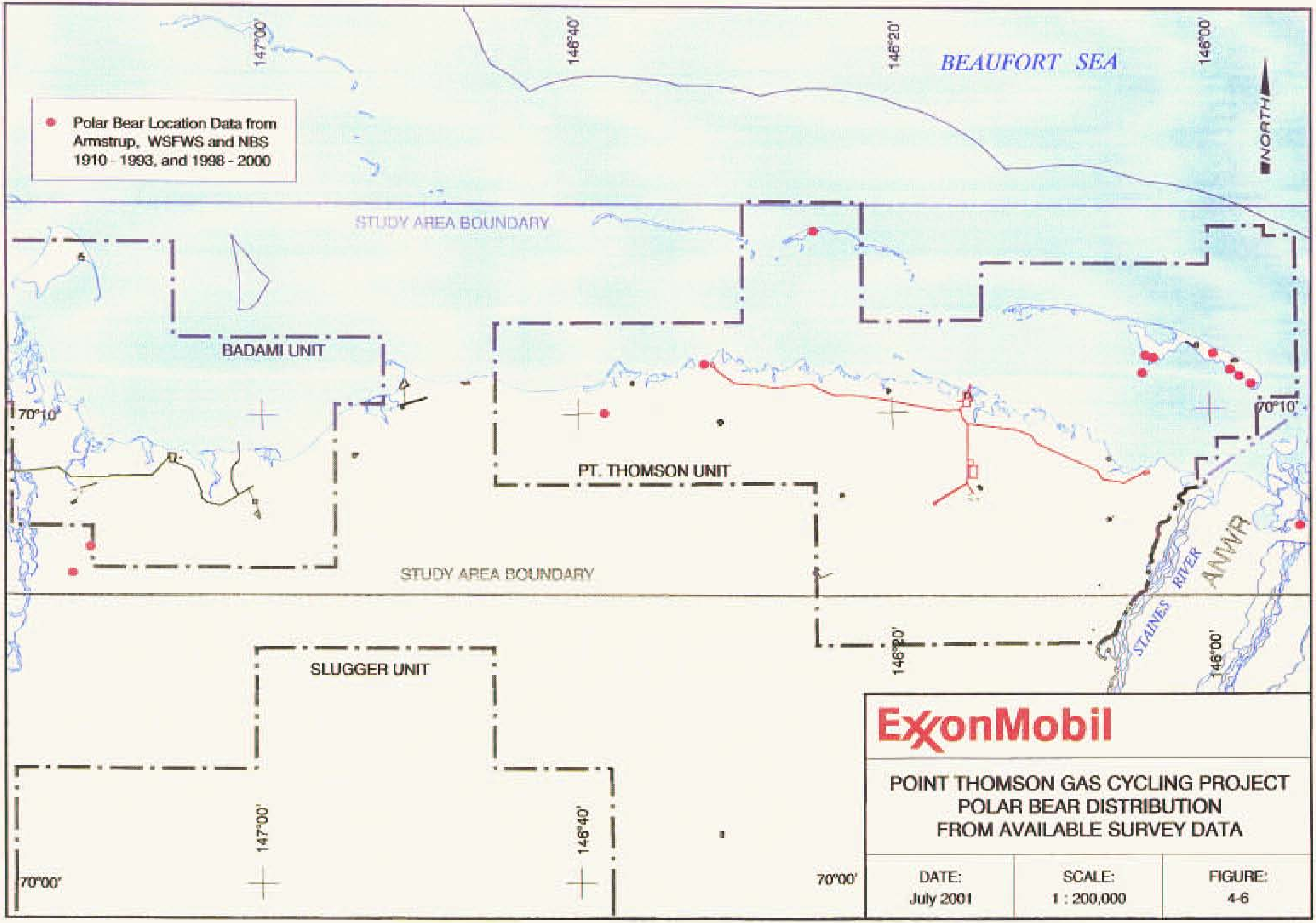

BEAUFORT SEA
NORTH
Polar Bear Location Data from Armstrup, WSFWS and NBS 1910 - 1993, and 1998 - 2000
147°00'
146°40'
146°20'
146°00'
STUDY AREA BOUNDARY
BADAMI UNIT
PT. THOMSON UNIT
70°10'
STUDY AREA BOUNDARY
SLUGGER UNIT
STAINES RIVER
ANWR
70°00'
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
POLAR BEAR DISTRIBUTION
FROM AVAILABLE SURVEY DATA
DATE: July 2001
SCALE: 1 : 200,000
FIGURE: 4-6

fig4_6.dgn

4.10 TERRESTRIAL MAMMALS

Mammals, especially large mammals and arctic foxes, have been the subject of extensive research in the region of the North Slope oilfields in the last 3 decades. These studies have provided important information for the region as a whole, but only a few have directly addressed terrestrial mammal populations in the proposed Point Thomson Gas Cycling project area. Field investigations of terrestrial mammals in the Point Thomson study area have focused primarily on aerial surveys of caribou (*Rangifer tarandus*). Observations of muskoxen (*Ovibus moschatus*), moose (*Alces alces*), and grizzly bears (*Ursus arctos*) were documented incidentally during those surveys and other fieldwork. The earliest large mammal surveys that included portions of the Point Thomson study area were conducted in the mid- to late 1970s (described in WCC and ABR 1983). More systematic surveys covering some or all of the Point Thomson study area were conducted in 1983 (WCC and ABR 1983, Lawhead and Curatolo 1984), 1984 (Curatolo and Reges 1984), 1987–1990 (Lawhead and Cameron 1988, Smith and Cameron 1992), and 1993–2000 (Pollard 1994, Pollard and Noel 1995, Noel 1998, Noel and Olson 1999a, Noel and King 2000). In addition, the Alaska Department of Fish and Game (ADF&G) conducted surveys of grizzly bears in the Point Thomson study area in 1997 and 1999 (Shideler 1999), and recorded incidental observations in 1998. Surveys of arctic fox (*Alopex lagopus*) dens were conducted in the Point Thomson study area in 1983 (WCC and ABR 1983), 1992 (Burgess et al. 1993), and 1999 (Perham 2000). Table 4-9 lists the terrestrial mammal species expected to occur within the proposed development area and the seasonal time frame in which they are most likely to be present.

4.10.1 Caribou

The Alaska Department of Fish and Game (ADF&G) manages caribou (Inupiaq name Tuttu) and follows Skoog (1968) in identifying herds based on their fidelity to calving grounds. Based on this criterion, four herds are recognized in Arctic Alaska (moving from west to east): the Western Arctic Herd (WAH), the Teshekpuk Lake Herd (TLH), the Central Arctic Herd (CAH), and the Porcupine Herd (PCH). Caribou from both the CAH and the PCH use the Point Thomson study area.

The CAH ranges from the Colville and Itkillik rivers on the west to the Canning and Tamayariak rivers on the east (Figure 4-7). Telemetry studies have shown that about half of the CAH (called the eastern segment) tends to spend the calving and insect seasons east of the Sagavanirktok River. The other half of the CAH (western segment) ranges on the west side of the Sagavanirktok River, including the area occupied by the Prudhoe Bay and Kuparuk oilfields and associated satellite developments (Lawhead 1988, Cameron et al. 1995). The two segments of the CAH are not isolated from each other; some interchange occurs between segments, primarily among years rather than within years (Lawhead and Curatolo 1984).

The CAH increased steadily from about 4,000–6,000 animals in the mid-1970s, when it was first described by ADF&G as a distinct herd (Cameron and Whitten 1979), to a peak of about 23,400 in July 1992 (Woolington 1995) before declining. Between 1992 and 1995, the CAH declined 23%, to about 18,100 caribou (James 1996). The herd subsequently increased to about 19,700 caribou by July 1997 and about 27,100 caribou by July 2000 (E. Lenart, ADFG, pers. comm.), the largest size since it was first described. Figure 4-8 shows the change in size of the CAH since 1972. Hunting mortality of CAH caribou is relatively light, estimated at 200–600 animals annually in recent years (Woolington 1995). It consists mostly of subsistence harvest by villagers from Nuiqsut and, to a lesser extent, Kaktovik, as well as sport harvest along the Dalton Highway. The western segment of the herd regularly encounters oil-field infrastructure (e.g., drill-site pads, roads, pipelines, processing facilities) and industrial activity on its summer range. The eastern segment likely encounters the Badami pipeline each summer. All members of the herd probably encounter the Trans-Alaska Pipeline at some point during their lifetimes.

Table 4-9 Terrestrial Mammals Known or Suspected to Occur in the Point Thomson Area

COMMON NAME	SCIENTIFIC NAME	STATUS
Barrenground Shrew	*Sorex ugyunak*	√
Tundra Shrew	*Sorex tundrensis*	√
Snowshoe Hare[a]	*Lepus americanus*	*
Tundra Hare[a]	*Lepus othus*	*
Arctic Ground Squirrel	*Spermophilus parryii*	√
Northern Red-Backed Vole[a]	*Clethrionomys rutilus*	*
Tundra Vole	*Microtus oeconomus*	√
Singing Vole	*Microtus miurus*	√
Brown Lemming[b]	*Lemmus trimucronatus*[b]	√
Collared Lemming[c]	*Dicrostonyx groenlandicus*[c]	√
Porcupine[a]	*Erethizon dorsatum*	*
Coyote[a]	*Canis latrans*	*
Gray Wolf	*Canis lupus*	√
Arctic Fox	*Alopex lagopus*	√
Red Fox	*Vulpes vulpes*	√
Brown Bear	*Ursus arctos*	√
Ermine, Short-Tailed Weasel	*Mustela erminea*	√
Least Weasel	*Mustela nivalis*	√
Mink[a]	*Mustela vison*	*
Wolverine	*Gulo gulo*	√
River Otter[a]	*Lontra canadensis*	*
Lynx[a]	*Lynx canadensis*	*
Moose	*Alces alces*	√
Caribou	*Rangifer tarandus*	√
Muskox	*Ovibos moschatus*	√

Except where noted, names are from Wilson and Reeder (1993). √ indicates species is documented or very likely in the study area. * indicates species, if present, is rare and at the limits of its range.

[a] These species, although they may occur in some areas of the Arctic Coastal Plain, are unlikely to occur in the Point Thomson study area due to its distance from major riparian corridors.
[b] Name from Chernyavsky et al. (1993)
[c] Name from Jarrell & Fredga 1993

The range of the PCH on the ACP extends east from the western edge of ANWR (the eastern edge of the Point Thomson study area) in northeastern Alaska and into the north-central Yukon and western Northwest Territories in Canada (Figure 4-7). This herd typically calves on the coastal plain and northern foothills of the Brooks Range in ANWR and the Yukon Territory. After increasing about 5% annually during 1976–1989, the PCH decreased 10% from 178,000 in 1989 to 160,000 in 1992 (Whitten 1995). The population was thought to have stabilized at

~160,000 animals after 1992 (K. R. Whitten, pers. comm.), but declined to ~129,000 by 1998 (Stephenson 1999). Throughout its range, the PCH is an important subsistence resource for Inupiat, Inuvialuit, and Gwich'n villages in both northeastern Alaska and northern Yukon, although hunting mortality is considered to be relatively light (1–3% of the herd); the estimated annual harvest has ranged from 1,600 to 4,800 animals in recent years (Stephenson 1999). PCH caribou have no exposure to industrial activity on summer range, although some cross road corridors such as the Dempster Highway in the Yukon during spring and fall migrations.

The annual cycle of CAH and PCH caribou has been subdivided into different phases for descriptive purposes by various authors (Roby 1978, Russell et al. 1993). The greatest use of the Point Thomson study area by caribou occurs in summer, from the calving period (late May–mid-June) through the insect harassment season (late June–August).

4.10.1.1 Calving Season

Most CAH caribou occur on the northern coastal plain during the calving and insect seasons (Lawhead and Curatolo 1984). By May, pregnant cows move north and disperse widely over the coastal plain to calve in late May–early June. Each cow bears one calf. In most years, calving by the CAH is concentrated in two general areas: one west of the Sagavanirktok River, in the vicinity of the Kuparuk oilfield, and the other east of the Sagavanirktok River, south of Bullen Point (Whitten and Cameron 1985; Lawhead and Cameron 1988; Murphy and Lawhead 2000). A substantial amount of effort has been invested in aerial surveys of caribou distribution and abundance in the Bullen–Staines calving concentration area, which was used by the CAH from the late 1970s to mid-1980s (Whitten and Cameron 1985), and which includes the Point Thomson study area. Besides partial coverage annually by ADF&G from the late 1970s to the early 1990s, calving surveys were done in 1983 (WCC and ABR 1983, Lawhead and Curatolo 1984), 1984 (Curatolo and Reges 1984), 1987–1990 (Lawhead and Cameron 1988, Smith and Cameron 1992) and 1993 and 1997–2000 (Noel 1998, Noel and Olson 1999a, Noel and King 2000a). Wolfe (2000) conducted a retrospective Geographical Information System (GIS) analysis of calving habitat selection based on ADF&G radio telemetry from 1980 to 1995.

Calving surveys since the late 1970s show that the Bullen–Staines concentration area was most heavily used for calving before the mid-1980s, in terms of the proportion of the CAH using the area. The area of most concentrated calving activity identified by Wolfe (2000) encompassed the Point Thomson study area in 1980–1982, then shifted inland and to the west during 1983–1989, before shifting back toward the coast west of Bullen Point in 1990–1992 and back inland again in 1993–1995. Recent surveys corroborate the shift of most concentrated calving activity to the southwest of the proposed Point Thomson facilities.

Because of the interest generated by the debate about opening the 1002 are of the ANWR coastal plain to oil exploration and development, calving surveys for PCH caribou have been conducted annually since the mid-1970s. The location and level of annual use of the PCH calving grounds have been described and mapped in detail (e.g., refer to the summary maps on ANWR web site: http://www.r7.fws.gov/nwr/arctic/pchmap2.html#section6). Most of the calving data analyses, based on telemetry using standard and satellite collars, have been summarized by USFWS researchers in a series of publications (e.g., Clough et al. 1987, Russell et al. 1993). Extensive telemetry data demonstrate that very little calving activity by the PCH occurs in the western portion of ANWR coastal plain, in the Tamayariak River drainage east of the Canning River and the Point Thomson study area (Russell et al. 1993). Transect surveys by Pollard and Roseneau

(1991) confirmed that little calving occurred in the Tamayariak drainage. The dearth of PCH caribou calving in that area indicates that the caribou calving in the Point Thomson study area belong to the eastern segment of the CAH. Lawhead and Curatolo (1984) found some radio-collared CAH animals east of the Canning River on a few occasions during the calving season.

4.10.1.2 Insect Season

Following calving, CAH caribou generally stay within 20 mi (32 km) of the Beaufort Sea coast through the insect season (Lawhead and Curatolo 1984). Mosquito and oestrid fly (warble fly *Hypoderma tarandi*; nose-bot fly *Cephenemyia trompe*) harassment strongly influences caribou movements between late June and early August (White et al. 1975, Roby 1978). Warm, calm weather conditions promote insect flight activity (Dau 1986), although insect activity is lowest near the coast (Dau 1986) because of lower air temperatures and higher wind speeds (Brown et al. 1975, Walker et al. 1980). Mosquito-harassed caribou form large groups and move generally upwind toward the coast (Lawhead and Curatolo 1984, Dau 1986) until reaching "relief habitat." Because prevailing winds in July are northeasterly (Brown et al. 1975), the eastern segment of the CAH typically seeks mosquito-relief habitat along the coast east of the Sagavanirktok River delta, regularly moving as far east as the Canning River delta (Figure 4-9) (Lawhead and Curatolo 1984, Pollard and Noel 1995, Noel 1998, Noel and Olson 1999a, Noel and King 2000a).

Telemetry studies show that CAH caribou make extensive east–west movements through the Point Thomson study area in the insect season (Lawhead and Curatolo 1984). These movements account for the large range of variation in distribution and abundance (e.g., 3–5730 caribou in 1993, 1–2714 in 1998, 0–2500 caribou in 1999) documented on periodic surveys during the insect season (Noel and Olson 1999a, Noel and King 2000a). Under mosquito harassment, caribou aggregate and move to the coast to seek relief. Under continuing harassment, they then may move along the coast in large numbers. These coastal aggregations can range from a few hundred to several thousand caribou along the entire stretch of coast between Badami and the Canning River delta, with the areas of specific use depending on the weather and insect conditions in any given year (WCC and ABR 1983, Lawhead and Curatolo 1984, Pollard and Noel 1995, Noel 1998, Noel and Olson 1999a, and Noel and King 2000a). The maximum group size of CAH caribou recorded in the Point Thomson study area during the 1983 insect season was 2600 caribou near Bullen Point in 1983 (WCC and ABR 1983), about 20% of the CAH at that time.

Insect-harassed PCH caribou infrequently move across the Canning River from the east. PCH caribou usually do not remain on the coastal plain during the insect season. The typical pattern is for the largest numbers to approach the Beaufort Sea coast during the post-calving period and beginning of the insect season (Clough et al. 1987, Russell et al. 1993), when mosquitoes predominate. The majority of the herd then moves southeast into the foothills and mountains of the Brooks Range as July progresses. In some years, however, PCH caribou may mix with caribou from the eastern segment of the CAH. In those unusual circumstances, very large numbers of caribou may enter the Point Thomson area. The largest group of caribou documented using the Point Thomson study area was an aggregation of ~20,000 caribou, comprising a mixture of CAH and PCH animals (as confirmed by radio telemetry), that moved west through the study area to within 7 mi (11.3 km) of the Sagavanirktok River Delta during 10–12 July 1988 (Lawhead and Smith 1990). Under mosquito harassment, the aggregation returned eastward into the study area on 13 July 1988 to the vicinity of Point Gordon (Lawhead and Smith 1990). The late 1980s was a period when a substantial amount of mixing of CAH and PCH caribou occurred on the summer range, thwarting attempts to complete a photocensus of the CAH (Woolington 1995).

When temperatures cool and mosquito activity abates, CAH caribou move away from the coast, usually to the south and west. Mosquito harassment declines markedly by late July (Roby 1978, Dau 1986, Lawhead and Curatolo 1984), leaving oestrid flies as the predominant insect pests. By mid-July, oestrid flies drive caribou to seek relief in a variety of unvegetated and elevated sites, such as river bars, mud flats, dunes, pingos, gravel pads, and roads (Roby 1978, Dau 1986). In areas of human activity, relief from flies is often sought in the shade of elevated pipelines, buildings, and even parked vehicles. Fly harassment typically continues into August (Lawhead and Curatolo 1984, Dau 1986), when CAH caribou begin to disperse inland and migrate south off the coastal plain.

4.10.1.3 Migration and Winter

The decline of mosquito activity in late July and early August marks the beginning of a period of inland dispersal. In an intensive telemetry study in 1983, radio-collared CAH caribou that had summered in the Point Thomson area had begun dispersing inland and far to the west by early August, with some crossing the Sagavanirktok River (Lawhead and Curatolo 1984). Although a few caribou breed and winter (October–April) on the outer coastal plain, most of the CAH moves considerably farther south to the foothills and mountains of the Brooks Range during this period (Cameron and Whitten 1979, Carruthers et al. 1987, Murphy and Lawhead 2000). In October 2000, large numbers of CAH caribou were on the south side of the Brooks Range west of Arctic Village (E. Lenart, ADF&G, pers. comm.). No winter survey data of caribou are available for the Point Thomson study area. In contrast to the CAH, which have relatively limited seasonal migrations, PCH caribou undertake extensive migrations (with some exceeding 3,000 mi/yr (4,828 km/yr)) in moving to and from winter ranges well south of the Brooks Range in the Yukon and eastern Alaska (Fancy et al. 1989, Russell et al. 1993).

4.10.1.4 Summary

In summary, the greatest degree of use of the Point Thomson study area by caribou occurs between late June and August during the insect season, when large aggregations form and move to and along the coast under insect harassment. The highest density of caribou calving in the region currently occurs southwest of the study area from late May to mid-June; although relatively few cows calve in the study area. Most CAH caribou and nearly all PCH caribou breed and winter considerably south of the Point Thomson study area.

4.10.2 Muskoxen

Native muskoxen in Alaska were extirpated from the North Slope by the late 1800s (Smith 1989). Muskoxen were reintroduced on the Arctic Coastal Plain at Barter Island (in ANWR) in 1969 and at the Kavik River (between Prudhoe Bay and ANWR) in 1970 from Nunivak Island in western Alaska. The reintroduced population expanded west and east within a decade (Garner and Reynolds 1986). The ANWR population stabilized at 350 to 400 muskoxen after 1986, whereas numbers to the west continued to increase (Reynolds 1992a, 1995). Stephenson (1993) estimated that 165 muskoxen inhabited the region between the Colville River and ANWR, out of a total population exceeding 550 animals in northeastern Alaska and the northern Yukon.

Muskoxen move in response to seasonal changes in snow cover and vegetation but most activities occur in riparian habitats associated with the major river drainages on the coastal plain. During the winter, muskoxen use upland habitats near ridges and bluffs where shallow snow cover allows easy access to forage plants (Klein et al. 1993). During spring, muskoxen use moist tussock tundra and moist shrub tundra habitats, which provide high quality flowering sedges (Jingfors 1980; Reynolds et al. 1986). By summer most muskoxen are found on river terraces, gravel bars, and shrub stands along rivers and tundra streams where forage includes willow leaves, forbs and sedges (Jingfors 1980; Robus 1981, 1984; O'Brien 1988). Muskoxen calving areas are poorly known, but the majority of the population appears to calve in the southern portion of the coastal plain on wind-blown, snow-free banks along rivers, and in upland foothill sites. Studies of muskoxen in the 1002 area of ANWR suggested that calving and winter (November to February) distributions were similar. Reynolds (1992b) reported little movement during winter, although some mixed-sex groups moved relatively long distances. In ANWR, long distance movements from winter to summer ranges were common in mid-to-late June, but were more pronounced in the eastern portion of the ACP in ANWR, while in the western portion, there was less shifting between winter and summer ranges.

Muskoxen groups typically include 10–30 animals and numbers decrease in summer as the breeding season (rut) [Aug.–Sep.] approaches (Reynolds et al. 1986; Reynolds 1992a). Bull muskoxen may move between mixed-sex groups during the summer and form bull groups during the winter. Calving occurs from late April to late June, peaking in mid-May (Reynolds et al. 1986). Cows produce single calves at intervals of one to three years. Few muskoxen calve within the project area and it is probable that most calving occurs at inland sites south of the project area (P. Reynolds USFWS, ANWR, pers. comm.).

Aerial surveys of muskoxen adjacent to the proposed project area were conducted in 1983 (WCC and ABR 1983), from June through September 1993–1995, and 1997–2000 (Pollard 1994, Pollard and Noel 1995, Noel 1998, Noel and Olson 1999a, Noel and King 1999a) (Figure 4-10). No muskoxen were observed in the Point Thomson study area during surveys in 1983 (all muskoxen observations were east of the Staines River) or 1997. However, several animals were observed on Flaxman Island during the summer of 1997 (pers. communication B. Trimm). During other years, the majority of animals observed during surveys were in small mixed-sex groups moving up and down the major rivers in the area. The largest number of muskoxen in the Point Thomson study area was 32 (4 groups) observed during 1999 (Noel and King 2000).

4.10.3 Grizzly Bear

Grizzly bears (Inupiaq name Aglaq) occur throughout northern Alaska from the Brooks Range northward to the ACP. The ADF&G manage grizzly bears by controling hunting seasons and bag limits. Conservative management practices have been implemented since the 1960s, when a statewide decline in bear numbers resulted primarily from aircraft-supported hunting associated with guiding (Hicks 1999). The Point Thomson study area is located is Game Management Unit (GMU) 26B (near 26C) where the long-term trend in grizzly bear population is thought to be stable at about 262 bears (1.7 bears/100 km^2 [1.7 bears/62 mi^2]); Hicks 1999). Densities are highest in the foothills of the Brooks Range and lowest on the ACP, although an artificially high concentration of bears developed near Prudhoe Bay (23 bears/1500 km^2 [23 bears/930 mi^2])

because discarded food was available in dumpsters and at the Borough Landfill (Hicks 1999). Artificial food sources are powerful attractants for grizzly bears and often have resulted in increased density and productivity of bears, including in the Prudhoe Bay oil fields (Shideler and Hechtel 2000). Grizzlies in the Prudhoe Bay and Kuparuk oil fields have larger litters, higher growth rates, and greater body sizes than bears elsewhere on the ACP (Shideler and Hechtel 1993, 1995a, 2000).

Since the 1989-90 hunting season, annual grizzly bear harvest in GMU 26B has ranged between 11 (1995-96) and 26 (1996–97 and 1997–98) (Hicks 1999). The management objective of the ADF&G in GMU 26B is to maintain a population capable of sustaining an annual harvest of 13 bears, with at least 60% males in the harvest. Since 1985, about one-half of the reported bear harvest in GMU 26B was by nonlocal residents and the other half by nonresidents (only one hunter of 176 total during that period was listed as a local resident of GMU 26B) (Hicks 1999). Unreported take by local hunters is unknown, but likely (Hicks 1999). Hunting pressure is higher in GMU 26B than other North Slope units because of the increased access allowed by the Dalton highway. Harvest of grizzly bears in GMU 26B is closely monitored and was subject to emergency closure in 1998 after harvest objectives were exceeded in 1996-97 and 1997-98.

Grizzlies use river drainages on the ACP as primary travel routes and foraging areas (Shideler and Hechtel 1995a; Johnson et al. 1996, 1997). Grizzly bears have large home ranges (1000-2000 mi^2 [1600-3200 km^2]) and may move 30 or more mi (49 km) in one day (Shideler and Hechtel 1995a). Bears move north from denning areas in the foothills in late May, and are most abundant on the coastal plain during June and July when caribou also are present. In late July, after caribou have left, bears gradually return to the foothills (Clough et al. 1987).

Riverine habitats contain preferred foods, such as legumes (flowering plants in the pea family) and ground squirrels. Bears also feed on sedges and other graminoids, root plants, berries, eggs, fox pups, and microtine rodents (Quimby 1974; Garner and Reynolds 1986; Garner et al. 1986).

Frequently used habitats include forb-rich river bars (which contain root plants, bearberry, and ground squirrels), dry shrub tundra along river terraces (with ground squirrels and bearberry), and both coastal and river-delta dunes (having abundant ground squirrels). Within the proposed Point Thomson project area, most grizzly bear foraging habitat is concentrated in riparian areas to the east or west or along the coast. ADF&G suggested that use of the Point Thomson project areas by grizzly bears would comprise mainly movements between preferred riparian areas to the east and west or attraction of bears to carcasses or seaweed along the coast (Shideler 1999).

Grizzly bears in northern Alaska den from early October to late April or early May. One to three cubs (average of two) are born per litter in December or January (Reynolds 1979, Garner and Reynolds 1986, Shideler and Hechtel 1995a). Males and females remain separate for most of the year, coming together only briefly to court and mate between May and July (Garner et al. 1986). Grizzlies dig dens in pingos, banks of rivers and lakes, dunes, and steep gullies in uplands on the coastal plain (Harding 1976; Shideler and Hechtel 1995b; Shideler, ADF&G, pers. comm.). Most of the bears studied by ADF&G in the Prudhoe Bay oil fields denned within 30 mi (48 km) of the oilfields, although a few denned 60 to 100 mi inland (Shideler and Hechtel 1995b; Shideler, ADF&G, pers. comm.). Figure 4-11 shows surveyed grizzly bear dens located in the region. No collared bears have denned in the Point Thomson study area (Shideler 1999).

Little information exists about grizzly bear use of the proposed Point Thomson project area before 1991. However, unconfirmed reports from Bullen Point Distant Early Warning (DEW) station personnel in the 1970s, and the reported harvest of two bears in 1969 from sites along the Kadleroshilik River (ADF&G files) provide some evidence of grizzly bear presence in the region. Figure 4-12 shows locations of grizzly bear sightings over the period 1991 through 1994. In addition, since 1997, ADF&G has reported nine separate observations of bears (two of these females with single cubs) in the Point Thomson study area (Shideler 1999). Other incidental observations include three bears, each about 15 mi (24 km) inland in 1997 (Noel 1998), two bears 8 mi (13 km) south of Bullen Point in 1998 (Noel and Olson 1999a), and two observations of the same bear near the southwestern edge of the study area in 1999 (Noel and King 2000a). In addition, bird survey crews observed several grizzly bears near Point Thomson Unit #3 in the summer of 2001 (pers. communication D. Trudgeon). Grizzly bears have been sighted somewhat more frequently in the adjacent Badami development area, where riparian habitats occur on the Kadleroshilik and Shaviovik rivers (LGL 1993, Pollard 1994, Pollard and Noel 1995, and Noel and Olson 1999b).

4.10.4 Arctic Fox

Arctic foxes (Inupiaq name Pisukkaaq) occur across the ACP including the Point Thomson area. Great temporal fluctuations in populations of arctic foxes are well known from fur harvest data in North America and Russia. On the North Slope, as in other regions, the population cycle (based on fur harvest data) is believed to be 3 to 4 years, fluctuating in response to lemming population cycles (Burgess 2000). However, actual population estimates are difficult to obtain and generally lacking. Arctic foxes are readily attracted to areas of human activity and to artificial food sources, such as dumpsters or open pit garbage dumps (Eberhardt et al. 1982, Burgess et al. 1993, and Burgess 2000). When not harassed, arctic foxes show little natural fear of humans and human structures provide readily used shelter for arctic foxes in all seasons, including use as dens during the breeding season. Development activities in the Prudhoe Bay oil fields have led to increases in fox numbers and productivity (Eberhardt et al. 1983, Burgess et al. 1993, Rodrigues et al. 1994, Burgess 2000, and Ballard et al. 2000a). The average density of dens is three to five times higher in developed portions of the oil fields (one den/4-5 mi^2 [6.4-8.0 km^2]) than in undeveloped areas of the coastal plain (one den/13-28 mi^2 [20-45 km^2) (Garrott 1980, Eberhardt et al. 1983, Burgess et al. 1993, Johnson et al. 1999a, and Burgess 2000). In addition, both the rate of den occupancy and litter sizes are substantially higher in the oil field than in adjacent undeveloped areas (Eberhardt et al. 1983, Burgess et al. 1993, and Rodrigues et al. 1994). These effects have been attributed to the availability of garbage as a food source, especially during winter. Fox extirpation efforts have been undertaken periodically to remove foxes from the oil field when there was a perceived overabundance of foxes (Burgess 2000 and Ballard et al. 2000b). The main concern is that overabundance of arctic foxes, especially those that are habituated to humans, increase the risk to humans of rabies and hydatid disease. An additional concern regarding the higher densities and reduced population fluctuations of fox populations in the oil fields is the potential impact on nesting shorebirds and waterfowl (Burgess 2000).

Arctic foxes are opportunistic predators and scavengers and their movements reflect their ability to exploit locally, seasonally, or artificially abundant food sources. In times of food scarcity, arctic foxes may move long distances in distinct seasonal patterns between dispersed summer breeding territories on the tundra and winter habitats along the coast or on the sea ice (Chesemore 1975 and Clough et al. 1987). Those on the sea ice move back onshore in late winter or early spring and again establish breeding territories (Chesemore 1975). Remarkable long-distance movements by individual arctic foxes have been documented, including movements of 80 to 1,400 mi (129 to 2,253 km) by eight arctic foxes marked and released near Prudhoe Bay (Eberhardt and Hanson 1978 and Burgess, unpub. data). In contrast, when food is locally abundant, arctic foxes may remain resident near their natal dens year around. During summer, territorial aggression between mated pairs tends to disperse foxes on the tundra (Eberhardt et al. 1983 and Burgess 1984). During fall, arctic foxes gradually abandon territorial den defense and, depending on food availability may simply increase their home range sizes or disperse widely. During winter, arctic foxes are less territorially aggressive and usually nonsocial, although they may congregate and interact in areas where food is abundant. Dense aggregations of arctic foxes may occur where food is superabundant during winter, e.g., at marine mammal carcasses and garbage dumps.

Small mammals (mainly collared and brown lemmings but also singing and tundra voles and ground squirrels) are the most important prey of arctic foxes, supplemented by caribou and marine mammal carcasses and, in summer, by nesting birds and their eggs (Chesemore 1968, Garrott et al. 1983, and Burgess 1984). During summers when lemmings are scarce, arctic foxes typically rely on the eggs of ground-nesting birds, sometimes devastating local egg production. When lemmings are scarce during other seasons (i.e., when birds are absent), arctic foxes eat mainly carrion, often on the coast or sea ice, and in late winter they may prey on seal pups in lairs (Smith 1976). When food is abundant during summer, arctic foxes cache many food items; an adaptation to regulate the wide seasonal and annual fluctuations in food abundance that occur in high-latitude environments. In villages, construction camps, and developed oil fields, garbage, and handouts may become important food sources (Urquhart 1973, Eberhardt 1977, Eberhardt et al. 1982, Fine 1980, Burgess et al. 1993, Rodrigues et al. 1994, and Burgess 2000).

Arctic foxes forage in a wide variety of habitats, but they exhibit strong habitat preferences for denning (Johnson et al. 1996 and 1997) and their dens are more or less permanent and widely recognized components of the coastal plain landscape. Preferred sites include pingos, small mounds, low hills, and ridges 3 to 13 ft (1 to 4 m) high – sites that are chosen for their thin snow accumulations, elevations above water tables, deep active (thaw) layers, surface stability, and sandy soils (see Burgess 2000 for review). These typical dens generally are stable structures that persist for decades (Macpherson 1969), and older dens, which are strongly preferred by arctic foxes, are large, conspicuous structures, often with >50 burrow entrances and strongly modified vegetation. However, many dens on the coastal plain are less conspicuous than the large "typical" dens, and these may be newly developing dens or "temporary" dens that are not likely to be used in subsequent seasons (Burgess 2000). Arctic foxes may use the same den site in successive years and, although populations fluctuate widely between years, in general, more dens are available each year than are used. Arctic foxes living in the oilfields have also been reported to den in artificial structures, such as utility corridors, culverts, abandoned vehicles or heavy equipment, and crawl spaces (Burgess 2000) and to use both natural and artificial dens for winter shelter (Eberhardt et al. 1983). Despite strong denning-habitat preferences, the scarcity of "typical" den sites is not likely to limit the abundance of arctic foxes in any area (Macpherson 1969 and Burgess 2000). Arctic foxes are capable of denning in a wide variety of sites and most tundra landscapes on the coastal plain have an abundance of unused dry mounds, vegetated dunes, and low ridges that are suitable for den sites.

The breeding cycle of arctic foxes begins in late winter to early spring, when foxes adopt breeding territories, mate (March-April), and den. Pups are born between May and early July after a seven to eight week gestation. Litter sizes can be remarkably large in arctic foxes and show considerable annual and regional variability. The most comprehensive evaluation reported that litters averaged 10.6 pups at birth and 6.7 pups at weaning (Macpherson 1969). In the Prudhoe Bay region in 1992, the mean litter size in late summer was 4.6 and the largest litters had 13 pups (Burgess et al. 1993). In years of lemming scarcity, the only foxes with litters that survived to late summer were those living near oil-field facilities.

Because most arctic fox den sites have a history of repeated used and because arctic foxes appear to prefer such sites for breeding, den locations can be mapped and censused annually to obtain an index to local arctic fox abundance and productivity. Four separate investigators have surveyed all or portions of the Point Thomson study area for arctic fox dens: Quimby and Snarski (1974), WCC and ABR (1983), Burgess and Banyas (1993), and Perham (2000). Only Perham (2000) conducted systematic surveys of the entire Point Thomson study area (as currently defined). A few arctic fox dens have been located in the Point Thomson study area to date (Figure 4-13):

- Den 99, located by Burgess and Banyas 1993, on a pingo approximately 7.5 mi (12 km) south of the Badami facility;
- Den 203, located by WCC and ABR 1983, on the bank of a small stream about 6.2 mi (10 km) west of the Staines River; and
- Den 204, located by WCC and ABR 1983, on the bank of a small stream about 1.9 mi (3 km) west of the Staines River.

Den identification numbers were taken from the inventory of arctic fox dens in the region, established by Burgess and Banyas 1993 and appended by Perham (2000). Another arctic fox den was recorded on the western end of Duchess Island, offshore of the Point Thomson study area by Noel and Perham (1999). The small number of dens in the Point Thomson study area could be attributed to the lack of relief in the area (i.e., few elevated mounds or pingos) and to inadequate survey conditions (Perham 2000). The Point Thomson study area lies on an alluvial fan of the Canning River, with sand and gravel soils, lack of relief, and lack of riparian habitats (streambanks and river bluffs that also provide relief). These geomorphological factors may not be favorable to the development of "typical" arctic fox dens; i.e., sites with a long history of use and strongly modified vegetation, making them easy to locate during late summer surveys. For this reason, early spring surveys (in which arctic fox dens are located by arctic fox tracks and evidence of recent excavation in a snow-covered landscape) may be more successful at locating arctic fox dens in the Point Thomson study area. However, according to Perham (2000) snow cover was not optimal during the spring surveys conducted in 1999, and even the two dens that were later documented to be active in 1999 (Dens 203 and 204) were not located during that survey (see discussion in Perham 2000).

4.10.5 Moose

Moose are distributed across the North Slope in low numbers, concentrating in all seasons in narrow strips of shrub communities along major river drainages (Mould 1977 and Hicks 1998). Moose on the North Slope are at the limit of their range and are susceptible to nutritional stress and starvation during bad winters (Hicks 1998). Moose populations on the North Slope have fluctuated widely from very low numbers, mainly in the Colville River, in the 1940s, to an estimated 1600 moose in the 1980s. The Point Thomson study area is on the eastern edge of GMU 26B. ADF&G has conducted early winter composition counts in GMU 26B almost annually since 1986 (ADF&G 1996 and 1998). Before 1992, the population was thought to include 1000 to 1200 moose in GMU 26B. In the 1990s, North Slope moose populations experienced a rapid decline; in GMU 26B there was a 75% decline between the late 1980s and 1994, and populations remained at low levels through 2000. Figure 4-10 includes moose sightings recorded in 1994. Calf survival and recruitment have remained extremely low through the 1990s. The causes of population decline on the North Slope remain unknown but predation, insect harassment, and range deterioration all may have contributed. The precipitous decline in numbers led to total closure to moose hunting in GMU 26B (and other North Slope GMUs) in 1996.

Kaktovik and Nuiqsut are the only subsistence communities in the eastern North Slope GMUs 26B and 26C), and residents took 5-10 moose annually prior to season closure (note that Nuiqsut residents hunt mainly in the Colville River drainage, which lies in GMU 26A) (Hicks 1998). Although travel to the area is expensive and logistically difficult, the impacts of sport hunting were considerable prior to closure, particularly near better known aircraft landing sites. The reported moose harvest in Unit 26B ranged from 24 to 52 during 1986-1995 (Hicks 1996). Harvests declined during the early 1990s, apparently due to the decreases in moose numbers that lead to total closure. The concentrated nature of moose distribution and the open habitat create a potential for excessive harvest in accessible areas.

During all seasons, moose activity on the North Slope of the Brooks Range is concentrated in riparian habitats of major rivers. In winter, riparian areas are especially important, as forage is available only in willow stands that are not covered by drifting snow (Mould 1977). Following snow-melt in May, moose may be somewhat more dispersed across the tundra, as casual observations suggest occasional movements between river drainages in snow-free seasons. In the 1002 area of ANWR (east of the Point Thomson study area), moose concentrated in the foothills of the Brooks Range during winter and moved northward along river drainages (including the Canning River) in late spring-early summer (Clough et al. 1987).

Moose calve during mid-May to early June and rut during late September and early October. Gestation is about 243 days. Females typically breed annually and give birth to a single calf, although twins are not uncommon when nutrition is good.

Among all large mammal surveys in the Point Thomson study area conducted during 1993, 1994, 1995, 1997-2000, only four bull moose were sighted during three surveys in 1994 (Figure 4-10) (Pollard 1994, Pollard and Noel 1995, Noel 1998, Noel and Olson 1999a, and Noel and King 2000).

4.10.6 Other Mammals

Wolves (*Canis lupis*) (Inupiaq name Amaruq) occur in low densities on the ACP and are more common in the mountains and foothills. The North Slope population has remained low since federal predator control in the 1950s and 1960s, but reports of local trappers in Nuiqsut suggest that the population may be increasing in recent years (G. Carroll, NSB, pers. comm.). Other canids that may occur in low numbers in the Point Thomson study area include coyotes and red foxes. Both are associated primarily with higher productivity riparian habitats on the North Slope and, therefore, probably rarely occur in the Point Thomson study area.

Wolverines (*Gulo gulo*) (Inupiaq name Qavvik) occur in low numbers on the Arctic coastal plain, but are more common in the Brooks Range and the foothills (Bee and Hall 1956). Denning occurs primarily in the mountains and foothills in areas with deep snow cover. Habitats used most frequently by wolverines include tussock tundra meadows, riparian willow and alpine tundra (USDI 1978). Wolverines are predators and scavengers of caribou and are found in association with caribou calving and post-calving areas, suggesting that they may be present during caribou calving in the Point Thomson study area. Stomach contents of wolverines harvested in the northern NPRA have consisted primarily of caribou (USDI 1978).

The arctic ground squirrel (*Spermophilus parryii*) (Inupiaq name Sigzik) is abundant on the Arctic coastal plain, with highest densities along major river drainages (Bee and Hall 1956). Because they live underground, ground squirrels require unfrozen soils that are deep enough for burrowing. Typical habitats are uplands, such as sand dunes, ridges, riverbanks, bluffs and pingos. On the coastal plain, ground squirrels are most abundant along major river drainages. Ground squirrels hibernate from September to May (McLean and Townes 1981 and Garner and Reynolds 1986). Mating occurs immediately after hibernation and young are born in June following a three to four week gestation. Ground squirrels eat mainly plants (at least 40 species have been documented to be consumed) as well as occasional carrion, lemmings and voles, and eggs of ground-nesting birds (Batzli and Sobaski 1980 and McLean 1985). Squirrels are an important prey species for golden eagles, foxes, and grizzly bears (Garner and Reynolds 1986).

Lemmings are the most common small mammals on the ACP and their numbers fluctuate dramatically in a 3-4 year cycle in most areas. Collared lemmings (*Dicrostonyx torquatus*) prefer drier habitats found in tussock tundra and high center polygons, while brown lemmings *(Lemmus sibiricus*) inhabit wet sedge meadows and polygonized areas. Collared lemmings eat mostly shrubs (willows and *Dryas*) and forbs, while brown lemmings and tundra voles eat sedges and grasses (Pitelka 1957 and Batzli et al. 1983).

The ermine (or short-tailed weasel) (Inupiaq name Itiriaq) and least weasel (Inupiaq name Naulayuq) are relatively common predators of small mammals on the ACP. Little is known of their population sizes or densities, but they are important predators of lemmings and may play a role in population cycles of those species (MacLean et al. 1974). Other mustelids that may occur in low numbers include mink and river otter, both of which are highly associated with major rivers and, therefore, probably very rarely occur in the Point Thomson study area.

Other small mammals likely to be found in the Point Thomson study area include tundra voles, and barren ground and tundra shrews. Tundra voles are less common than lemmings and are patchily distributed on the Arctic coastal plain. Little is known of the abundance or distribution of shrews on the Arctic coastal plain, although they appear to be widely distributed.

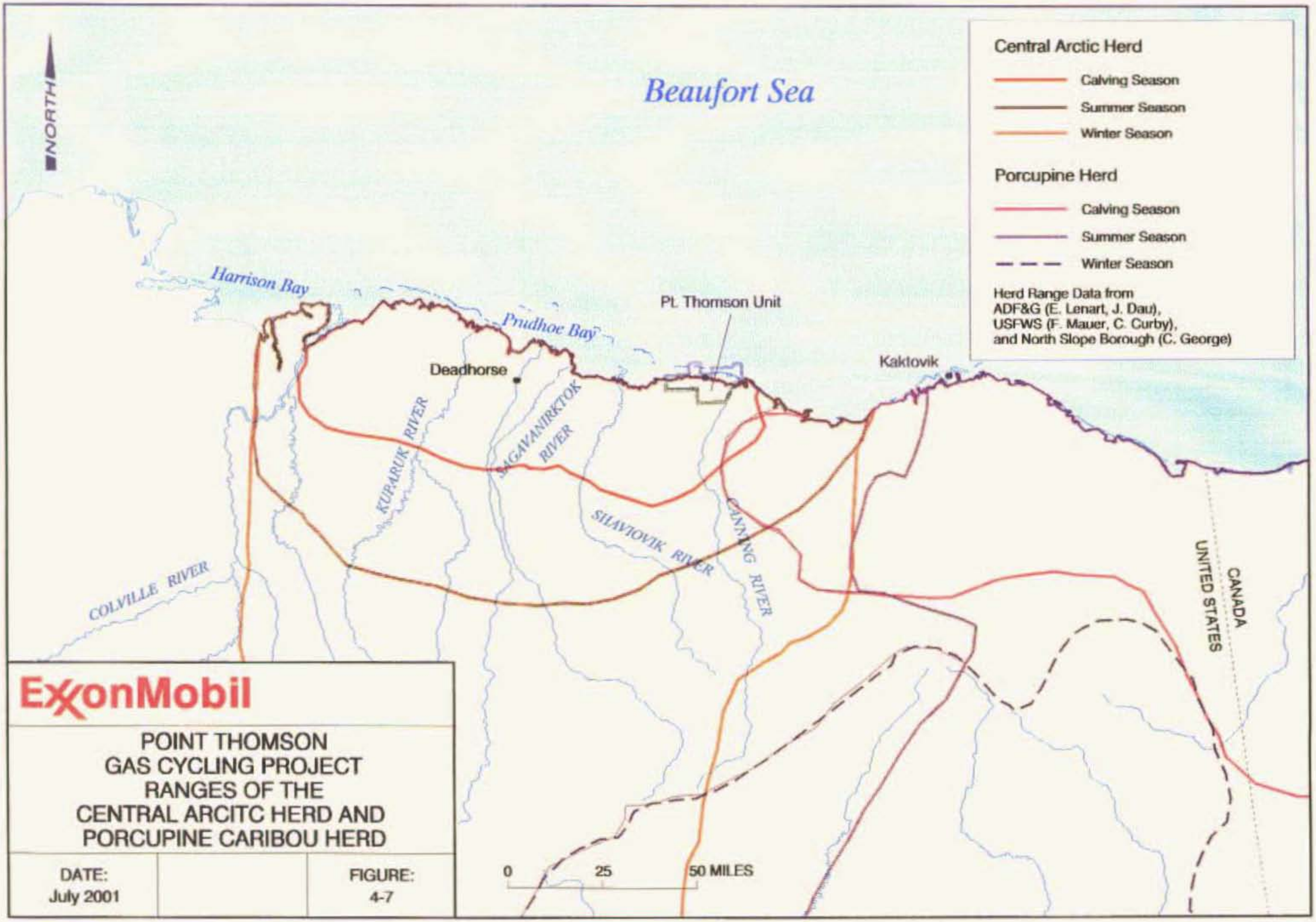
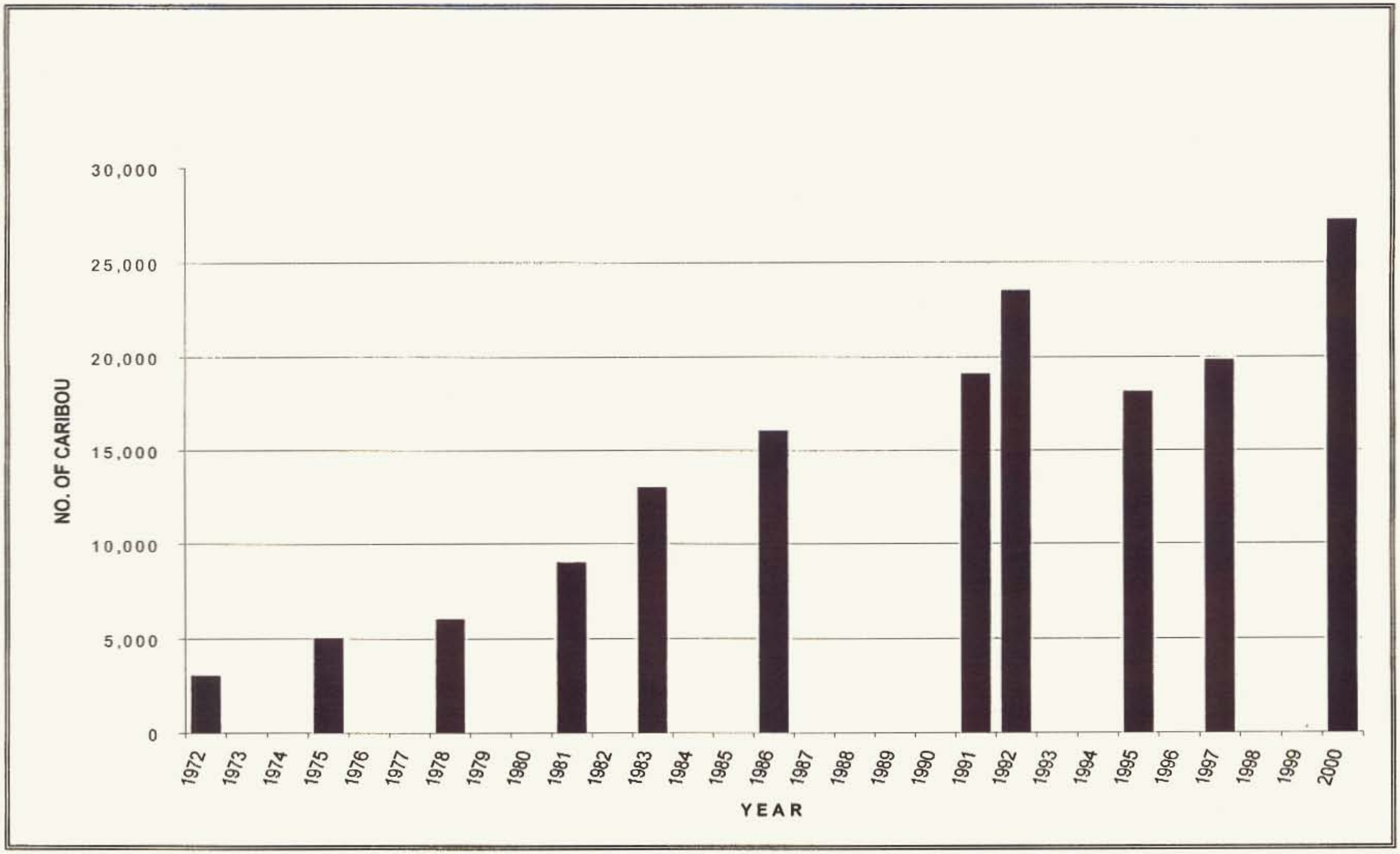
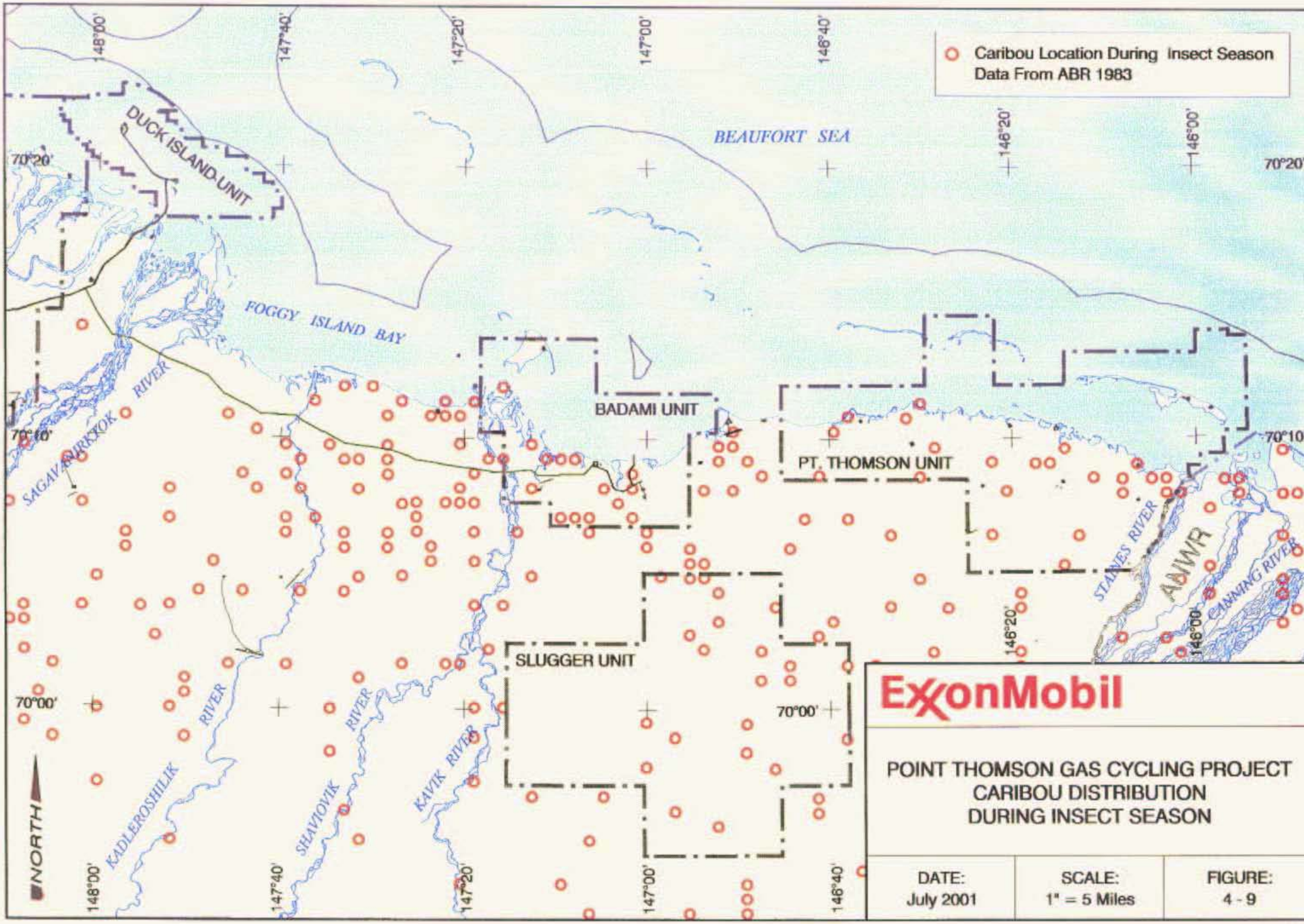

NORTH
Beaufort Sea
Central Arctic Herd
Calving Season
Summer Season
Winter Season
Porcupine Herd
Calving Season
Summer Season
Winter Season
Herd Range Data from
ADF&G (E. Lenart, J. Dau),
USFWS (F. Mauer, C. Curby),
and North Slope Borough (C. George)
Harrison Bay
Prudhoe Bay
Pt. Thomson Unit
Kaktovik
Deadhorse
KUPARUK RIVER
SAGAVANIRKTOK RIVER
SHAVIOVIK RIVER
CANNING RIVER
COLVILLE RIVER
UNITED STATES
CANADA
0
25
50 MILES
ExxonMobil
POINT THOMSON
GAS CYCLING PROJECT
RANGES OF THE
CENTRAL ARCITC HERD AND
PORCUPINE CARIBOU HERD
DATE:
July 2001
FIGURE:
4-7

fig4_7.dgn

Figure 4-8 Central Arctic Caribou Herd Size





ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
CARIBOU DISTRIBUTION
DURING INSECT SEASON

DATE:	SCALE:	FIGURE:
July 2001	1" = 5 Miles	4 - 9

fig4_9.dgn

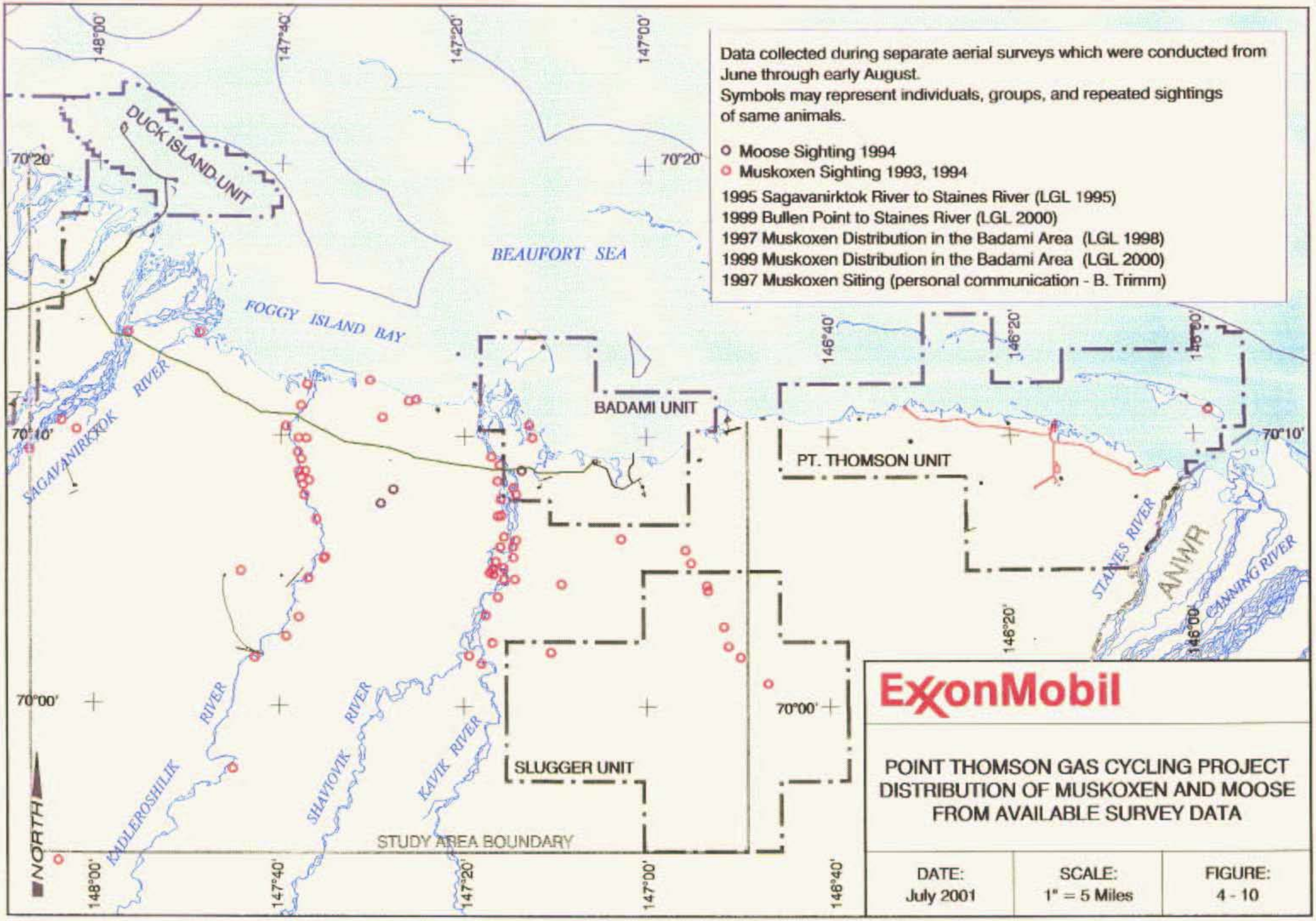
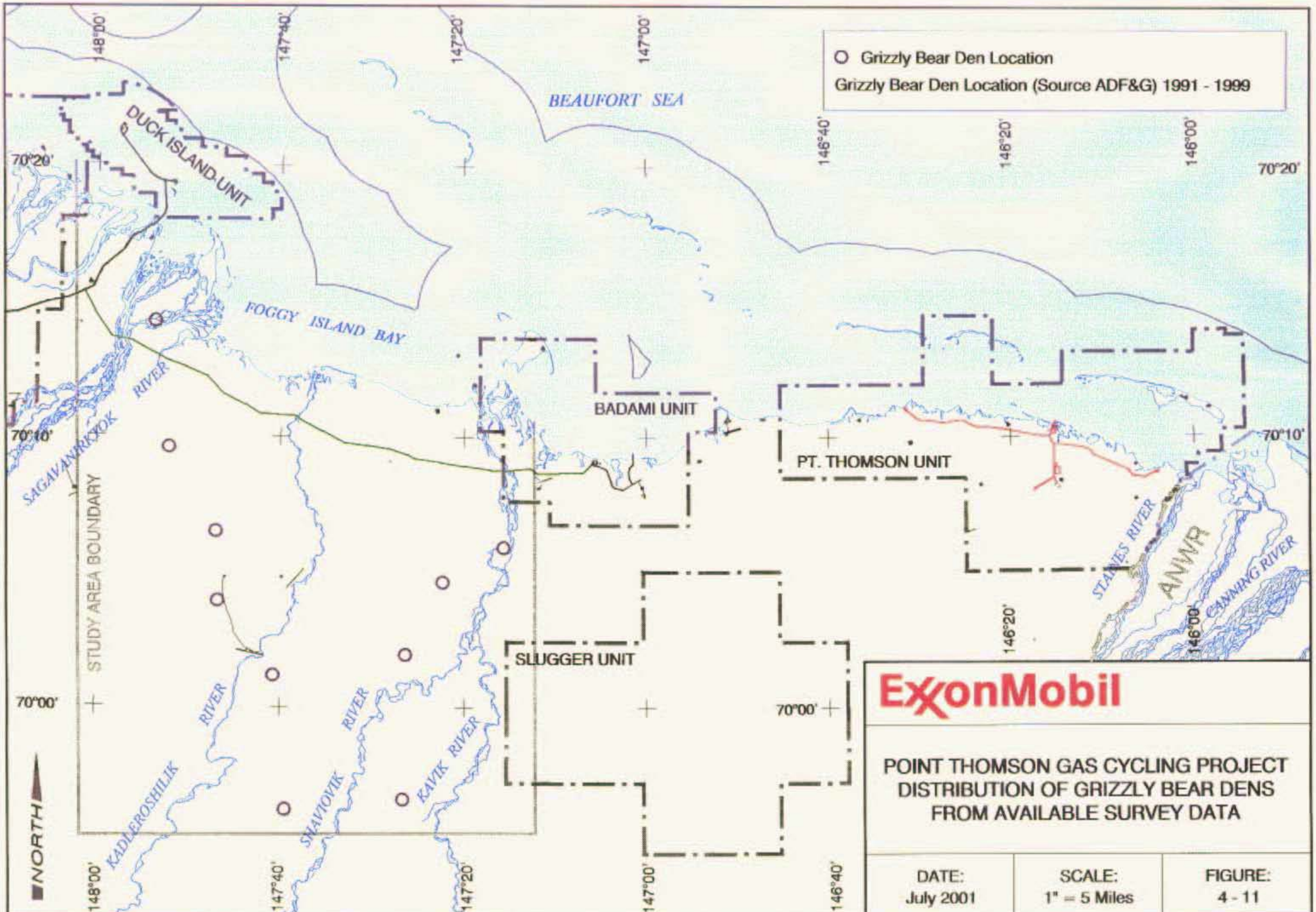
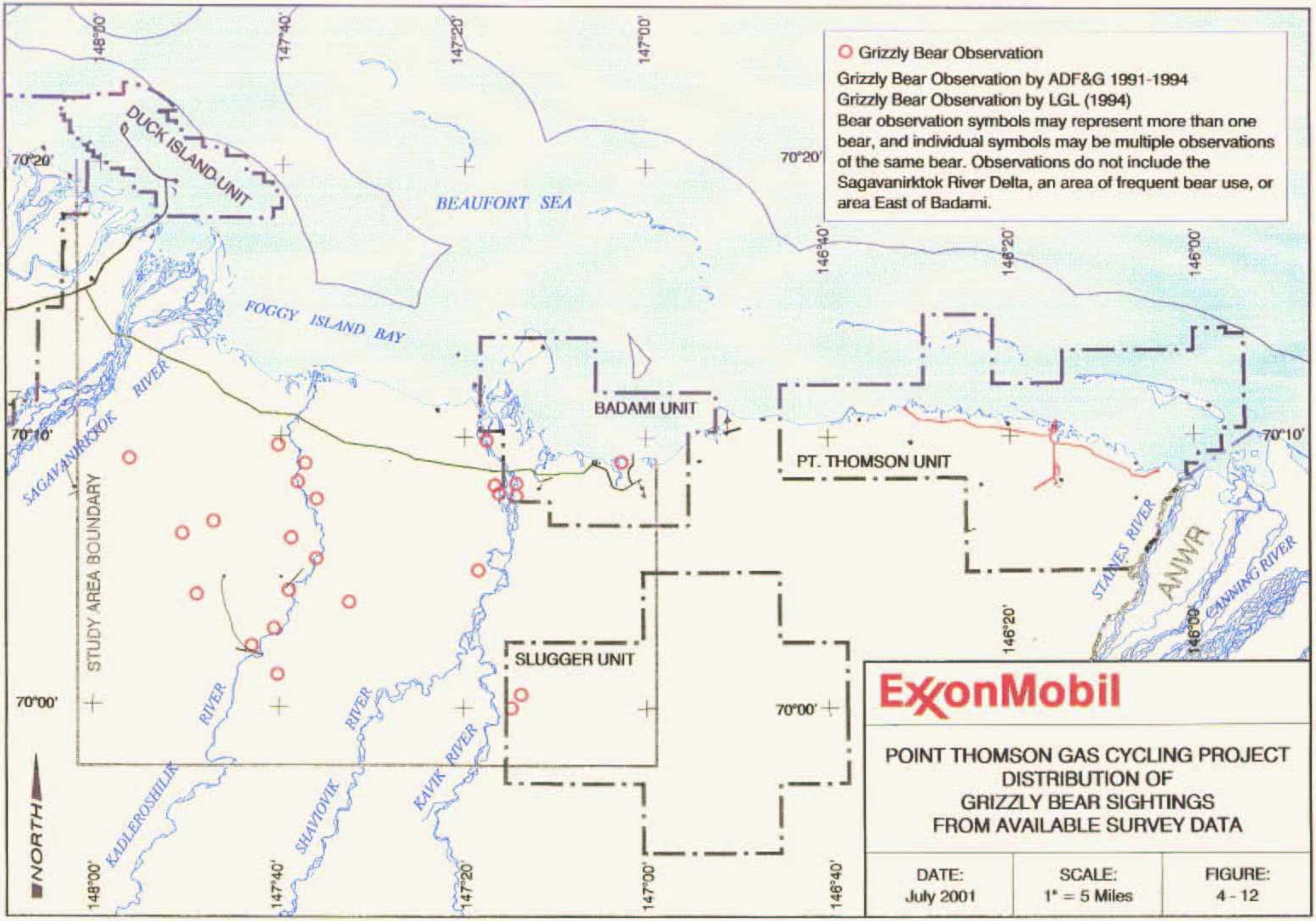

Data collected during separate aerial surveys which were conducted from June through early August.
Symbols may represent individuals, groups, and repeated sightings of same animals.
Moose Sighting 1994
Muskoxen Sighting 1993, 1994
1995 Sagavanirktok River to Staines River (LGL 1995)
1999 Bullen Point to Staines River (LGL 2000)
1997 Muskoxen Distribution in the Badami Area (LGL 1998)
1999 Muskoxen Distribution in the Badami Area (LGL 2000)
1997 Muskoxen Siting (personal communication - B. Trimm)
148°00'
147°40'
147°20'
147°00'
146°40'
146°20'
146°00'
70°20'
70°10'
70°00'
DUCK ISLAND UNIT
BEAUFORT SEA
FOGGY ISLAND BAY
SAGAVANIRKTOK RIVER
BADAMI UNIT
PT. THOMSON UNIT
STAINES RIVER
ANWR
CANNING RIVER
SLUGGER UNIT
KADLEROSHILIK RIVER
SHAVIOVIK RIVER
KAVIK RIVER
STUDY AREA BOUNDARY
NORTH
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
DISTRIBUTION OF MUSKOXEN AND MOOSE FROM AVAILABLE SURVEY DATA
DATE: July 2001
SCALE: 1" = 5 Miles
FIGURE: 4 - 10

fig4_10.dgn



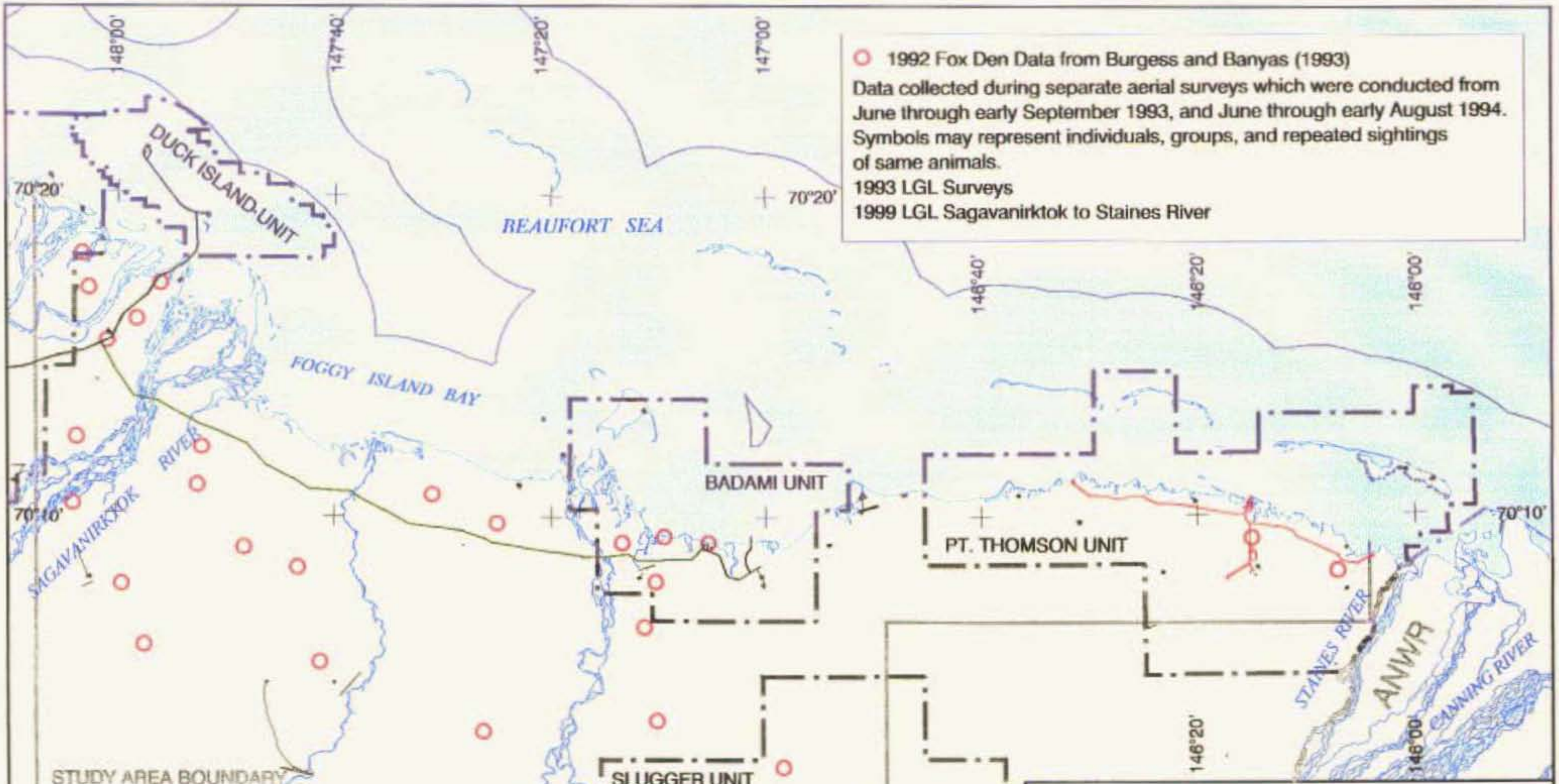
Grizzly Bear Den Location
Grizzly Bear Den Location (Source ADF&G) 1991 - 1999
BEAUFORT SEA
DUCK ISLAND UNIT
FOGGY ISLAND BAY
BADAMI UNIT
PT. THOMSON UNIT
SLUGGER UNIT
SAGAVANIRKTOK RIVER
STUDY AREA BOUNDARY
KADLEROSHILIK RIVER
SHAVIOVIK RIVER
KAVIK RIVER
STAINES RIVER
CANNING RIVER
ANWR
NORTH
148°00'
147°40'
147°20'
147°00'
146°40'
146°20'
146°00'
70°20'
70°10'
70°00'
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
DISTRIBUTION OF GRIZZLY BEAR DENS
FROM AVAILABLE SURVEY DATA
DATE:
July 2001
SCALE:
1" = 5 Miles
FIGURE:
4 - 11

fig4_11.dgn



Grizzly Bear Observation
Grizzly Bear Observation by ADF&G 1991-1994
Grizzly Bear Observation by LGL (1994)
Bear observation symbols may represent more than one bear, and individual symbols may be multiple observations of the same bear. Observations do not include the Sagavanirktok River Delta, an area of frequent bear use, or area East of Badami.
148°00'
147°40'
147°20'
147°00'
146°40'
146°20'
146°00'
70°20'
70°10'
70°00'
DUCK ISLAND UNIT
BEAUFORT SEA
FOGGY ISLAND BAY
SAGAVANIRKTOK RIVER
BADAMI UNIT
PT. THOMSON UNIT
STUDY AREA BOUNDARY
SLUGGER UNIT
STAINES RIVER
ANWR
CANNING RIVER
KADLEROSHILIK RIVER
SHAVIOVIK RIVER
KAVIK RIVER
NORTH
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
DISTRIBUTION OF
GRIZZLY BEAR SIGHTINGS
FROM AVAILABLE SURVEY DATA
DATE:
July 2001
SCALE:
1" = 5 Miles
FIGURE:
4 - 12

fig4_12.dgn



ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
DISTRIBUTION OF ARCTIC FOX DENS
FROM AVAILABLE SURVEY DATA

DATE:	SCALE:	FIGURE:
July 2001	1" = 5 Miles	4 - 13

fig4_13.dgn

4.11 THREATENED AND ENDANGERED SPECIES

The Point Thomson project area is seasonally occupied by the spectacled eider, which has been identified as threatened under the Endangered Species Act (ESA). Steller's eiders, which also have been listed as threatened could occur in the project area, but have not been sighted during recent surveys. In addition, the listed bowhead whale migrates offshore of the barrier islands that separate Lions Lagoon from the Beaufort Sea.

4.11.1 Bowhead Whale

The bowhead whale is listed as endangered under the ESA and is designated as depleted under the MMPA. The western Arctic population of bowhead whales was estimated to be 8,200 (6,900 to 9,200 confidence interval) animals in 1993 (NMFS, MMC 2000). The population appears to be increasing at a rate of 3.2% per year despite subsistence harvests of 14 to 74 bowheads per year from 1973 to 1993. Western Arctic bowhead whales winter in the central and western Bering Sea, and spend the summer in the Canadian Beaufort Sea. Migration through the western Beaufort Sea occurs in spring and autumn. For more information of the bowhead whale see Section 4.9.1.1.

4.11.2 Spectacled Eider

The spectacled eider, a threatened bird species, has declined by more than 96 % from historical levels (50,000 pairs) on the Yukon–Kuskokwim Delta in western Alaska (Stehn et al. 1993). Historical records of spectacled eider abundance on the ACP are unavailable, but the USFWS has estimated the current population to be at least 5,000 to 7,000 breeding birds (Larned et al. 2001). Recent estimates suggest that the ACP now supports the main breeding population of spectacled eiders in Alaska (USFWS 1994 and Larned et al. 1999). Spectacled eiders also nest on the Yukon–Kuskokwim Delta, possibly on the Seward Peninsula, and in arctic Russia. Data for the nesting population in the Prudhoe Bay area suggest that it may have declined by as much as 80% between 1981 and 1992 (Warnock and Troy 1992 and TERA 1993). However, recent estimates for the breeding population across the entire ACP, based on aerial survey counts since 1992, suggest that the spectacled eider population is relatively stable (Larned et al. 2001).

Aerial surveys for spectacled eiders were conducted in the Point Thomson region in 1994 (Byrne et al. 1994) and during 1998–2000 (TERA 1999, TERA 2000, and D. Troy, TERA pers. comm.), and this area has been encompassed by surveys conducted across the entire ACP by USFWS since 1992 (Larned et al. 1999 and 2001). Surveys of breeding pairs of spectacled eiders in the Point Thomson region have not been conducted for a sufficient time period to identify discernable trends, but densities in the region are lower than those found in other areas in and adjacent to the oil fields (Table 4-10). Most of the spectacled eiders seen during the aerial surveys were in the vicinity of the Kadleroshilik and Shaviovik rivers and few eiders were seen east of the Shaviovik River (Figure 4-14). No nests of spectacled eiders have been found in the Point Thomson area, although breeding in the area was confirmed by the observation of one brood (female with 4 young) south of Point Sweeny in July 1998 (LGL et al. 1999). Day et al. (1995) observed one pair of spectacled eiders and one male flying west along the coast at the Bullen Point Dewline site during a ground survey of that site in 1994. They also found one badly decomposed carcass of a female-plumaged spectacled eider. No spectacled eiders were seen at the Bullen Point Dewline site during an aerial survey there in June 2000 (Day and Rose 2000). In general, Point Thomson is thought to be located at the eastern range of this species.

Table 4-10 Abundance and Density (birds/mi²) of Eiders in the Point Thomson Study Area, 1993, 1998–2000.

SPECIES / YEAR	BREEDING PAIRS[A] NUMBER PAIRS	DENSITY PAIRS/MI²	SURVEY AREA (MI²)	SOURCE
Spectacled Eider				
1993				
(Sagavanirktok to Mikkelsen Bay)	50	0.37	136.6	Byrne et al. (1994)
(Mikkelsen Bay to Staines River)	4	0.07	56.5	Byrne et al. (1994)
1998	2	0.03	76.7	TERA (1999)
1999	3	0.04	76.7	TERA (2000)
2000	0	0	76.7	D. Troy (pers. comm.)
King Eider				
1993				
(Sagavanirktok to Mikkelsen Bay)	81	0.59	136.6	Byrne et al. (1994)
(Mikkelsen Bay to Staines River)	32	0.57	56.5	Byrne et al. (1994)
1998	133	1.73	76.7	TERA (2000)
1999	127	1.66	76.7	TERA (2000)
2000			76.7	
Common Eider				
1993				
(Sagavanirktok to Mikkelsen Bay)	1	0.01	136.6	Byrne et al. (1994)
(Mikkelsen Bay to Staines River)	1	0.02	56.5	Byrne et al. (1994)
1998 (inland)[b]	5	0.25	76.7	TERA (1999)
1998 (including coast)	14	0.18	76.7	TERA (1999)
1999 (inland)	18	0.23	76.7	TERA (2000)
1999 (including coast)	75	0.98	76.7	TERA (2000)
2000 (inland)			76.7	
2000 (including coast)			76.7	

[a] Breeding pairs equals numbers of males seen on the surveys.

[b] Common Eiders seen inland from the coast.

Critical habitat had been proposed for spectacled eiders on the North Slope by USFWS (65 FR 6114), but final rulings on this designation (66 FR 9146) did not delineate specific areas for critical habitat protection in the region. Critical habitat was not designated for the North Slope since habitat, and in particular nesting habitat, is not limiting. However, the proposal did identify elements of critical habitat that that may warrant more scrutiny during oilfield planning. These elements included five specific habitats for the North Slope: all deep water bodies; all water bodies that are part of basin wetland complexes; all permanently flooded wetlands and water bodies containing either *Carex aquatilis*, *Arctophila fulva* (pendant grass), or both; all habitat immediately adjacent to these habitat types; and all marine waters out to 25 mi (40 km) from shore, its associated aquatic flora and fauna in the water column, and the underlying benthic community. Many of these habitats are found in the Point Thomson area.

Spectacled eiders arrive on the ACP of northern Alaska in late May (Warnock and Troy 1992, Anderson and Cooper 1994, Johnson 1995, and Johnson et al. 1996 and 1997). Observations during the pre-nesting period suggest that habitats containing open water early in the season are important to spectacled eiders (Anderson and Cooper 1994 and Johnson et al. 1999). Nesting begins in mid-June and eggs start hatching in mid-July; males disperse from the area by late June (Warnock and Troy 1992 and Anderson and Cooper 1994). In recent studies on the Colville River delta, spectacled eiders nested in a variety of habitats, including salt-killed tundra, aquatic sedge with deep polygons, brackish water, and non-patterned wet meadow (Johnson et al. 2000a). Spectacled eiders in the Kuparuk Oilfield nested primarily in non-patterned wet meadows within wetland complexes containing emergent grasses (*Arctophila fulva*) and sedges (*Carex* spp.) (Anderson and Cooper 1994, and Anderson et al. 2000). Spectacled eiders in the Prudhoe Bay Oilfield nested principally in non-patterned wet meadows (Warnock and Troy 1992).

During brood-rearing, from mid-July to when the young fledge in early September (TERA 1995), spectacled eiders use a variety of aquatic habitats on the coastal plain. For example, broods on the Colville River delta were observed in nine different habitats, but most broods were seen in two habitats, salt-killed tundra and deep open water with islands or polygonized margins (Johnson et al. 2000a). Brood-rearing in the Kuparuk, Milne Point, and Prudhoe Bay oilfields primarily occurs in water bodies with margins of emergent grasses and sedges, basin wetland complexes, and occasionally deep open lakes (Warnock and Troy 1992, Troy 1994, Anderson and Cooper 1994, and TERA 1995). These results demonstrate that brood-rearing (and nesting) habitat is strongly associated with aquatic habitats, particularly coastal habitats when available. When young are capable of flight, spectacled eiders depart the ACP usually by mid-September, when freeze-up begins.

4.11.3 Steller's Eider

The Steller's eider was listed as a threatened species on 11 June 1997 (62 FR 31748). Historically, Steller's eiders nested throughout much of western and northern coastal Alaska and in arctic Russia (Kertell 1991 and Quakenbush and Cochrane 1993) but currently they nest only on the Yukon–Kuskokwim Delta (a few pairs since 1994), the ACP, and arctic Russia (Kertell 1991, Quakenbush and Cochrane 1993, and Flint and Herzog 1999).

Critical habitat was proposed for Steller's eiders on the North Slope by USFWS west of the Colville River delta (65 FR 13262); no critical habitats were proposed in the Point Thomson area. The final ruling did not designate any areas on the North Slope as critical habitat (66 FR 8850). The primary constituent elements identified in the original proposal were "... small ponds and shallow water habitats (particularly those with emergent vegetation), moist tundra within 326 ft (100m) of permanent surface waters including lakes, ponds, and pools, the associated aquatic invertebrate fauna, and adjacent nesting habitats" (65 FR 13267).

Nesting densities on the ACP are highest near Barrow, but the current breeding range on the ACP probably extends from near Point Lay in the west to the vicinity of the Colville River delta in the east (Day et al. 1995 and Quakenbush et al. 1995). Nonbreeders and post-breeding birds use the nearshore zone of the northeastern Chukchi Sea and large lakes around Barrow for molting and summering, and a few occasionally occur as far east as the Canadian border. Steller's eiders have not been recorded in the Point Thomson region, but have been seen periodically in the Prudhoe Bay area (Quakenbush et al., in review). The preferred habitats of Steller's eiders near Barrow are waterbodies with *Arctophila fulva* (pendant grass). The Point Thomson area is probably not used at all by Steller's Eiders.

This page intentionally left blank

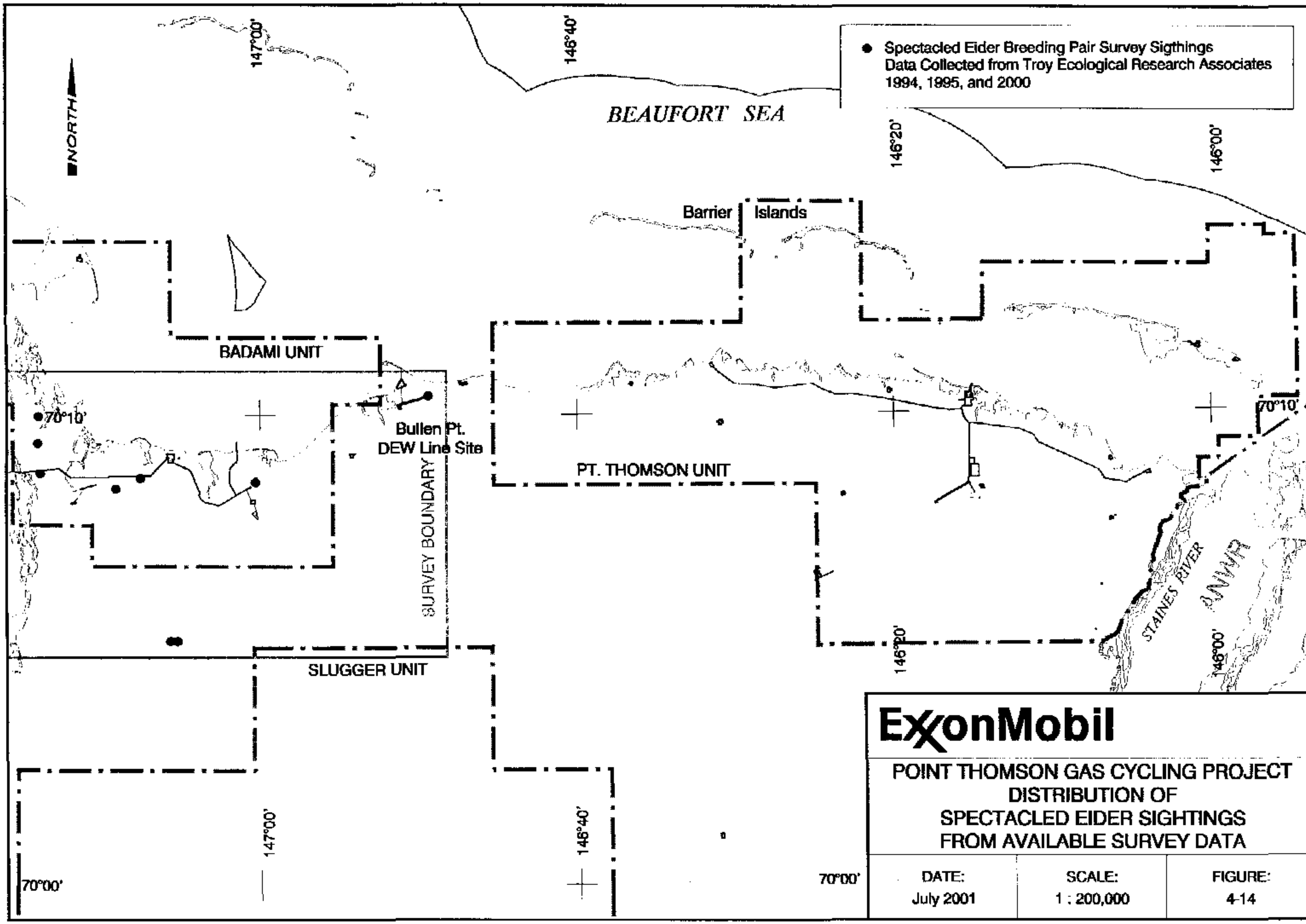

Spectacled Eider Breeding Pair Survey Sigthings
Data Collected from Troy Ecological Research Associates
1994, 1995, and 2000
NORTH
BEAUFORT SEA
147°00'
146°40'
146°20'
146°00'
Barrier Islands
BADAMI UNIT
70°10'
Bullen Pt.
DEW Line Site
PT. THOMSON UNIT
SURVEY BOUNDARY
SLUGGER UNIT
STAINES RIVER
ANWR
70°00'
ExxonMobil
POINT THOMSON GAS CYCLING PROJECT
DISTRIBUTION OF
SPECTACLED EIDER SIGHTINGS
FROM AVAILABLE SURVEY DATA
DATE:
July 2001
SCALE:
1 : 200,000
FIGURE:
4-14

fig4 14.dgn

4.12 CULTURAL RESOURCES

Cultural resource sites on Alaska's North Slope contain non-renewable data about human history prior to European contact (prehistoric) and after contact (historic). On the North Slope, the contact era began in the 1800s, although indirect influences (especially from Siberia) through established trade networks occurred much earlier. Historic and prehistoric cultural resources include sites, features, structures, buildings, and objects that can provide information on human prehistory or history. These resources can be located in uplands, the intertidal zone, and/or underwater.

4.12.1 Regulatory and Compliance Background

Prehistoric or historic sites (also termed "historic properties" in the National Historic Preservation Act of 1966) are those listed in or eligible for the National Register of Historic Places (36 CFR 800). A site must be over 50 years old to be considered "historic" unless it has exceptional national, state, or local significance. Certain Alaskan Native sacred sites may also be significant (Executive Order 13007 1996), and certain traditional cultural properties also may be eligible for the National Register (36 CFR 60.4). The State of Alaska Historic Preservation Act and the North Slope Borough (NSB) also stipulate protection of area cultural resources.

The Alaska Office of History and Archaeology (OHA) and the NSB Inupiat History, Language, and Culture Commission (IHLC) are the primary repositories of archaeological and historic land use data for the North Slope. The OHA maintains the Alaska Heritage Resource Survey (AHRS), a statewide listing of archaeological site data. The NSB's Traditional Land Use Inventory (TLUI) database contains place-names and site data primarily related to important historic (post-contact) subsistence use areas, although some of these sites may also have prehistoric components. TLUI sites include a variety of site types including villages, camps, graves, hunting and fishing sites, graves, quarries, trails, and landmarks. The Geographical Information System (GIS) version of the database contains both Inupiaq and English descriptions and visual information (ESRI 1999).

Past and present local subsistence, Western exploration, trade, and commercial resource extraction has involved small boats, ships and barges. Although this project is not likely to involve submerged cultural resources, historic shipwrecks-particularly those associated with commercial whaling-are a component of the area's archaeological and historical record. Small boat wrecks and boat parts can also found on area shorelines. Department of the Interior Minerals Management Service (MMS) maintains a historic shipwreck database including over 50 wrecks in the Beaufort Sea management unit (Tornfelt and Burwell 1992). The MMS Handbook for Archaeological Resource Protection 620.1-H and Notice to Lessee 00-A03 describes current management schemes for shipwrecks.

4.12.2 North Alaska Prehistory

Tools left behind by ancient Paleoindians in the Arctic may be as old as 11,800 years and as recent as 8,800 years ago (Figure 4-15). The Mesa Site is the oldest and best-dated (Kunz and Reanier 1994), followed by the Putu (Alexander 1987) and Bedwell sites (Alexander 1974 and Reanier 1995) where ancient lanceolate projectile points were found.

Paleoarctic sites from northern Alaska include the Gallagher Flint Station (Dixon 1972, Bowers 1983, and Ferguson 1995), a site that also yielded Northern Archaic and Arctic Small Tool Tradition materials; and the Lisburne Site (Bowers 1982 and 1999). The early chapters in Alaska prehistory are still being written. New discoveries are affecting New World cultural migration and habitation scenarios. While each new site helps illuminate the ancient past, Lobdell et al. (2000) noted, "There is much of the peopling of the Americas, including the Arctic, which is not yet understood."

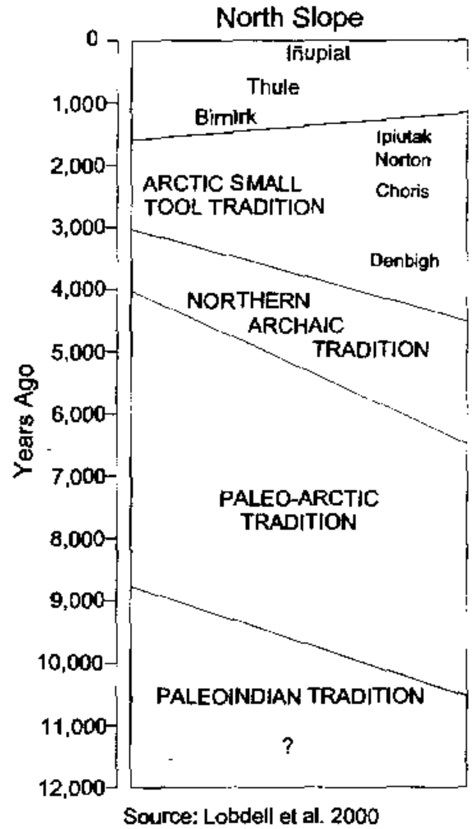


Figure 4-15 North Alaska Prehistory

Northern Archaic side-notched projectile points start appearing throughout Northern Alaska 6,500 to 6,000 years ago (Anderson 1968), possibly indicating an expanding boreal forest tradition (Anderson 1984). On the North Slope, the Kuparuk Pingo (Lobdell 1986) and the Putuligayuk River (Lobdell 1981) contain these diagnostic projectile points.

The Arctic Small Tool Tradition (ASTT) sites are known by their well made, minutely flaked, tools that may mark an emerging bow and arrow technology. Various Choris, Norton, and Ipiutak expressions of the Arctic Small Tool tradition are now recognized. The North Slope ASTT sites include Putuligayuk River Delta Overlook (Lobdell 1981) and the Central Creek Pingo (Lobdell 1992d).

Expanded marine mammal hunting in the first millennium, combined with caribou hunting and fishing, set the scene for a Thule cultural explosion that flourished in Arctic Alaska, Canada, and southern Greenland. Modern Inupiat life evolved out of a cultural milieu focused on whaling and featuring intensive exploitation, trade, and exchange of a wide variety of coastal and interior resources. The cooperative nature of the subsistence lifestyle that once enabled the Thule culture to flourish on the North Slope of Alaska continues into the present and has been a key to modern Inupiat cultural survival. In the Historic Era, Inupiat people adapted to rapid and extensive culture change brought by disease epidemics, commercial whaling, fox skin trading, and reindeer herding. Inupiat culture has absorbed the impact of Western military, educational, medical and religious institutions, and the effects of oil development. Cooperative resource harvesting and sharing persist in the third millennium among the Inupiat and continue to bind people to their homeland on the North Slope.

4.12.3 Point Thomson Cultural Resources

Scores of commercial whalers passed by the Point Thomson area in the late 1800s as they followed the bowhead migration past ancient Inupiat villages and into the Beaufort Sea. Historic Period archeological sites with traditional land use associations dating to the commercial whaling and fox trapping eras are the principal cultural resource sites in the project area (LGL et al. 1998). Libbey (1981) recorded Inupiat elders' oral histories and traditional accounts of some project areas from Josephine Itta, Mary Akootchook, Sarah Kukaknana, Joe Koganaluk, and others. Leffingwell (1919), Dawson (1916) and others record coastal trade activities on Flaxman Island, at Brownlow Point, and in the eastern Beaufort Sea. Jenness (1957) and Steffanson (1913) recorded aspects of area Inupiat life during their explorations and scientific investigations.

Summer trade fairs had brought Inupiat people together from villages all along the Arctic coast and throughout the interior until the practice ended in the early 1900s (Hoffman et al. 1977). Shortly after the trade fairs ended, commercial enterprises run by former commercial whalers-turned-entrepreneurs, Tom Brower, Tom Gordon, Bill Allen and others, sprang up along the Arctic coast. Photos of Gordon's and others' trading posts from this era are present in historic photograph collections at the NSB IHLC and elsewhere.

Inupiat people adjusted to new social conditions after commercial whaling ceased in 1908, as inland caribou populations crashed around the same time. In addition, flu epidemics caused devastation and the survivors coalesced into new social units through migration, amalgamation and altered land and resource use strategies. A portion of the Inupiat population living along the Beaufort Sea coast in the early to mid twentieth century were members of inland bands who had moved to the coast because of depopulation and the caribou decline. Sod house and trading post ruins, ice cellar and food rack/cache remains, skin-processing features and implements, hunting tools, domestic refuse including metal, boat and sled parts, and other transportation-related artifacts are associated with sites from the early to mid 1900s.

The commercial fur-trapping era along the Beaufort Sea coast was an important social period, sandwiched in between the 1919 and 1945 epidemics on the North Slope. It was a readjustment phase as trading posts and related historic ruins in the project area attest. Local furs provided a source of cash for the mixed subsistence/cash economy after commercial whaling ceased. The Panningonas ran their trapline from Flaxman Island as far as Point Gordon (NSB 1980:84) and also hunted caribou in this area. (ibid:146). Located at Point Thomson were three interconnected sod houses belonging to Pausanna, Utuayuk, and Kuniochiak. Sara Kunaknana's family wintered in the same area during the 1920s (ibid).

Evidence of Inupiat heritage in the proposed project area was apparent in testimony concerning the original Point Thomson lease sale in 1978 (ADNR 1978). A hearing transcript documented that several elders living in Barrow, including Johnny Tookak, Lora Oyaga, Olive Ahkivgak, Josephine Itta, Nellie Ahnupkana, Thomas Panningona, and Henry Nashanik, had local knowledge of the area:

> *These people have, through personal experience, knowledge of wildlife, hunting and fishing locations, land use patterns, and historic sites in the area proposed for the Point Thomson lease sale...*

Inupiat ties to the Point Thomson area, although difficult to document archaeologically because of the extensive recent coastal erosion in certain localized areas such as Flaxman Island, remain an important heritage issue. Numerous site-specific and general archaeological surveys focused on identifying eligible cultural resources in the Point Thomson project area beginning with Campbell (n.d.) in 1974. Surveys conducted for oil and gas exploration and development (Bacon 1982a, 1982b, 1983, and 1985; Dames & Moore and Lobdell 1986; Lobdell 1980, 1992a, 1992b, 1992c, 1997a, 1997b, 1998, and 2000) have documented seventeen AHRS and TLUI sites in the project area, two of which are on Flaxman Island (Table 4-11). The nature of the project area's landscape, specifically Point Thomson area shorelines and the expansive areas of low-lying wet tundra, reduces the archaeological sensitivity of the proposed project area.

The fact that the only site in this area listed on the National Register of Historic Places is the geological exploration ruins at the Leffingwell Camp (XFI-00002) continues to be a source of local concern (Jana Harcharek, personal communication 1999). Local residents consider traditional Inupiat land use sites to be equally important. Other cultural resource sites in the project area include DEW (Distant Early Warning) line facilities at Bullen Point. Two of the sites at Bullen Point, SRRS Road System (XFI-00027) and SRRS Airfield (XFI-00028) were determined eligible for the National Register in 1999.

Shoreline erosion continues to alter and remove archaeological sites in certain areas along the Beaufort Sea, such as the recent loss of the gravesite XFI-007 on Flaxman Island (Lobdell 1997a). Although coastal erosion has likely erased ancient shoreline sites that may once have been located along the Beaufort Sea coast, the surviving historic sites and features attest to Inupiat heritage ties to the land. Even though ancient sites are unlikely to be preserved along project area shorelines, and although extensive prior reconnaissance surveys have not produced many archaeological sites, undiscovered sites or site remnants may still exist in the project area. Previously undiscovered, buried, and prehistoric sites could be located on elevated landforms or along stream channels away from the shoreline within the project area.

Table 4-11 TLUI and AHRS Sites in Project Area

AHRS #	TLUI#	Site Name, notes
XFI-00001	TLUIXFI002	POW-3 Bullen, Savaguik, Flaxman Island DEW Line Station
XFI-00002		Leffingwell Camp
XFI-00004	TLUIXFI003	Point Gordon
XFI-00005	TLUIXFI004	Point Hopson
XFI-00006	TLUIXFI006	Point Thomson
XFI-00007	TLUIXFI007	Flaxman Island (*)
XFI-00008	TLUIXFI018	East Flaxman Island
	TLUIXFI005	Point Sweeney
XFI-00021	TLUIXFI002	BULLEN POINT LRRS (POW-3) DEW LINE FACILITIES
XFI-00022	TLUIXFI002	BULLEN POINT LRRS (POW-3) DEW LINE FACILITIES
XFI-00023	TLUIXFI002	BULLEN POINT LRRS (POW-3) DEW LINE FACILITIES
XFI-00024	TLUIXFI002	BULLEN POINT LRRS (POW-3) DEW LINE FACILITIES
XFI-00025	TLUIXFI002	BULLEN POINT LRRS (POW-3) DEW LINE FACILITIES
XFI-00026	TLUIXFI002	BULLEN POINT LRRS (POW-3) DEW LINE FACILITIES
XFI-00027	TLUIXFI002	BULLEN POINT SRRS ROAD SYSTEM [WACS, AC&W]
XFI-00028	TLUIXFI002	BULLEN POINT SRRS AIRFIELD [WACS, AC&W]
XFI-00029	TLUIXFI002	BULLEN POINT SRRS GRAVEL PAD SYSTEM [WACS, AC&W]
XBP-28	TLUIXFI001	Mikkelson Bay Village

* site destroyed

This page intentionally left blank

4.13 SOCIOECONOMIC CHARACTERISTICS

The socioeconomic geographic scope for the Point Thomson Gas Cycling Project is defined as the area from Nuiqsut east to Kaktovik and seaward of the barrier islands south to the Brooks Range. This section discusses the socioeconomic characteristics of the proposed project area, and to a lesser extent the State of Alaska, including population, employment, income, and taxation. These characteristics are discussed separately from subsistence, making a distinction between socioeconomic issues and subsistence issues. This should not obscure the reality that wage employment, revenue from taxation, and subsistence are all vital components of the North Slope socioeconomic system (LGL et al. 1998).

The North Slope Borough (NSB) encompasses the entire northern coast of Alaska and is composed of about 88,281 mi^2 (14,000 km^2) (15 % 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. A major motivation for the formation of the borough was to maintain 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 courts and the Alaska State Legislature ultimately defined the taxing authority of the NSB.

The Point Thomson Unit lies within the NSB, approximately 100 mi (161 km) east of the community of Nuiqsut and 60 mi (97 km) west of the community of Kaktovik. The North Slope oil field support center of Deadhorse is located 40 mi (64.4 km) west of the Point Thomson Unit.

4.13.1 Population, Employment and Income

The population, employment, and income characteristics of the State of Alaska and communities on the North Slope are affected by resource development projects such as proposed Point Thomson Gas Cycling Project. In addition to the potential effects of direct project employment, indirect effects occur through sales of services and materials to the petroleum industry, and from North Slope services and capital projects funded by revenues derived from oil and gas development projects.

4.13.1.1 Population

<u>**State Of Alaska**</u>

The Alaska population from 2000 census information is approximately 627,000. This is about 5,000 more than the 1998-1999 estimates prepared by the Alaska Department of Labor (ADOL). Over the past decade, ADOL estimates of annual population growth have ranged from 0.2 to 3%. Figure 4-16 presents population data for the State of Alaska since 1950.

<u>**North Slope Borough**</u>

The North Slope population from 2000 census information is 7,385; approximately 74% of the population are Alaskan Natives. The 2000 estimate is roughly the same as the estimated 1998 population of 7,413 prepared by the ADOL. Over the past decade, ADOL estimates of annual NSB population growth have ranged from 2 to 5%.

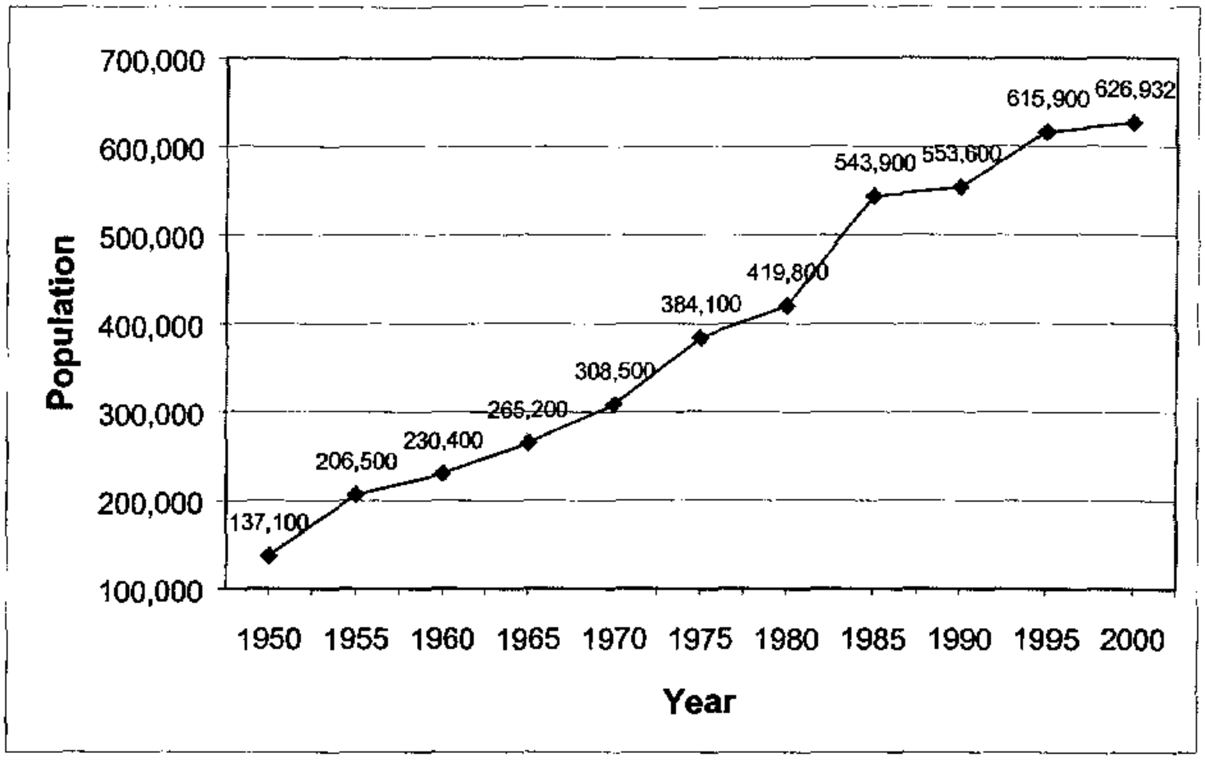


Figure 4-16 Population of the State of Alaska, 1950-2000

Nuiqsut

Nuiqsut's population grew from a total of 175 when it was re-established in 1973 to about 340 in 1985 (Pederson 1995). The Nuiqsut population from 2000 census information is 433; approximately 88 % of the population are Alaskan Natives. The 2000 estimate is slightly less than the estimated 1998 population of 486 prepared by the Alaska Department of Labor. Over the past decade, ADOL estimates of annual Nuiqsut population growth have ranged from 2 to 5%. Figure 4-17 presents current and historic population data for Nuiqsut.

Kaktovik

The Kaktovik population from 2000 census information is 293; approximately 75% of the population are Alaskan Natives. The 2000 estimate is slightly higher than the estimated 1998 population of 259 prepared by the Alaska Department of Labor. Over the past decade, ADOL estimates of annual Kaktovik population growth have ranged from 1 to 3 %. Figure 4-17 presents current and historic population data for Kaktovik.

4.13.1.2 Employment and Income

North Slope Borough

Total employment of resident and non-resident workers within the NSB region in 1994 was estimated at about 7,000, from a peak of over 10,300 in 1983. Oil industry jobs comprised 5,000 of the 1994 jobs and 7,800 of the 1983 jobs (LGL et al. 1998). Most, if not all, oil industry jobs are held by people residing outside of the NSB in other parts of Alaska or outside of Alaska.

Relatively few NSB residents are directly employed by the oil industry. However, most NSB employment is indirectly dependent on oil industry activity (through taxation revenue). NSB residents are also employed indirectly in support and service functions contracted to Alaska Native Claims Settlement Act (ANCSA) corporations by the oil industry.

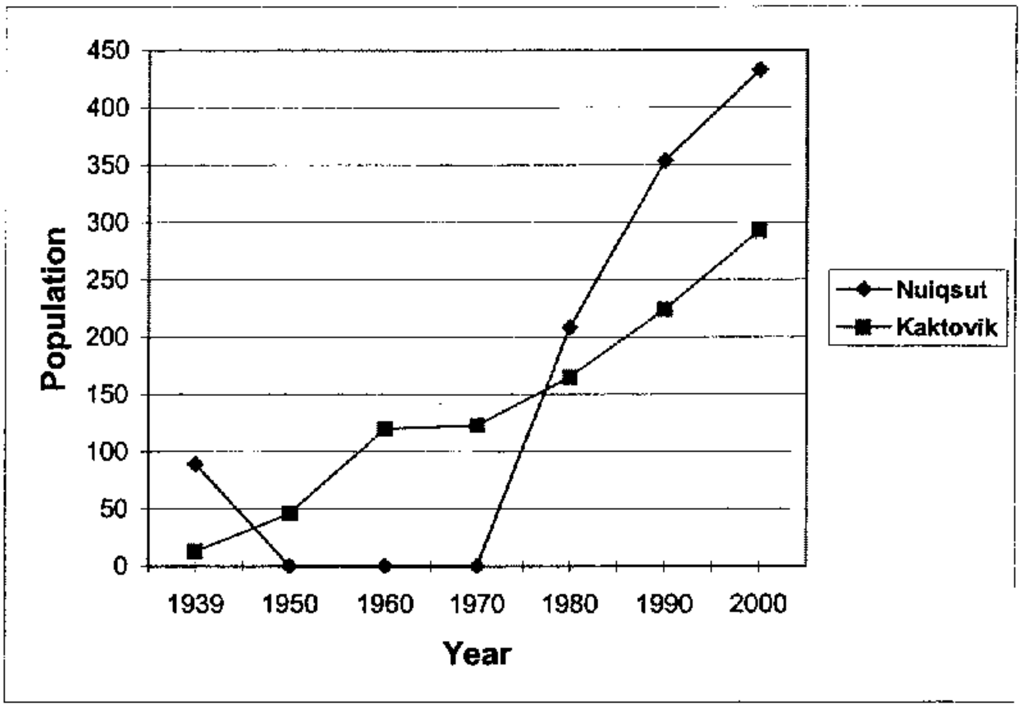


Figure 4-17 Population of Nuiqsut and Kaktovik, 1939-2000

The NSB is the most important employer other than the oil industry. The NSB, including the school district, employed 62 % of all working NSB residents in 1994. Most of the other residential workforce was employed by the regional or ANCSA corporations (or subsidiaries and joint ventures), or local community governments. Construction workers for all NSB Capital Improvements Program (CIP) projects from 1989 to 1994 consisted of 64 % NSB residents (LGL et al. 1998).

Unemployment is a difficult concept to discuss in terms of the NSB workforce. Official statistics are not always meaningful, since an unemployed person must be actively seeking work to be counted. Discouraged workers who are not actively seeking work are thus not counted; and seasonal workers, who do not desire full-time work, may also not be counted. The 1993/94 NSB survey computed an unemployment rate borough-wide of 11 %, with 22 % of the workforce reporting that they worked less than 40 weeks in the previous year, not including school district employees (LGL et al. 1998).

Declines in oil industry employment have resulted from consolidation and increased efficiency of operations, as well as the decline in production from the Prudhoe Bay, Endicott, and Kuparuk oil fields. Exploration and production from new fields could partially or totally offset these declines, but will not require the same labor force as has been historically employed. Since relatively few NSB residents are directly employed by the oil industry, this decline will not greatly affect them. However, North Slope regional and village ANCSA corporations provide oil field services, and employment could be affected by declines in oil field activities.

NSB revenues and expenditures are projected to decline over time, as decreased oil production yields lower taxation revenues. This will reduce employment opportunities for NSB residents. The NSB has historically funded an ambitious CIP, 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.

Nuiqsut

Information presented in this section is drawn from the NSB's survey of 1993/94, which itself is based on responses from 90 of 105 households (about 86 % of all households). In 1993/94, Nuiqsut had a labor force of 193 out of a total population of 403. Ninety-six survey respondents reported being employed. Unemployment was officially at 5.2 %, with underemployment being perceived as a locally important issue. Thirty percent of employed respondents identified themselves as underemployed, with 40% reporting less than 40 weeks of work in the preceding year. Members of the workforce identified unemployment and underemployment as persistent and serious problems (LGL et al. 1998).

Many jobs are seasonal, primarily those in construction (NSB for the most part) or with oilfield service companies (ice road building and maintenance). In 1993/94, approximately 63 % of regularly employed Nuiqsut residents worked for the NSB. The village corporation, Kuukpik Corporation, employed approximately 20 % of the workforce. The city had three employees, the state none, and the federal government one (the postmaster). All other employers accounted for approximately 13.5 % of total employment (LGL et al. 1998)

Over the period from 1973 to 1985, the average Nuiqsut household income increased from $32,125 to $56,743 (not adjusted for inflation). Average non-Inupiat household income in was $49,999 per year ($33,333 per capita) in 1993/94, while average Inupiat household income was $37,999 per year ($8,745 per capita). Approximately 36 % (32 of 90) of surveyed Nuiqsut households qualified as very low income households under federal regulations, 18 % (16 of 90) had low to moderate incomes, 46 % (42 of 90) had moderate or higher incomes (LGL et al. 1998).

Non-Inupiat households in Nuiqsut are generally smaller than Inupiat households, consisting primarily of salaried schoolteachers with typically one or two adults and no children. Inupiat households are generally comprised of more members and fewer wage earners. As a result of the NSB's building plan, many multigenerational households have been split up into smaller family units (Galginaitis et al. 1984). Housing has been improved through time on a number of measurable indices, for example, space per household member, heating systems, water systems, waste disposal, and construction and insulation quality (LGL et al. 1998).

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 (e.g., heat, utilities, transportation, and cost of imported goods) are often twice those of state averages (LGL et al. 1998).

Subsistence resources are an important component of Nuiqsut household economies, but cannot be easily quantified, either in terms of contribution to diet or cost of production (harvest). While subsistence production contributes significantly to household economies, cash expenditures for subsistence activities are also quite high. Of the 56 Nuiqsut households responding to this area of the 1993/94 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 (LGL et al. 1998).

Kaktovik

Information presented in this section is drawn from the NSB's survey of 1993/94, which itself is based on responses from 66 of 71 households (about 93 % of all households). In 1993/94, Kaktovik had a labor force of 128 out of a total population of 230. Sixty-four survey respondents reported being employed. Unemployment was officially at 9.5 %, with underemployment being perceived as a locally important issue. Twenty-three percent of employed respondents identified themselves as underemployed, with 29 % reporting less than 40 weeks of work in the preceding year. Members of the workforce identified unemployment and underemployment as persistent and serious problems (LGL et al. 1998).

Many jobs are seasonal, primarily those in construction (NSB for the most part) or with oilfield service companies (ice road building and maintenance). Approximately 67 % of regularly employed Kaktovik residents worked for the NSB in 1993/94. The village corporation, Kaktovik Inupiat Corporation, employed approximately 16 % of the workforce. The city had two employees, the state none, and the federal government one (the postmaster). All other employers accounted for approximately 14 % of total employment (LGL et al. 1998).

Average non-Inupiat household income in Kaktovik was $71,874 ($43,230 per capita) in 1993/94, while average Inupiat household income is $30,984 ($9,832 per capita). Approximately 30 % (20 of 66) of surveyed Kaktovik households qualified as very low income households under federal regulations, 6 % (4 of 66) had low to moderate incomes, and 64 % (42 of 66) had moderate or higher incomes (LGL et al. 1998).

Non-Inupiat households in Kaktovik are generally smaller than Inupiat households, consisting primarily of salaried schoolteachers with typically one or two adults and no children. Inupiat households are generally comprised of more members and fewer wage earners. Anecdotal information indicates that new housing is being constructed in Kaktovik, attracting families from Canada related to Kaktovik residents to immigrate to the village. The village plans for upgrading the power and water plants and construction of a water and sewer system could attract more immigrants and provide more local employment (LGL et al. 1998).

As in Nuiqsut, living expenses in Kaktovik 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 (e.g., heat, utilities, transportation, and cost of imported goods) are often twice those of state averages (LGL et al. 1998).

Subsistence resources are an important component of Kaktovik household economies, but cannot be easily quantified, either in terms of contribution to diet or cost of production (harvest). While subsistence production contributes significantly to household economies, cash expenditures for subsistence activities are also quite high. Of the 41 Kaktovik households responding to this area of the 1993/94 NSB survey, 29 spent between $500 to $4,000 each year on subsistence activities, while 12 spent more than $4,000 each year. Four of these 12 households spent more than $10,000 each year, probably in connection with whaling (LGL et al. 1998).

4.13.2 Public Revenues and Expenditures

The NSB relies primarily upon property tax receipts to fund its operations and pay interest and principal on its bonds. While the establishment of an NSB permanent fund has diminished the reliance on the property tax in recent years, the NSB collected 71 % or $230 million of its revenue from property tax during fiscal year 1995. Nearly all property tax (approximately 98%) comes from assessments on the oil industry, with State and Federal revenue-sharing programs provide most of the rest of the NSB budget (ADNR 2001). About half of the NSB budget is for operations, and half is for debt service, primarily on bonds sold to fund the CIP (LGL et al 1998).

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 (DOI 1998). These figures are projected to decline somewhat, barring substantial new investment by the oil industry, due to depreciation of the existing tax base.

The main problem facing the NSB is one of operational expense. 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 with the greatest CIP budgets, peaking at $302 million in 1983 (LGL et al. 1998). Anything that the borough builds must be maintained under the legal operational tax cap of 4.78 mills (DOI 1998 and LGL et al. 1998). 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.

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 existing and potential State-imposed limits on NSB taxing authority, NSB residents' willingness to assume higher property-tax burdens, and State and Federal revenue-sharing policies.

4.13.3 Subsistence and Traditional Land Use Patterns

In general, communities harvest the subsistence resources most available to them, concentrating their efforts along rivers and coastlines and at particularly productive sites (Figures 4-18 to 4-22). Determining when and where a subsistence resource will be harvested is a complex activity due to variations in seasonal distribution, migration, and extended cyclical variation in animal populations. Areas that are infrequently used can be important harvest areas at times (DOI 1998). Figure 4-18 shows known historic and current subsistence harvest areas.

Two broad subsistence-resource niches occur on the North Slope:

- Coastal/marine: harvesting of whales, seals, waterfowl, fish, and other marine species
- Terrestrial/aquatic: harvesting of caribou, fish, moose, grizzly bears, other terrestrial animals, and edible roots and berries

Regardless of which subsistence-resource niche or combination of niche resources communities harvest, bowhead whales, caribou, and fish are the primary resources harvested. The bowhead whale harvest is important because it provides a unique and powerful cultural basis for sharing and community cooperation. Bowhead whaling strengthens family and community ties and provides a sense of common heritage and culture in Inupiat society (DOI 1998). Sharing and community cooperation were essential in the past. Cooperative harvesting and sharing of food was the best insurance against starvation, maximizing everyone's chances of survival during times of shortage (ADNR 2001).

Non-edible parts of subsistence resources are used to make many functional and/or artistic items. Hides and pelts are used to make bedding, clothing, slippers, mukluks, hats, dolls and other toys, drums, and masks. Ivory, bone, and antler are carved for knife handles, needle cases, and figurines. Jewelry and decoration for clothing and other item is made from many items, including ivory, antler, and feathers (ADNR 2001).

The relationship between engaging in subsistence activities and earning cash wages differs for each individual. The availability of jobs, community goods and services, and subsistence resources also affects the cash-subsistence relationship. The social costs of not participating in traditional subsistence activities of the village economy may be greater that the cash benefits derived from participation in the labor force. NSB residents earning cash wages participate in subsistence activities during weekends and vacations, and employers are encouraged to allow such employees time off during key seasonal events such as whaling (ADNR 1998).

The Point Thomson area encompasses lands traditionally and presently used for subsistence harvest by residents of Nuiqsut and Kaktovik. Traditional subsistence land use of the Point Thomson area included harvesting of fish, marine mammals, terrestrial mammals, birds, fur-bearing mammals, and plants. In addition, many of the marine mammal, fish, and terrestrial mammal species harvested by Nuiqsut and Kaktovik residents in areas other than Point Thomson migrate through the Point Thomson area. The following sections discuss the subsistence activities of Nuiqsut and Kaktovik in relation to the Point Thomson area.

4.13.3.1 Nuiqsut

In 1985, Nuiqsut was still a very young community, being 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. The residents had a strong identification and historical relationship with the local area, but many did not have great personal knowledge of the marine subsistence areas. Per capita subsistence harvest doubled from 1985 to 1993 in Nuiqsut, indicating continued sharing of traditional knowledge (LGL et al. 1998).

Pedersen (1995) states that the average Nuiqsut household reportedly spent close to $800 a month for food, while at the same time 63 % of Nuiqsut households obtain over half of their food from subsistence resources. Only one person surveyed did not consume wild foods. Roughly 67% mentioned that one reason they ate wild foods was the high cost of store-bought food, and 93 % considered wild foods to be healthier than store-bought food (ADNR 1997 and LGL et al. 1998).

Marine mammals, fish, and terrestrial mammals each comprise about a third of the community's subsistence harvest. Birds and eggs provide a small percentage of the subsistence harvest, and plants yet a smaller amount (LGL et al. 1998 and ADNR 1999). Although Nuiqsut is located approximately 100 mi (161 km) west of the Point Thomson area, its residents may occasionally use the area to meet part of their subsistence needs.

Whales are the primary marine mammal resource harvested. In years when a whale is not harvested, fish and terrestrial mammals are more important to the subsistence harvest. Muktuk and whale meat from other communities is shipped into Nuiqsut during such years, although not in the quantities that would be consumed in the community if they had harvested their own whale meat (LGL et al. 1998).

Nuiqsut has a relatively high per capita harvest of subsistence resources. In years of a successful bowhead whale hunt, the per capita harvest average is higher than in years when a bowhead is not harvested. There are clear indications that Nuiqsut residents are investing more resources (both time and money) in these activities than they did in 1985. The proposed project is located onshore in the broad area described by Nuiqsut whalers as most important to them. Nuiqsut's self-described whaling use area extends from the Midway Islands eastward to Brownlow Point, and includes the Flaxman Island area. Whaling further west has not proven to be productive and moving further to the east requires too long a tow to a location where a whale could be butchered. 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. Current Nuiqsut whalers typically hunt for whales no further east than Point Gordon. Most Nuiqsut whales are harvested near a base camp on Cross Island or on the seaward side of the barrier islands (LGL et al. 1998). Figure 4-19 shows the maximum range of subsistence harvest areas for Bowhead Whales.

Nuiqsut seal harvest activity is not well documented. Seals are typically hunted close to the community near the mouth of the Colville River (DOI 1998). Nuiqsut seal hunters state that they have used the proposed project area as well as Flaxman Island in the past, but current usage is thought to be low (LGL et al. 1998).

Nuiqsut residents harvest caribou mainly from the CAH. Subsistence use of the Point Thomson area for caribou is infrequent due to the distance from Nuiqsut. However, caribou harvested in the Point Thomson area could be from either the CAH or the PCH (LGL et al. 1998). Figure 4-21 depicts the maximum range of subsistene harvest areas for caribou. Depending on annual herd movements and weather, caribou are harvested year-round by Nuiqsut hunters (DOI 1998). In September, the CAH typically moves down the Ublutuoch River and east across the Colville River before heading south to their overwintering grounds in the Brooks Range. Late August is considered a prime time for harvesting caribou for two reasons: they are fat from grazing all summer and their hides are in good condition for making clothing (ADNR 1999).

Fishing is an important subsistence activity for Nuiqsut residents. Harvesting of fish is not seasonally limited and the community is located on the Nechelik Channel of the Colville River, which has large resident fish populations (DOI 1998). Subsistence fish harvested from July 1994 to June 1995 consisted primarily of Arctic cisco and broad whitefish (DOI 1998).

4.13.3.2 Kaktovik

Ninty-six percent of households surveyed in Kaktovik used locally harvested wild resources. Additionally, 89% of the surveyed households attempted to harvest wild resources, 89% were successful harvesters, 92% received shares of wild resources from other households, and 83% gave wild resources away to other community households (Pedersen 1995 and LGL et al. 1998).

Kaktovik's present subsistence area covers the northern part of ANWR and south into the Brooks Range to the headwaters of the Hulahula River. The coastal area west of ANWR may also be used during the summer, often to Flaxman Island and Bullen Point and occasionally west to the Shaviovik River and Foggy Island (LGL et al. 1998). Approximately 30% of the onshore subsistence areas used by Kaktovik residents are located on state land (Clough et al. 1987). Although the mid-Beaufort Sea area west of ANWR is no longer a primary area used for subsistence, it is where some present day Kaktovik residents were born or grew up, so strong associations remain.

The largest community resource use area is that used for caribou hunting. It covers 6,852 mi^2 (17,747 km^2) of terrestrial and coastal lagoon/barrier island area, extending 180 mi (290 km) along the coast and up to 70 mi (112.7 km) inland. Figures 4-21 and 4-22 depict the maximum subsistence harvest areas range and Kaktovik's caribou harvest areas in 1990, respectively. Caribou hunting takes Kaktovik hunters into a variety of habitats where they encounter a wide variety of resources. Nearly all of terrestrial subsistence resource categories are contained within the caribou use area, notable exceptions being Dall sheep and small mammal resource categories. The usual Kaktovik summer subsistence harvest area is from the Canadian border to Tigvariak Island (west of Mikkelsen Bay), and encompasses the Point Thomson area. To the east, the area beyond Griffin Point/Pokok Lagoon is usually avoided because of the lack of safe anchorage. Kaktovik residents frequent a summer caribou hunting and camping area to the east of Bullen Point, on the coast. This area is located approximately 10 mi (16.1 km) west of the proposed project area. This relatively small and localized area was the only site west of the Staines/Canning River discussed by the Kaktovik residents but is probably an example of the general use pattern (LGL et al. 1998).

Caribou are the staple and preferred terrestrial mammals in Kaktovik's subsistence diet (LGL et al. 1998). Kaktovik residents harvest caribou from the PCH and CAH. Caribou are hunted on the coast by boat in the summer, and are harvested where they are found, typically close to the community. Caribou are expected to be so common in summer that few hunters anticipate long trips for harvesting. The only exceptions are areas frequented by caribou where coastal water is too shallow for boat access. The limited information available indicates that over half of the caribou harvested by Kaktovik residents are taken during the period from June through September, at or near coastal sites (Pederson and Coffing 1984, Coffing and Pedersen 1985, Pedersen 1990, Wentworth 1979, and LGL et al. 1998). Caribou harvest also occurs inland during the winter when snow machine travel is possible (LGL et al. 1998).

Bowhead whales migrate past Barter Island to and from the eastern Beaufort Sea, and the village currently has a fall whale hunt. Kaktovik's primary whaling area is to the east of the Canning River (Figure 4-20). Other marine mammal hunting (e.g., bearded and hair seals) is also generally confined to that area, although a hunter from Kaktovik may occasionally travel farther for other reasons and take a seal on an opportunistic basis (LGL et al. 1998).

Presently there are more whaling crews from Kaktovik, and more effort is devoted to whaling in Kaktovik than at any time in the past (ADNR 2001). There is more investment in boats and equipment than previously reported (as in Nuiqsut). The community bowhead whale quota has increased, and the local hunt has become very well organized and coordinated; consequently the rate of success has increased (LGL et al. 1998).

4.13.4 Land Ownership, Use and Management

There are three important aspects of land use that affect development of the Point Thomson area: the general land ownership and jurisdiction in the project area, existing land and water uses of the area, and land use regulations and management plans that apply to activities in the area.

4.13.4.1 Land Ownership

State Lands

Most of the Point Thomson Gas Cycling Project area is patented to the State of Alaska. The Alaska Department of Natural Resources has jurisdiction over the state lands (including tidelands, submerged lands within 3 mi (4.8 km) of the coast, and barrier islands) and state waters (including offshore waters within 3 mi (4.8 km) of the coast, freshwater lakes, rivers, and streams). 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.

Federal Lands

Federal lands are located to the east and adjacent to the Point Thomson Unit. These lands are part of ANWR, and are under the jurisdiction of USFWS.

Native Allotments

A Native allotment is a parcel of land, containing 160 acres or less which can be conveyed to a Native based on that individual's use and occupancy of the land under the authority of the Native Allotment Act, May 17, 1906 (43 U.S.C. 270-1), as amended August 1956, and repealed by the Alaska Native Claims Settlement Act of December 18, 1971 (43 U.S.C. 1617). Within ANWR, the Federal government has begun to process conveyances of 25 applications, involving 34 parcels for Native allotments. These applications cover approximately 2,315 acres (DOI 1987). There is a Native Allotment application on Flaxman Island (*Bureau of Land Management, Fairbanks District File (F) 18780:* located within T10N, R17E, UM on Flaxman Island). No determination has been made in this case to date. The claim is in the immediate area of the Leffingwell camp, which is on the National Register of Historic Sites.

4.13.4.2 Land and Water Use

Historic and current land and water use of the Point Thomson area includes oil and gas exploration, traditional and subsistence use by Native Alaskans, scientific research and surveys, and occasional summer recreation uses that are primarily along the Canning River in ANWR. The area was originally leased for oil and gas exploration in 1970's. Activities associated with exploration for oil and gas have occurred intermittently in the area since that time. The Point Thomson Unit currently includes 32 individual oil and gas leases encompassing 83,825 acres.

Occasional summer recreation use occurs in the nearshore waters behind the barrier islands and along the Canning River on the western edge of ANWR. A very small number of sea kayakers and other classes of boats traverse the coast off the Point Thomson Unit. The Canning River is floated each year by a limited number of rafts, kayaks, and canoes (see section 4.13.6 for further detail).

4.13.4.3 Land Management and Regulations

The Point Thomson area has been unitized, and is subject to specific agreements and state regulations governing activities within unitized areas. An application is pending to change the unit boundaries by adding 16 leases and 58,376 acres (24,000 ha). The area between the Point Thomson Unit and the Badami Unit is not subject to a unit agreement.

The Point Thomson Unit is located within the boundaries of the North Slope Borough, and all project facilities are located within the boundary of the North Slope Borough coastal zone. Uses and activities within the Point Thomson Unit are subject to the provisions of the North Slope Borough Title 19 Land Management Regulations (LMR's), and the North Slope Borough and Alaska Coastal Management Programs. The LMR's establish zoning districts and performance-based land management policies. An overall intent of the Borough Comprehensive Plan and LMR's is to maintain and protect subsistence resources. As an existing oil and gas unit, Point Thomson is zoned for resource development and is subject to an existing Master Development Plan. However, the area between the Point Thomson Unit and the Badami Unit has not been unitized and is zoned as a Conservation District. Construction of pipeline from Point Thomson would require rezoning to resource development and preparation of a Master Development Plan for the area.

The NSB and Alaska Coastal Management Programs (ACMP) also establish performance-based land and water management policies. Uses and activities on lands and waters within the coastal boundaries must be consistent with Borough coastal management policies and the standards of the ACMP. The western boundary of ANWR is co-located with the eastern boundary of the Point Thomson Unit.

4.13.5 Transportation

Construction, operation and maintenance of the Point Thomson project will require movement of personnel, equipment, materials, and supplies by marine, highway/road, and air modes of transportation. Within the North Slope, the primary modes of transportation between communities and to access subsistence harvest areas are by airplane, snowmachines in the winter and boats during the ice-free months.

4.13.5.1 Marine Transportation

The major Alaska ports for transportation of supplies to the North Slope are Anchorage, Seward, Whittier, and Valdez. Marine transportation of supplies to the North Slope, known as sealift, occurs during a limited seasonal window when the North Slope coast is ice-free. The primary dock and barge landing facilities are located at Prudhoe Bay, although some of the satellite facilities, such as Endicott and Badami, have their own dock facilities.

4.13.5.2 Highway/Road Transportation

The James Dalton Highway is the only ground transportation route connecting Prudhoe Bay to Alaska's other major highway systems. The highway was opened for public access in 1996 as far as Deadhorse. Trucks transporting freight in support of oil field activities at Prudhoe Bay dominate traffic along the highway; however, privately owned and commercial tour vehicles also use the highway.

Within the Prudhoe Bay complex, there is an extensive gravel road system for accessing facilities and transporting supplies. Temporary ice roads are used extensively in the winter for access to remote facility and exploration sites off the gravel road system.

4.13.5.3 Air Transportation

The Barrow and Deadhorse Airports and Kuparuk airstrip provide air transportation service for North Slope oil facilities. Alaska Airlines serves these airstrips through public and charter service. Gravel airstrips at outlying facilities (e.g., Badami) and villages accommodate air service from Prudhoe Bay.

4.13.6 Recreation

Recreational activities on the North Slope take place mostly in ANWR, the National Petroleum Reserve, Alaska (NPRA), and along the Dalton Highway. The U.S. Bureau of Land Management and the Alaska Department of Transportation and Public Facilities conducted a survey and concluded that the most important reasons visitors travel the Dalton Highway is to view scenery and wildlife (Robbe 1996). Visitors on the Dalton Highway typically take a day trip from Fairbanks to Deadhorse and back to experience crossing the Arctic Circle (Robbe 1996).

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; however there are no public facilities in these areas.

Recreational opportunities available while floating the Canning River and other rivers in ANWR and the NPRA or camping in ANWR include scenic viewing, camping, sport fishing, hiking, hunting, rafting, recreational gold mining, and photography. Visitors travel to ANWR to view wildlife such as moose, wolf, bear, caribou, Dall Sheep, Arctic fox, red fox, wolverine, muskox, various small mammals, waterfowl, shorebirds, passerines, falcons, and golden eagles (Jensen 1994).

Recreation and tourism occur in limited parts of the proposed project area. Typically there are few participants and minimal revenues derived from these activities. Tourism to the North Slope and ANWR in particular tends to spike when Congress is considering legislation that could affect the status of ANWR. In addition to floating the Canning River just east of the project area, a very small number of sea kayakers and other classes of boats traverse the coast off the Point Thomson Unit (Clough et al. 1987, USFWS 1993, and BPXA 1995).

Point Thomson workers will not be allowed to hunt or hike over tundra during summer. Fishing is allowed with a valid ADF&G fishing license.

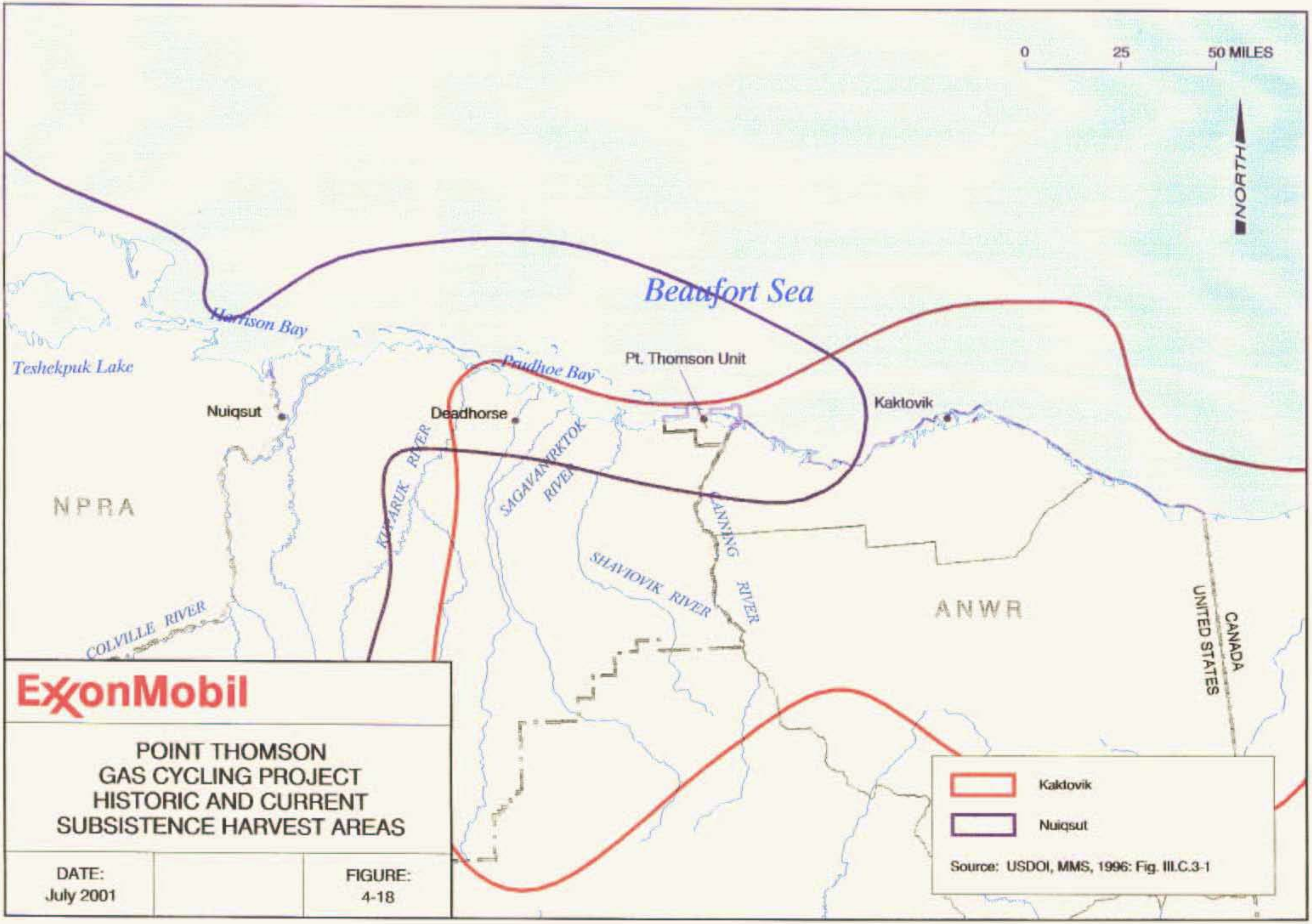
4.13.7 Aesthetic Characteristics

The Arctic coastal plain is a treeless, low relief landscape dominated by numerous lakes and ponds and low lying vegetation. The terrain is frozen and covered by ice and snow during the Arctic winter, which typically lasts more than 9 months with 56 days of darkness. The brief summer of continuous daylight lasts from June through August (Strahler and Strahler 1987). Cone shaped mounds that reach elevations of more than 100 ft (31m), are the only land forms on the coastal plain with significant height. Steep stream and riverbanks, coastal sand dune deposits, and steep coastal bluffs also create contrast in landscape elevation. Large rivers typically are braided and have broad floodplains and drainages. Smaller rivers and streams consist of thaw pools that are interconnected by narrow channels.

Oil field facilities are characterized by gravel pads, small and large buildings, gravel roads, pipelines with galvanized metal jackets, snow fences, heavy equipment, drilling rigs, flares, and lights. The Inupiat have expressed concern about the visual impacts of oil and gas development in the Prudhoe Bay area. Unnatural colors and lights are considered intrusive to the natural landscape and some colors and bright lights are thought to disturb or displace marine mammals that are important to the Native subsistence lifestyle. Light from Prudhoe Bay oil field activities is sometimes visible as a distant glow in the community of Nuiqsut, serving as a constant reminder of oil and gas activity in the region. Oil and gas development is an obvious visual change in the homogenous tundra environment and is considered to change the traditional subsistence way of life.

Public testimony received during scoping and other meetings held in North Slope communities indicates that people are concerned about industrialization and associated degradation of visual qualities of the area. The range of comments included visual impacts of dock facilities, degradation of rivers, and the creation of burning pits within the North Slope region. Additional concern has been raised about oil and gas development becoming widespread throughout the region, resulting in a further reduction in aesthetic value of the area (USACE 1998).

This page intentionally left blank



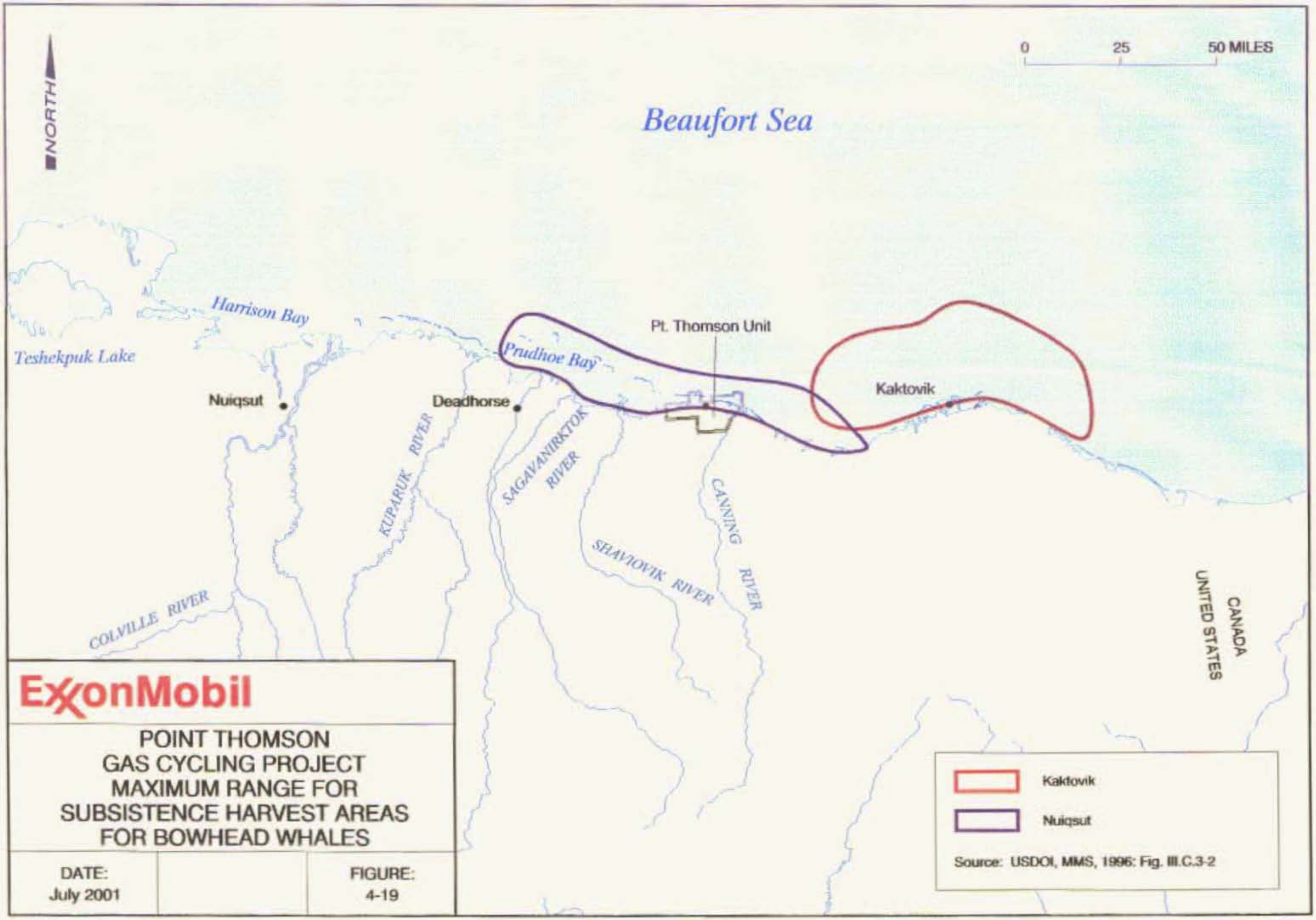
ExxonMobil

POINT THOMSON
GAS CYCLING PROJECT
HISTORIC AND CURRENT
SUBSISTENCE HARVEST AREAS

DATE: July 2001

FIGURE: 4-18

fig4_18.dgn



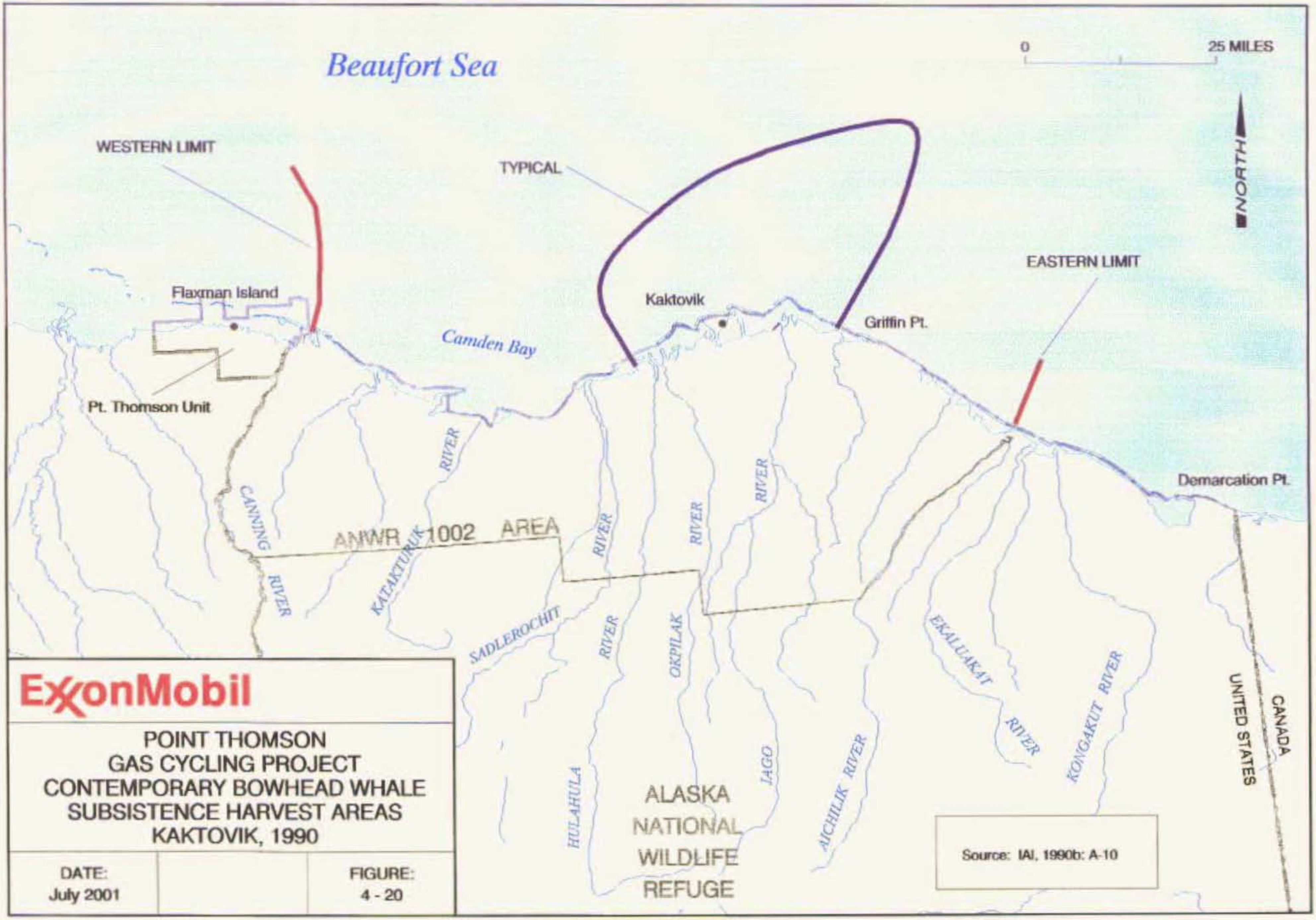
ExxonMobil

POINT THOMSON
GAS CYCLING PROJECT
MAXIMUM RANGE FOR
SUBSISTENCE HARVEST AREAS
FOR BOWHEAD WHALES

DATE: July 2001

FIGURE: 4-19

fig4_19.dgn

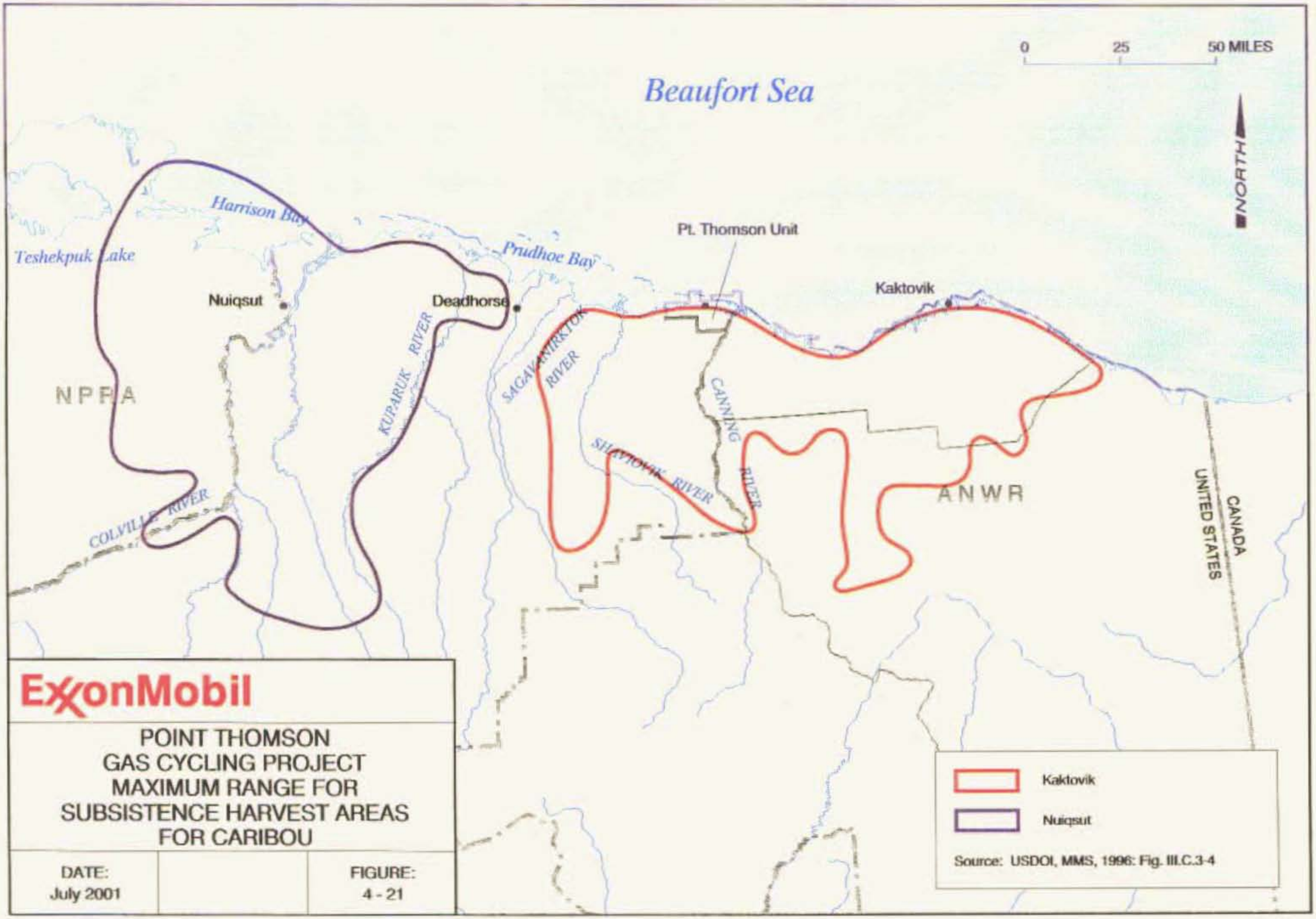


ExxonMobil

POINT THOMSON
GAS CYCLING PROJECT
CONTEMPORARY BOWHEAD WHALE
SUBSISTENCE HARVEST AREAS
KAKTOVIK, 1990

DATE: July 2001		FIGURE: 4 - 20

fig4_20.dgn

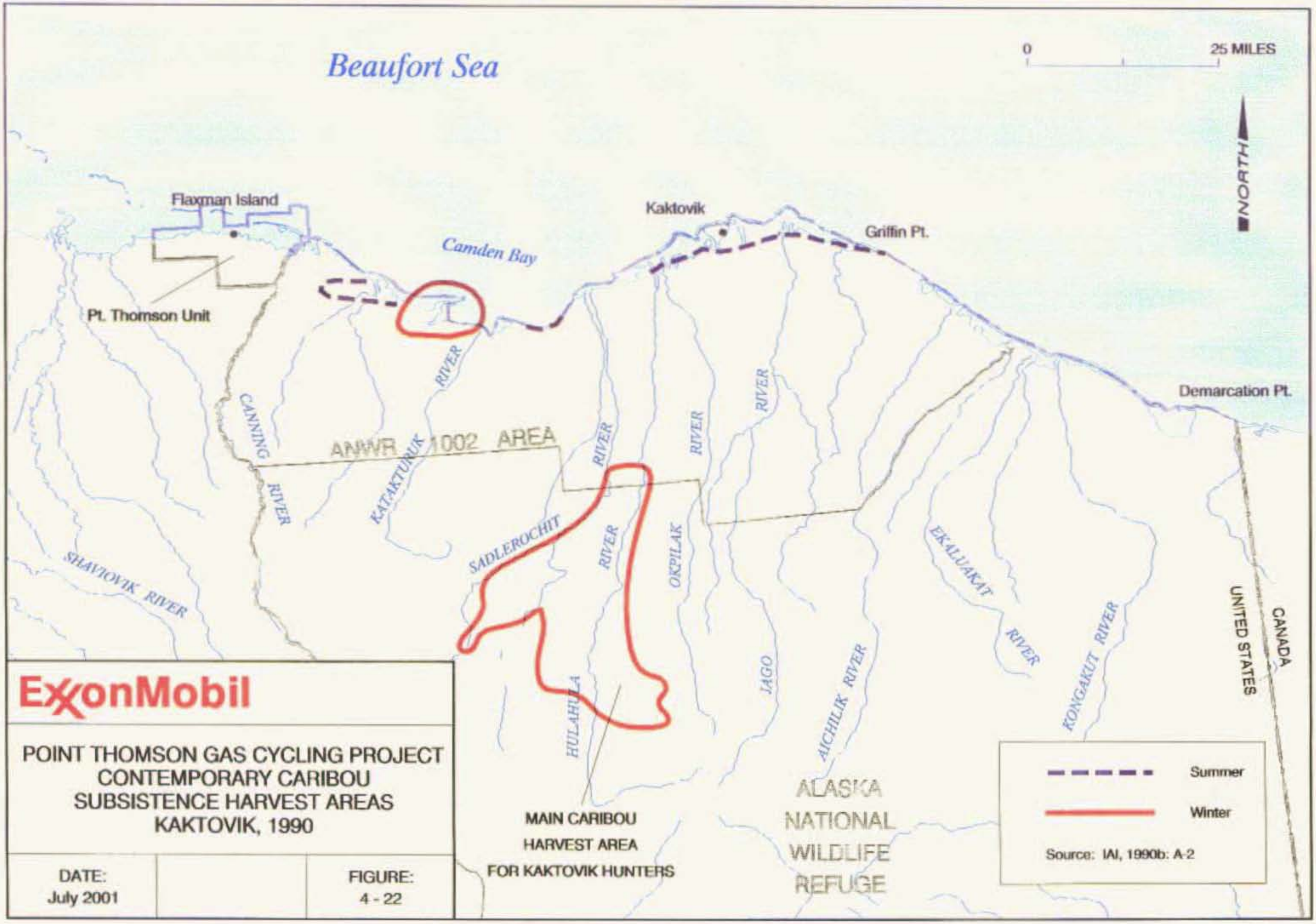


ExxonMobil

POINT THOMSON
GAS CYCLING PROJECT
MAXIMUM RANGE FOR
SUBSISTENCE HARVEST AREAS
FOR CARIBOU

DATE:		FIGURE:
July 2001		4 - 21

fig4_21.dgn



ExxonMobil

POINT THOMSON GAS CYCLING PROJECT
CONTEMPORARY CARIBOU
SUBSISTENCE HARVEST AREAS
KAKTOVIK, 1990

DATE: July 2001		FIGURE: 4 - 22

fig4_22.dgn

5.0 ENVIRONMENTAL CONSEQUENCES

Environmental consequences of the proposed action at Point Thomson have the potential to impact the physical, biological and social/cultural resources of the area. The following sections discuss the potential effects, their anticipated severity, and ways that they may be mitigated.

5.1 PHYSICAL/CHEMICAL RESOURCES

Physical and chemical resources of the Point Thomson area include air, freshwater, and marine water quality, surface hydrology, and permafrost and soils. Project actions such as the placement and/or removal of gravel, emissions, discharges, and spills of materials to the environment, the removal of water from area ponds, lakes, and streams and offshore dredging operations have the potential to locally impact these resources. Project actions and the effects they produce are likely to differ among winter or summer construction periods and operations. Therefore, the potential effects on the resources due to project actions during different project phases are considered separately. Table 5-1 indicates the potential effects of the project on the physical and chemical resources of the area, and during which project phase the effects are anticipated.

The following paragraphs describe the project actions or mechanisms that have the potential to create an effect on the physical and chemical resources, and the methods used for assessing the potential effect.

Placement of Gravel

Placement of gravel to create the roads, pads, airstrip, and dock will directly effect the tundra through burial. These effects on vegetation are described in Section 5.2.2. In addition, gravel placement has the potential to effect soil conditions. One effect to the nearshore zone of Lions Lagoon is a temporary increase in suspended sediment in the vicinity of the dock. Gravel placement also has the potential to cause indirect impacts on air quality due to the generation of dust.

Obstruction of Flow/Circulation

Placement of gravel on the tundra to create roads, pads, and the airstrip could divert, impede, or otherwise block flow into stream channels or braided wetlands. The placement could also affect sheet flow over the tundra creating dry areas on one side of the structure and pools or wetter areas on the other side. Placement of a gravel-filled dock in Lions Lagoon could also locally impact the nearshore circulation patterns.

Emissions/Discharge/Spills

Emissions and discharges are defined as liquid or gaseous materials that are released during construction and operations activities at the Point Thomson facility. These releases will be regulated under water and air permits, and will be required to meet the discharge requirements of the permits. Spills are considered to be out-of-control events and can range from small to large quantities. Effects due to small-scale spills during construction and operations activities will be considered in this section. Impacts from large spills are considered in detail in Section 5.4.

Table 5-1 Potential Physical and Chemical Consequences

Physical/Chemical Resources	PROJECT ACTIONS				
	Placement of Gravel	Obstruction of Flow/ Circulation	Emissions/ Discharges or Spills	Water Removal	Gravel Removal
Air Quality	Y (W)[1]	N/A	Y (W,S,O)	N/A	Y (W)[1]
Surface Hydrology	N/A[2]	Y (W,S,O)[3]	N/A	Y (W,S,O)[3]	Y (W)
Freshwater Quality	Y(W,S)[4]	Y(W,S,O)	Y(W,S,O)	Y (W,S,O)[3]	Y (W)
Marine Water Quality	Y(W)[4]	Y (W,S,O)	Y(W,S,O)	N/A	N/A
Marine Currents	N/A[2]	Y (W,S,O)	N/A	N/A	N/A
Permafrost and Soils	Y (W,S,O)	N/A	N/A	N/A	Y (W)

[1]generation of dust
[2]impacts considered under obstruction of flow/circulation
[3]mitigated through project design and controls
[4]temporary increase in turbidity during construction; longer-term impacts considered under obstruction of flow/circulation

Notes: N/A = not applicable
O = operations
S = summer construction
W = winter construction
Y = potential consequence

Gravel Removal/Mining

A gravel mine has been identified for the project in Section 3.0. This section discusses the effects of vegetative cover removal and excavation of the gravel for use in dock, pad, road, and airstrip construction. It discusses the effects of dust generated during gravel mining, with potential impacts to water quality.

Freshwater Removal

It will be necessary to remove quantities of freshwater to cap the sea ice road and to build infield onshore roads during the two proposed construction seasons. In addition, water will be needed for dust control on gravel surfaces and for camp support needs during construction and operations. An effect of water removal could include exacerbation of already low oxygen levels under the ice in tundra lakes. This effect and others are discussed in more detail in this section.

Offshore Dredging

The preferred alternative for providing a dock with capability for landing modules weighing up to 6,000 tons requires a one-season summer dredging operation offshore of the dock to provide sufficient water depth. Impacts of the dredging activity and subsequent spoils disposal include localized disturbance to marine mammals, fish, and birds from the generation of one or more turbidity plumes.

5.1.1 Air Quality

Effects on local air quality will occur during project construction and operations due to emissions from vehicles, vessels, aircraft, machinery, generators, and compressors. Air quality impacts may also include effects of dust from gravel mining and placement during construction of the dock and facility pads and roads, and from dust generated by vehicles during both construction and operations.

5.1.1.1 Emissions

The Point Thomson Gas Cycling Project activities have the potential to produce the following regulated air pollutants: nitrogen oxides (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter, and volatile organic compounds (VOCs). The type and amounts of air pollutants expected from this project will differ under construction and operations phases.

Winter and Summer Construction

Sources of emissions possible during both winter and summer construction phases include:

- Heavy construction equipment including gravel-hauling dump trucks
- Construction support equipment including cranes, pumps, generators, compressors, pile drivers, welders, and heaters
- Vehicles, vessels (in summer), helicopters, and airplanes used to transport equipment, materials, and personnel to and from Point Thomson

The main emission from these sources will be NOx, with lesser amounts of CO, SO_2, and particulates. Vehicle, vessel, and airplane emissions are expected to consist mainly of CO with small amounts of VOCs from aviation and other fuels.

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 will be identified in the Air Quality Permit to Construct submitted to the Alaska Department of Environmental Conservation (ADEC). It is anticipated that there will be no significant, long-term, adverse effects from the construction emissions.

Drilling and Operations

Sources of emissions possible during the drilling and operations phases include:

- Diesel generators to provide power for drilling initial wells, switching to gas turbines once fuel gas is available
- Drilling rig support equipment such as generators, boilers and heaters
- Gas turbine driven compressors and process heaters used for condensate production and gas re-injection
- Venting and flaring (intermittent source, with the exception of the pilot and purge volumes)
- Vehicles, vessels (in summer), helicopters, and airplanes used to transport equipment, materials, and personnel from to the site

The main source of emissions during drilling and operations would likely be the gas turbines for power generation and gas compression. The emissions from these turbines will consist mainly of NOx, and CO, with lesser amounts of SO_2 and particulates. Diesel generators and support equipment will produce NOx, with lesser amounts of SO_2, CO, and particulates. Flaring will burn up any emissions of VOCs, but will produce amounts of NOx, with lesser amounts of SO_2, CO, and particulates. Vehicle vessel and airplane emissions are expected to consist mainly of CO with small amounts of VOCs from aviation and other fuels..

Air emissions during drilling and operations at Point Thomson will be regulated under the facility's Title V Air Permit to Operate that will be issued by the ADEC. Lease operators at Point Thomson will be required to comply with the requirements of Title I, Part C, of the Clean Air Act (Prevention of Significant Deterioration of Air Quality). Therefore, air emissions for the drilling and production activities at Point Thomson will be evaluated to determine if they exceed Prevention of Significance Deterioration levels. An assessment of air quality effects will be conducted using the dispersion model approved by the United States Environmental Protection Agency. Air quality-related values, such as visibility, local vegetation, threatened and endangered species, and population growth, also will be reviewed; and a Best Available Control Technology assessment will be conducted on emissions sources. New Source Performance Standards will also be met as required. Significant effects from air emissions at the Point Thomson facility are not expected.

5.1.1.2 Dust

Removal of gravel from the mine and subsequent placement of gravel fill material for pads, roads, dock, and, airstrip are not likely to generate large concentrations of airborne dust. Because these construction activities are expected to occur during the winter months, minimal dust will be generated from the frozen materials. All gravel needed for facility maintenance over an estimated 20 year period will be mined during the first winter of construction and stockpiled.

It will be necessary to regrade and compact the pads, roads, dock, and airstrip during the first summer construction period. These activities will likely result in increased airborne dust particles, and a temporary reduction in air quality in the immediate vicinity of the activity. To mitigate the dusty conditions, water will be used to wet the areas prior to regrading. Long-term effects from the initial regrading and compaction activities are not anticipated.

Occasionally during the operations phase, it will be necessary to repair and re-grade the roads, airstrip, and possibly the dock. As described above, these activities will likely result in a temporary increase in airborne dust. Operations-related vehicle and aircraft traffic is another source of airborne dust. The airborne dust can be kept under control through mitigation measures such as watering of gravel surfaces and enforcing speed limits. Potential water sources for dust mitigation are provided in Figure 3-19. Long-term effects on air quality are not anticipated due to dust generated during operations.

5.1.2 Surface Hydrology and Fresh Water Quality

Impacts to drainage patterns and surface hydrology can occur when placement of gravel for roads, pads, or an airstrip diverts, impedes, or obstructs flow in stream channels or wetlands. Water quality impacts to freshwater lakes and streams can occur due to obstruction of flow, discharges and spills, water removal, and gravel removal (see Table 5-1). Effects can be in the form of temporary or long-term blockages to the drainage patterns, or degradation of freshwater quality.

5.1.2.1 Placement of Gravel and Obstruction of Flow

Impacts due to obstruction of flow and placement of gravel are combined when discussing surface hydrology and fresh water quality because these actions are intrinsically related. The proposed roads may cross small streams or drainages at several locations. During construction, temporary or log-term disruption of natural drainage patterns could occur when gravel is placed on the tundra. The potential effects of construction and the subsequent presence of the roads, pads, and airstrip on surface hydrology and freshwater quality could be:

- Blockage of natural drainage patterns and overland sheet flow by airstrip, road, and pad embankments resulting in seasonal or long-term impoundments on the upstream side and drying downstream of the embankment. Proper location of culverts and/or berm breaks can mitigate these effects.
- Diversion of stream-flow due to gravel placed adjacent to or within stream-beds can result in increased bank or shoreline erosion or sedimentation. Effects can be minimized with the proper siting of roads, pads, and the airstrip.
- Sedimentation and eventual blockage of culverts can sometimes occur. A program to inspect and clear blocked culverts would minimize effects.
- Ice buildup in culverts could block water flow for a short period during spring breakup. Mitigation measures including manually checking and removing the blockages would help minimize these effects.
- Concentration of flow by culverts and berm breaks and subsequent erosion (scour) of disturbed ground. Soils within the study area tend to be ice-rich sands and silts that easily erode. Scour holes are typically created by concentrated water flow immediately downstream from culvert outlets. Proper siting and design of culverts can help mitigate these effects.
- Obstructions or diversions in the sheet or stream flow can impact freshwater quality. If the water exchange among ponds is disrupted due to flow obstructions, estuaries of streams or creeks may no longer provide favorable habitat for fish or vegetation.
- Increased turbidity in streams and ponds at or adjacent to road crossings could occur during placement of gravel at these sites, but effects would be short-term. Effects would be mitigated by constructing road crossings during winter when the soil and smaller drainages are frozen.
- Potential increases in turbidity associated with construction activities during the first summer (i.e., re-grading and ongoing road and airstrip maintenance) will be short term and may be within the magnitude of typical sedimentation events associated with spring breakup conditions.

Impacts on local drainage patterns can also occur due to the presence of ice roads. The presence of an ice road can result in delayed snowmelt and tundra compaction. The effects of delayed snowmelt are confined primarily to the first summer season following use of an ice road, where as effects of tundra compaction may persist. A delay in snowmelt can cause water flow obstructions during spring break up. This effect will be mitigated by breaching the ice road at the drainage locations as needed during breakup to allow flow. After each of the first and second construction seasons, ice roads will be abandoned and allowed to melt. While some ponding might occur during a rapid onset of snowmelt, melt-water channels can cut through naturally occurring river aufeis (overflow icing) and rapidly drain the impounded water (Sloan et al. 1975). Should onshore ice roads be used in the future, they could be offset somewhat from year to year, minimizing any effects of these short-term impoundments.

The pipeline will be suspended above the drainages or water bodies on VSMs. Large lakes and ponds will be avoided as much as possible. By having the pipeline suspended over the drainages, effects due to blockage of flow will be minimized.

5.1.2.2 Discharges

Impacts to fresh water quality can occur due to discharges that can occur during construction and operations activities. During construction, permitted discharges will include domestic wastewater, stormwater discharge, and may include pipeline hydrotest water. During operations, only the occasional, permitted, discharge of domestic wastewater will be required should the underground injection well be inoperable.

Accidental discharges due to small spills could occur during both construction and operations. These small spills typically consist of diesel fuel and other fluids necessary for vehicle operations and other chemicals stored onsite that are used in the process modules and other facilities. Impacts from large spills are considered in detail in Section 5.4.

Winter and Summer Construction

Permitted Discharges

Camp facility domestic and sanitary wastes will typically be treated on site and discharged to the tundra under the requirements of a National Pollution Discharge Elimination System (NPDES) General Permit for tundra disposal. During peak camp use approximately 30,000 gallons per day (gpd) (114,000 liters/day) of wastewater could be generated. Once the disposal well is operational during the second year of construction, domestic wastewater will be routinely disposed of by underground injection. Since the discharge of domestic wastewater will be short-term and will meet the specific NPDES effluent requirements, it is unlikely to have significant long-term effect on water quality.

Stormwater runoff from construction areas is also regulated by the EPA under the NPDES stormwater program. Runoff that is generated during summer construction activities at the Point Thomson facility will be regulated under the General NPDES permit for construction activity on the North Slope. Under the permit requirements, Best Management Practices will be developed and implemented to minimize any potential impacts of this discharge on water quality. Pipeline hydrotesting will occur during the second summer of construction. Hydrotest source water will be fresh, and is not likely to contain contaminants. However, the discharge location(s), amount(s), and characteristics will be regulated under an NPDES permit. Hydrotest discharges will meet the NPDES requirements; therefore, adverse effects to freshwater quality are not expected.

Spills and Leaks

Construction equipment, vehicles, and vessels are typically powered by diesel fuel. In addition, diesel generators will provide power until the gas fired turbine generators are brought on line. All storage of fuels and refilling of equipment and machinery will be conducted following the fuel transfer guidelines and liner use procedures outlined in Section 7 of the North Slope Environmental Field Handbook (BPXA and Phillips Alaska Inc.) and the refueling guidelines provided in Section 17 of the ExxonMobil Production Company Safety Manual. All employees will be trained in the proper methods and authorized locations for refueling. By limiting the locations of fueling and instituting controls for fueling methods, small spills and leaks can be prevented. Stored fuels have the potential to spill or leak and can cause temporary or long-term damage to fresh water quality. Fuels for construction equipment will be properly stored in approved containers in lined, bermed areas.

Ice roads can contain trapped contaminants from vehicle exhaust, antifreeze, oil, and other vehicle-related fluids. These contaminants could enter into the water system(s) each spring as the ice roads melt. The discharge is not anticipated to be significant since ice roads are only planned for the first two winter construction periods, and would potentially produce only short-term effects. Mitigation to include regular inspection for and clean up of road spills, scraping of the affected road surface and proper disposal of the scraped materials prior to breakup will further minimize effects.

The majority of wastes generated during drilling consist of drill cuttings and spent muds. All drilling fluids will be disposed of through onsite injection into a permitted disposal well. The materials will be temporarily stored on site in a lined and bermed area, during circumstances when the Grind and Inject facility is not functioning. Therefore, it is anticipated that drilling-associated wastes will not be spilled onto the tundra and effects to freshwater quality from these materials are not expected.

Operations and Maintenance

Permitted Discharges

As described above for the construction camp, domestic wastewater from the permanent operations camp will be treated and injected into the disposal well. During periods of full staffing about 7,500 gpd (28,400 liters/day) of domestic wastewater will be produced. At times when the injection well is not operational, the treated domestic wastewater will be discharged to the tundra under the requirements of the NPDES General Permit for tundra disposal. This discharge will be short-term and will only occur during emergency situations. Since this infrequent discharge of domestic wastewater will meet the specific NPDES effluent requirements, it is unlikely to have significant long-term effects on water quality.

Spills and Leaks

Facility operations and maintenance will require the storage of various fuels, lubricants and chemicals that could potentially affect freshwater quality if leaked or spilled. Emergency power will be available from diesel generators, and vehicles and vessels associated with transport of supplies and personnel will be utilized on a regular basis. Storage tanks to fuel the generators, vehicles, and vessels will be located on the Central Processing Facility (CPF) pad. Section 3.13.5 of this Environmental Report (ER) describes the types of materials and storage tanks required for operations activities. Storage tanks will be installed following all applicable ADEC regulations. Tank design and location, and the use of berms and liners will mitigate the risk that spills and leaks could affect freshwater quality.

Under the proposed operations plan, spill cleanup would be required should containers leak and/or berms or other containment fail, or due to accidental spills during use in operations. The size of such spills is likely to be small, and contained within a pad. Spills of chemicals or saline waters into a large lake or river would become diluted very quickly. In small lakes, tundra ponds, and shallow water tracks, spills could be pumped out or neutralized. Impacts from large spills are considered in detail in Section 5.4.

5.1.2.3 Water Removal

Freshwater sources are required to construct onshore and offshore ice roads for project access during winter construction activities. At present, an annual sea ice road connecting the Point Thomson facility to Endicott is not planned for every year; however, use of such an ice road may be required occasionally in the future. Upon melting, water from onshore ice roads would recharge area lakes.

Many of the lakes are shallow and freeze to the bottom each winter. These lakes could only serve as water sources early in the winter in the project area. Several lakes, which may be deeper, have been identified as suitable potential water sources (see Figure 3-19).

Since there are few deep lakes in the region, former mine sites that have now filled with freshwater such as the former mine sites at Badami, Shaviovik Pit, and Point Thomson may be the best sources of year-round freshwater. These sources would not freeze to the bottom and may be suitable as water sources for ice road construction and maintenance throughout the winter. However, these waterbodies could support overwintering fish populations. In the winter, these ice-covered lakes could have low oxygen levels and could be subject to further reduction of oxygen if large volumes of water were removed. Low oxygen levels can be detrimental to the health of fish-bearing lakes, and effect the optimal overwintering habitat for fish. Permit stipulations for the Point Thomson project could limit the amount of freshwater allowed to be withdrawn from area lakes that are found to be fish bearing. For similar projects in the past, water withdrawal has been limited to 15 percent (%) of the available free water under the ice.

During summer construction and throughout the operations period, fresh water will be needed to minimize dust generation on the roads, for human consumption, and for other facility requirements. This water will be obtained from a permitted water source, likely the former gravel mine; and it is anticipated that there will be minimal to no effect to freshwater quality during the summer months.

5.1.2.4 Gravel Removal/Mining

The gravel used for the construction of permanent facilities will be obtained from a permitted site within the project area (see Section 3.0). Improper siting of gravel removal operations can result in impacts to the surface hydrology such as changes in stream channel or lake configuration, stream-flow hydraulics, or lake dynamics, resulting in erosion and sedimentation. These effects can impact freshwater quality. These effects have been considered in siting the location for the Point Thomson gravel mine. Rehabilitation of the site will result in creation of a freshwater lake.

Gravel removal operations will only be conducted in the winter when frozen soils and tundra will be encountered. Impacts on surface hydrology and nearby freshwater quality will be mitigated by the frozen conditions. No increase in sedimentation is expected due to the removal operations. A gravel stockpile containing about 200,000 cubic yards (cy) (153,000 cubic meters [m^3]) will provide for future operations and maintenance needs. Potential runoff from the overburden pile, that could increase the suspended sediment of nearby waters, could be controlled, if necessary. Control measures could include collecting the runoff and allowing the solids to settle before draining to the nearby tundra.

5.1.3 Marine Environment

Activities associated with the proposed project construction and operations potentially could affect nearshore circulation (hydrodynamics) and water quality (hydrography). This section summarizes the potential effects of the dock construction, long-term dock presence, one-time excavation of a dredged channel, and the subsequent ocean dumping of spoils.

5.1.3.1 Placement of Gravel and Obstruction of Circulation

Environmental consequences associated with dock construction and its subsequent long-term presence in the nearshore marine environment potentially could affect marine waters immediately adjacent to the dock. It is anticipated that gravel placement during dock construction would temporarily result in elevated suspended sediment in the water column. The presence of the dock could affect water movement and the water column structure (i.e., vertical salinity profile) in the immediate vicinity of the dock, possibly resulting in observable changes in selected water quality parameters such as salinity and density.

Circulation

Solid-filled structures, including marine docks, influence the alongshore movement of water immediately adjacent to the structure, resulting in variations in the current velocity (i.e., speed and direction), and introduce local vorticity (i.e., wake effects such as eddies and secondary flows). During periods in which the nearshore water movement has an alongshore current component of sufficient speed, a wake eddy typically develops on the lee (down-current) side of the structure. The wake eddy effect has been apparent at the West Dock Causeway (WDC) since the 1976 Dock Head 3 extension (Colonell and Gallaway 1990).

As the wake eddy is established, a secondary vertical circulation soon develops that provides vertical mixing of the water column within the eddy. For stratified water columns, that is water columns with a fresh or brackish surface layer and an underlying higher salinity (i.e., marine) bottom water layer, the vertical mixing within the eddy could result in the transport of higher salinity waters to the surface. This occurs when the surface and bottom waters have similar alongshore current velocities. However, during conditions in which the alongshore currents do not coincide with bottom water movement, the wake eddy formation is restricted to the surface layer because of poor frictional coupling with the bottom layer. If the alongshore current is similar in both surface and bottom layers, the eddy will involve both layers and promote movement of bottom layer waters into the upper part of the eddy, where it is mixed and carried downstream by the alongshore current (Colonell and Gallaway 1990).

Wind-induced upwellings occur naturally and regularly due to east and northeast winds on a regional scale across the North Slope (Colonell and Gallaway 1990). Kinnetic Laboratories, Inc. (1983) conducted oceanographic studies within Lions Lagoon and on the seaward side of the barrier islands. They observed that major exchange of water masses in Lions Lagoon is driven by storm surges and local wind. Gallaway et al. (1991) review of data from the NOAA-9 polar-orbiting satellite indicated that the area between the Colville/Sagavanirktok River Habitat Unit and the Mackenzie River Habitat Unit often had cold, marine waters extending to the shore in open-water season. The Point Thomson Unit coastline falls within this area. Physical oceanographic studies conducted in 1997 and 1998 by URS Corporation in the Point Thomson area correlate with the Kinnetic and NOAA-9 data review (URS 1999).

The proposed dock would provide an alternative mechanism by which upwellings could occur but would not appreciably enhance naturally occurring upwellings. Because the water column within Lions Lagoon in the area of the proposed dock tends to be uniform (URS 2000), both horizontally and vertically, formation of a wake eddy would only mix waters with similar temperature and salinity characteristics.

__Water Quality__

Dock Construction

The dock is scheduled to be constructed during the winter, thus, sea ice will be present throughout the lagoon waters, entrances and other gaps between the barrier islands, and the Beaufort Sea. Within the construction area, sea ice will be removed to allow gravel placement. Gravel placement will elevate suspended sediment and turbidity in the adjacent nearshore waters. However, it is anticipated that the affected area of the marine environment will be quite limited since most of the dock coincides with the grounded sea ice zone–that is a band of sea ice attached to the seafloor and associated with shallow waters typically found adjacent to the shoreline and extending to the 6-ft isobath. Available bathymetry indicates that the dock will extend to the 7-ft isobath, thus, on average, only a 1-ft water column will be affected by the 750 ft long dock construction. It is anticipated that low current speeds and the relatively shallow water column affected by dock construction will limit the distribution of elevated suspended sediment. A water quality variance from the State of Alaska may be required for this minimal and short-term increase in turbidity that will occur.

Sediment contamination by selected heavy metals and hydrocarbons is anticipated to be negligible, if any, since there have been limited industrial or military activities at the construction site. Sediment quality sampling in support of the Liberty and Northstar Developments demonstrate that the nearshore Beaufort Sea sediments are typically absent of contaminants, and all of the samples to date result in chemical-of-concern concentrations below regulatory screening levels (URS 2000 and 2001).

Long-Term Presence of the Dock

Water quality alterations associated with solid-filled docks and causeways located along the Central Beaufort Sea coast have been documented for numerous years. The area of water quality alteration due to wake eddy development is a function of the relative difference between surface and bottom water salinities, duration of the wake eddy during easterly winds, dock length, and water depth.

It is anticipated that water quality alterations associated with increased surface water salinity will be intermittent yet locally observable down current of the dock; however, the effect will be temporary and restricted in size. During periods of sustained easterly winds coinciding with the summer open-water season, wake eddy formation on the lee (down current) side of the structure effectively mixes the water column within the eddy as bottom waters are brought to the surface. If the nearshore waters immediately adjacent to the dock are uniform, that is the surface and bottom water salinities are similar, vertical mixing will result in little to no detectable changes in surface water character. However, during times when the water column is stratified, that is when the surface waters tend to be notably fresher than the underlying saltier bottom waters, the vertical mixing associated with the wake eddy results in higher saline surface waters immediately down current of the dock. It should be noted that under westerly winds, nearshore waters tend to be relatively uniform and thus vertical mixing due to wake eddies typically results in minimal changes to the surface water salinity.

The hydrographic effects of WDC on Simpson Lagoon were evaluated by Colonell and Gallaway (1990). Persistent easterly winds induce upwelling through various channel entrances to Simpson Lagoon, including the channel between Stump Island and WDC. The wake effect at the tip of WDC promotes upward mixing of the bottom water in the water column. As a result, under persistent easterly winds cold saline marine waters fill the channel between Stump Island and WDC. A review of salinity data from 1976 to 1988 showed that water quality between Stump Island and WDC has not materially changed over this time period, indicating that the wake effect at WDC has a minimal effect compared to region-wide wind driven processes (Colonell and Gallaway 1990).

Lions Lagoon nearshore waters typically exhibit unstratified conditions from breakup and to freeze-up; however, persistent easterly winds and/or strong storm events create temporary stratified marine water conditions in nearshore waters (URS 2000). The water column within Lions Lagoon in the area of the proposed dock tends to be uniform, both horizontally and vertically, even during persistent easterly winds (URS 2000). Hydrographic changes from the formation of a wake eddy at the tip of the proposed dock would mix waters with similar temperature and salinity characteristics. Therefore, potential hydrographic effects due to the proposed dock are anticipated to be minimal compared to the naturally occurring wind driven upwellings.

5.1.3.2 Discharges

Increased turbidity associated with the summer nearshore dredging operation can be considered a discharge to the marine environment. It will be necessary to obtain a water quality variance from the State of Alaska for the short-term increase in turbidity that will occur. In addition, an ocean dumping permit under Section 103 of the Marine Protection, Research, and Sanctuaries Act will be required to dump the dredge spoils at sea.

A known consequence of summer dredging activities related to the 1,000-ft (305 m) temporary dredged channel is a suspended sediment plume; however, the effects will be temporary and generally restricted to lagoon waters within the project area. The distribution of the suspended sediment plume is a function of water depth, sediment grain-size, current velocity, and duration of the dredging. Shallower waters, coarser-grained sediments (i.e., sands, gravel), low current speeds, and abbreviated dredging operations tend to reduce the overall affected area.

During easterly winds, water typically enters the lagoon through Mary Sachs Entrance, and thus it is anticipated that a sediment plume associated with dredging will be attached to the mainland shoreline, effectively reducing the influence of the plume as it is transported into shallower waters. Under westerly winds, the suspended sediment plume is anticipated to move toward the shallow water shoals south of Flaxman Island.

Coarser-grained sediments fall out of the water column within a short distance from the excavation. While there is currently limited information regarding the sediment grain-size in the area of proposed dredging, it is assumed that the sediments will tend to have a coarse-grain component similar to the nearshore surface sediments collected along the proposed Liberty Development pipeline route.

Alongshore current movement is wind-driven, thus, higher wind speeds result in higher current speeds. Typically, storm events have a significant northerly component, regardless if the storm is from the east or west. Thus, higher current speeds should transport the plume to the mainland shore, limiting the overall effected area. Storms themselves create suspended sediment in nearshore waters, raising concentration in excess of 75 milligrams per liter (URS 2000). Similarly, ocean dumping discharge of spoils will create a temporary suspended sediment plume in offshore waters. It is anticipated that the effects related to ocean dumping will be similar to dredging with the exception of possible burial and associated morality of benthos immediately below the discharge.

Accidental discharges due to spills could occur during both construction and operations phases. These spills could consist of diesel fuel and other fluids necessary for vehicle operations, and spills and discharge of fuels or contaminated bilge water from support vessels. Impacts from large spills are considered in detail in Section 5.4.

All storage of fuels and refueling of equipment and machinery will proceed following the procedures outlined in the North Slope Environmental Field handbook and in ExxonMobil's Safety Manual. All employees will be trained in the authorized location and proper methods for refueling. By limiting the locations of fueling and instituting controls for fueling methods, small spills and leaks to the marine environment can be prevented.

5.1.4 Permafrost and Soils

The dominant ice-rich permafrost soils in the project area, if allowed to thaw, will slump and release melt water, could then pond. The ponded water will absorb more radiant energy and increase the area of thawed soils. Thermokarst is the term used for this land-surface configuration that results from the melting of ground ice in a region underlain by permafrost. In areas that have appreciable amounts of ice, small pits, valleys, and hummocks are formed when the ice melts and the ground settles unevenly. Thermokarst areas can continue well beyond the area of initial disturbance and may take several years to stabilize, even if the soils are only slightly disturbed. The placement of 5-ft (1.5 m) thick gravel on the tundra surface to support project facilities would prevent the degradation of the permafrost. Gravel removal at the mine site location will impact the permafrost in the immediate vicinity.

5.1.4.1 Placement of Gravel

All gravel coverage will take place during the winter months. Facilities requiring gravel placement include the pads, roads, and airstrip. The working surfaces for these structures will be approximately 5-ft (1.5 m) or more above ground level, after compaction, depending on local topography. The active layer beneath the gravel will be reduced to a narrow zone near the existing ground surface. This reduction of annual thaw into the ice-rich soils reduces the risk of thaw settlement under the gravel fill, and degradation of permafrost. Consequently effects to the permafrost are likely to be minimal. The gravel fill for the dock is anticipated to result in colder ground temperature below the sea floor, which would prevent the degradation of subsea permafrost.

5.1.4.2 Gravel Removal/Mining

Excavation and removal of gravel will completely remove the soils and permafrost in the gravel mine footprint. Localized degradation of permafrost areas may occur due to gravel mining activities.

This page intentionally left blank

5.2 BIOLOGICAL RESOURCES

Biological resources of the Point Thomson area include marine benthos, vegetation and wetlands, freshwater and marine fish, birds, marine mammals, and terrestrial mammals. The project actions and the impacts they could potentially produce are likely to be different whether the action occurs as part of winter or summer construction or during operations. Therefore, the potential impacts on the resources due to project actions during different project phases (winter and summer construction and operations) are considered separately. Table 5-2 summarizes the potential impacts associated with each category for the biological resources in the Point Thomson study area and indicates during which project phase the impacts are anticipated. The potential direct and indirect effects of construction and operation of the proposed Point Thomson Gas Cycling Project on biological resources can be grouped into three major categories:

Habitat Effects

- Long-term habitat loss or alteration from gravel extraction at the mine site and from gravel placement for the construction of the airstrip, roads, pads, and dock.
- Temporary habitat modification leading to temporary or localized habitat loss or decreased habitat value. Effects could include changes in wildlife use of habitats that would be altered by ice roads, dust fallout, persistent snow drifts, thermokarst, alteration of water flow, impoundments, and contaminant spills.

Disturbance Effects

- Impacts associated with behavioral reactions of wildlife to noise and visual disturbance from equipment operation and human activity (e.g., drilling, vehicles, heavy equipment, vessels, and aircraft) during project construction and operation. Effects could include energetic and other costs associated with startle responses or with fleeing from the area, and reduced nesting success or clutch sizes of birds nesting too close to facilities.
- Effects associated with loss of habitats (through avoidance or displacement), or reduction in quality of habitats in which wildlife are subject to disturbance.
- Attraction of wildlife to project facilities (e.g., herbivores to areas of early snowmelt in spring, birds to impounded areas adjacent to gravel pads and roads, caribou to gravel pads and pipelines for insect relief, and predator/scavengers to artificial food sources). Other effects could include increased abundance of opportunistic and easily habituated predator/scavengers, including Arctic foxes, grizzly bears, glaucous gulls, and ravens.

Direct and Indirect Mortality

- Injury and mortality of wildlife from collisions with aircraft, vehicles, or structures, or from contact with, or ingestion of, oil or other contaminants.
- Increased predation on prey species by foxes, bears, glaucous gulls, and ravens as a result of their increased abundance, or attraction to oil field facilities.

The following sections discuss the impacts depicted on the table.

Table 5-2 Potential Biological Consequences

BIOLOGICAL RESOURCES	POTENTIAL IMPACTS[1]			
	HABITAT		DISTURBANCE	MORTALITY
	LOSS	ALTERATION		
Marine Benthos	Y (W)	Y (W)	Y (W)	Y(W)
Vegetation/Wetlands	Y (W,S,O)	Y (W,S,O)	N/A	N/A
Freshwater Fish	Y (W)	Y (W)	N	Y (O)
Diadromous Fish	Y (W)	Y (W)	N	Y (O)
Marine Fish	Y (W)	Y (W)	N	Y (O)
Waterfowl and other Water Birds	Y (W,S,O)	Y (W,S,O)	Y (S,O)	Y (S,O)
Tundra –Nesting Birds	Y (W,S,O)	Y (W,S,O)	Y (S,O)	Y (S,O)
Predatory Birds	Y (W,S,O)	Y (W,S,O)	Y (W,S,O)	Y (W,S,O)
Cetaceans	N	N[2]	Y(S,O)	N
Pinnipeds	N	N[2]	Y(W,S,O)	N
Polar Bears	N	N[2]	Y(W,O)	Y(W,O)
Caribou	Y (W,S,O)	Y (W,S,O)	Y(S,O)	Y (W,S,O)
Muskoxen	Y (W,S,O)	Y (W,S,O)	Y(S,O)	Y (S,O)
Grizzly Bear	Y (W,S,O)	Y (W,S,O)	Y(S,O)	Y (S,O)
Arctic Fox	Y (W,S,O)	Y (W,S,O)	Y(S,O)	Y (W,S,O)
Moose	Y (W,S,O)	Y (W,S,O)	Y(S,O)	Y (S,O)
Steller's and Spectacled Eiders	Y (W,S,O)	Y (W,S,O)	Y(S,O)	Y (S,O)
Bowhead Whales	N	N[2]	Y(S,O)	N
Other Mammals	Y (W,S,O)	Y (W,S,O)	Y(S,O)	Y (W,S,O)

[1]Defined in text of Section 5.2
[2]Characterized as disturbance

Notes:
N/A = not applicable
N = no effect
O = operations
S = summer construction
W = winter construction
Y = potential consequence

5.2.1 Marine Benthos

As described in Section 4.5, the benthic community of Lions Lagoon is thought to be composed primarily of infaunal and epifaunal invertebrates similar to other Beaufort Sea coastal lagoons and bays. Since depths within the lagoon do not exceed 20 ft (6 m), the community is likely to be characterized by low density and diversity, as is characteristic of the nearshore zone of the Beaufort Sea (Carey and Ruff 1977 and Carey 1978). Table 5-2 summarizes the potential impacts on the benthic community.

5.2.1.1 Habitat Loss and Mortality Effects

Winter Construction

Effects of winter construction of the dock will be minimal, since the short dock will be mostly contained within the grounded ice zone. Within this zone, the benthic community consists of organisms that move into or recolonize the area after breakup. However, approximately 2 acres (<1 hectare [ha]) of the littoral zone including the area covered by gravel that extends from the shoreline to the 7 feet (ft) (2 meters [m]) depth would be lost as benthic habitat for subsequent open water seasons. Additionally, the area at the end of the dock, in the ice shear zone, is unlikely to support diversified benthic communities. Given the low density and diversity within the nearshore zone of the Beaufort Sea, and the opportunistic nature of the benthic community, loss of this area as habitat will not have a significant effect on the benthic community within Lions Lagoon.

Summer Construction

A proposed shallow channel approximate 0 to 2 ft (0.6 m) deep and approximately 400 ft wide (122 m) by 1,000 ft long (305 m) would be dredged from the end of the dock to the 9-ft (3-m) isobath. Since the dredging activity would take place in the summer, in an area offshore of the typical grounded-ice zone, the benthic community would be impacted. Approximately 9 acres (4 ha) of littoral zone would be directly impacted by the dredging, with additional areas potentially impacted by sediment fallout from the turbidity plume. However, the area directly impacted would likely be quickly recolonized by the opportunistic species found in this community, and the sediment plume effects will be temporary as the sediment is resuspended by wave and current action.

It addition to the dredging action itself, the disposal of approximately 30,000 cy (23,000 m^3) of dredge spoils will create turbid conditions at the location of disposal. The impacts of the disposal will be evaluated under Section 103 of the Marine Protection Research and Sanctuaries Act and will be included in the associated report.

Operations and Maintenance

Operations and maintenance activities will likely have none to minimal habitat loss and mortality impacts on the marine benthic community. These actions would not cause long-term habitat loss or additional mortality.

5.2.1.2 Habitat Alteration and Disturbance Effects

Disturbance effects to benthic organisms occurring in areas adjacent to the dock footprint could occur during winter construction, summer construction, and operations phases of the project. Although they tend to be localized and possibly more intense in a small area, activities such as those listed below can cause physical changes to the benthic habitat related to increased turbidity.

- Dredging of the 1000 ft by 400 ft (305 m by 122 m) channel (summer construction).
- Alteration of local water-flow patterns, and thus the deposition (or erosion) of sediment and organic material in the vicinity of the dock (summer and winter effect).

- Maintenance of the gravel-fill dock structure by placement of sand and gravel, some of which is eroded and then deposited in the nearby benthic community each open-water season (summer construction and operations).
- Tug-and-barge movement during the open-water season could disrupt bottom sediments (summer construction and operations).

During the winter in the grounded land-fast ice zone, impacts or disturbance to the benthic community adjacent to the dock are likely to be minimal. Very few organisms are found in both the grounded land-fast ice and nearshore ice zones for the entire length of the dock.

The increased turbidity that is possible during summer construction and operations activities is likely to be similar, if not smaller, in magnitude to that caused by natural events such as wind induced waves and increased sediment output from rivers during breakup (USACE 1987 and Britch et al. 1983). Based on the results of a five-year study of drilling discharges from the Endicott drilling islands (ENSR 1991), it is anticipated that benthos in adjacent areas are not likely to be affected by changes in water turbidity, and depositional and erosional patterns that may result from the presence and maintenance of the proposed structure.

5.2.2 Vegetation and Wetlands

As described in Section 4.6, about 35.3% of the project area is covered by water and predominant vegetation types are moist sedge, dwarf shrub/wet sedge tundra complexes, and moist sedge, dwarf shrub tundra. Table 5-3 summarizes the Point Thomson proposed facility gravel footprints by vegetation type. Table 5-4 provides the linear ft of proposed Point Thomson project pipeline corridors in each vegetation type.

5.2.2.1 Habitat Effects

Habitat effects in the project area depend upon the relationships between available habitat and resident wildlife species. Although the availability of food, nesting sites, and competition for habitat becomes restrictive at some threshold, there is no data currently available that indicates this threshold has been reached such that tundra habitat limits the size or natural growth rates of the wildlife species (Maki 1992).

Habitat effects can be considered long-term or temporary. Long-term effects occur when tundra is lost due to being covered with gravel or removed to reach gravel deposits. Temporary or short-term alterations of tundra vegetation in the Point Thomson area could be caused by ice roads, dust fallout from gravel roads, pads, and the airstrip, snow dumps, persistent snowdrifts, thermokarst, changes to surface hydrology, and spills and leaks during construction and operations phases.

Gravel Removal and Placement

Direct impacts to the vegetation and wetlands of the Point Thomson area will occur as gravel is placed on the tundra during winter construction of roads, pads, and the airstrip. Gravel placement for the proposed facilities will cover approximately 8,149,933 ft^2 (0.8 km^2) of tundra habitats (Table 5-3). The effects of gravel cover are long-term and vegetation recovery is slow following removal or remediation of gravel fill (Johnson 1987, Walker et al. 1987, and Jorgenson et al.

Table 5-3. Square feet of Point Thomson proposed facility gravel footprints by vegetation type.

Vegetation Type	Level C Vegetation Class	Airstrip	Airstrip Road (from intersection with east road)	Central Processing Facilities Pad	Central Well Pad	Dock	East Well Pad	East Well Pad Road (from CFP to East pad)	West Well Pad	West Well Pad Road (from intersection with east pad road)	Gravel Storage Pad	Overburden Pile	Water Source Access Road	Water Source Pad	Total Gravel Cover	% of Total	Gravel Mine	Total permanent habitat loss (gravel cover and mine)	% of Total
Water	Ia		158	45,971	24,606	130,131	26,359	46,075	8,466	26,900	14,208	219	435	10	**325,529**	3.99	**102,339**	**427,878**	4.35
Salt Marsh		0	0	24,431	74,291	3,129	0	0	0	34,892	0	0	0	0	**136,744**	1.68		*136,744*	1.39
	IIIb				*26,218*										*26,218*	*0.32*		*26,218*	0.27
	IXh														*0*	*0.00*		*0*	0.00
	IXj			*24,431*	*48,073*	*3,129*				*34,892*					*110,526*	*1.36*		*110,526*	1.12
Aquatic Graminoid Tundra	IIb							20,122		8,748					**28,869**	0.35		**28,869**	0.29
Water/Tundra Complex	IId														**0**	0.00		**0**	0.00
Wet Sedge Tundra	IIIa			280,379	45,640			20,859		45,745			3,824		**396,447**	4.86		**396,447**	4.03
Wet SedgeTundra/Water Complex	IIIc									28,182					**28,182**	0.35		**28,182**	0.29
Moist Sedge, Dwarf Shrub Tundra/ Wet Sedge Tundra Complex		934,840	160,226	82,686	49,288	0	170,743	428,119	67,441	531,572	202,971	303,754	27,450	0	**2,959,090**	36.31	608,405	**3,567,495**	36.28
	IIId	*620,892*	*160,226*	*40,853*	*40,992*			*41,169*	*21,430*	*198,953*	*202,971*	*303,754*	*23,278*		*1,654,517*	*20.30*	*495,321*	*2,149,837*	21.86
	IIIe			*41,834*	*8,297*										*50,130*	*0.62*		*50,130*	0.51
	IVa	*313,948*					*170,743*	*386,950*	*46,011*	*332,620*			*4,172*		*1,254,443*	*15.39*	*113,084*	*1,367,527*	13.91
Moist Sedge, Dwarf Shrub Tundra		0	183,161	609,743	0	0	2,374	857,835	168,408	1,050,605	267,864	29,869	31,548	13,833	**3,201,407**	39.28	971,868	**4,187,107**	42.58
	Va		*183,161*	*509,588*			*2,374*	*835,686*	*168,408*	*917,667*	*267,864*	*29,869*	*11,123*		*2,925,739*	*35.90*	*748,860*	*3,674,600*	37.37
	Ve			*100,154*				*22,149*		*132,938*			*20,425*	*13,833*	*275,667*	*3.38*	*223,007*	*512,507*	5.21
Moist Tussock Sedge, Dwarf Shrub Tundra	Vb														**0**	0.00		**0**	0.00
Dry Dwarf Shrub, Crustose Lichen Tundra	Vc		32,868	32,246				109,366		122,454			3,062		**299,996**	3.68		**299,996**	3.05
Dry Dwarf Shrub, Fruticose Lichen Tundra	Vd														**0**	0.00		**0**	0.00
Dry Barren/Dwarf Shrub, Forb Grass Complex	IXb							3,560							**3,560**	0.04		**3,560**	0.04
Dry Barren/Forb Complex	IXc														**0**	0.00		**0**	0.00
Dry Barren/Grass Complex	IXe														**0**	0.00		**0**	0.00
Dry Barren/Dwarf Shrub, Grass Complex	IXf														**0**	0.00		**0**	0.00
River Gravels	Xa					32,246	26,699	4,868							**63,813**	0.78		**63,813**	0.65
Bare Peat, Wet Mud		2,276	4,290	7,585	1,515	0	30,640	70,954	0	27,152	11,932	0	0	0	**156,344**	1.92	0	**156,344**	1.59
	XIa	*2,276*	*4,290*	*7,585*	*1,515*		*30,640*	*70,954*		*27,152*	*11,932*				*156,344*	*1.92*		*156,344*	1.59
	XIc														*0*	*0.00*		0	0.00
Gravel Roads and Pads (and washouts)		0	0	12,303	523,806	0	0	0	0	0	0	0	0	0	**536,110**	6.58	0	**536,110**	5.45
	Xc														*0*	*0.00*		*0*	0.00
	Xe			*12,303*	*523,806*										*536,110*	*6.58*		*536,110*	5.45
	Total	**937,116**	**380,703**	**1,095,345**	**719,147**	**165,507**	**258,814**	**1,561,758**	**244,315**	**1,876,251**	**496,974**	**333,842**	**66,319**	**13,843**	**8,149,933**	**100.00**	**1,682,612**	**9,832,544**	**100.00**

NOTE: Sum of AREA (Units = Square Feet)

1991). Therefore these effects are considered to be long-term. The vegetation types most affected by gravel placement would be moist sedge, dwarf shrub tundra (39% of the gravel footprint lies in this vegetation type) and moist sedge, dwarf shrub tundra/wet sedge tundra complex (36% of the footprint). No other vegetation type comprises more than 5% of the gravel footprint for the Point Thomson project.

Gravel mine development would cause long-term alteration of 1,682,612 ft^2 (0.2 km^2) of tundra habitats (Table 5-3). The vegetation types that would be most affected by gravel removal are the same as for the gravel footprint (together these two types comprise 94% of the gravel mine footprint) (Table 5-3).

Ice Roads

For the proposed Point Thomson Gas Cycling Project, ice roads on tundra will be used the first winter to support gravel mining, construction of the roads, pads, and airstrip, and during the second winter for pipeline construction. Ice roads typically result in delayed snowmelt and tundra compaction. The effects of delayed snowmelt are confined primarily to the first growing season following use of an ice road. Although some damage to tundra occurs from ice roads, the long-term effects are considerably less than those associated with gravel roads and pads. The magnitude of impacts will depend on the volume of ice in the underlying soil (Adam and Hernandez 1977), the vegetation type present (Racine 1977; Walker et al. 1987, Emers et al. 1995), and the duration of use (Buttrick 1973, Adam and Hernandez 1977).

Ice roads can result in torn and crushed sedge tussocks, and mortality of mosses and lichens (Adam and Hernandez 1977, Johnson and Collins 1980, Walker et al. 1987). Some individual plants may be killed or small areas damaged, but if the tundra organic mat is not torn, plant recovery usually occurs within a few years. However, removal of plant cover (ripped or scraped) or disruption of the soil surface can cause long-term damage or mortality to plants. The effects of ice roads are greater in dry and moist habitats than they are in wet habitats. Based on the pipeline alignment, the vegetation types with the largest proportion of ice road coverage would probably be moist sedge, dwarf shrub tundra/wet sedge tundra complex (37% of pipeline alignment) and moist sedge, dwarf shrub tundra (42% of pipeline alignment; Table 5-4). Areas that are most sensitive to damage from ice roads include ridges, banks, dunes, tussocks, and high centered polygons, which are most common in the following vegetation types: moist sedge, dwarf shrub tundra; moist tussock sedge, dwarf shrub tundra; dry dwarf shrub, crustose lichen tundra; dry dwarf shrub fruticose lichen tundra, and dry barren/dwarf shrub, grass complex. A total of 85,726 linear ft (26.1 kilometers [km]) of the pipeline alignment lies within these vegetation types.

Water Removal

Withdrawal from lakes could potentially alter wetland community structure by changing the hydrologic regime. Potential lakes identified for ice road construction are shown in Figure 3-19. At present, it is planned that the abandoned gravel mine will be used as the freshwater source for camp and operations needs. The abandoned gravel mine at Point Thomson is not known to be fish bearing.

Table 5-4 Linear Feet of Proposed Point Thomson Project Pipeline Corridors in each Vegetation Type

VEGETATION TYPE	LEVEL C VEGETATION CLASS	EAST PIPELINE	SALES PIPELINE	WEST PIPELINE	SUBTOTAL	% OF TOTAL
Water	Ia	2,424	6,070	2,845	11,339	6.34
Salt Marsh		183	187	189	559	0.31
	IIIb				*0*	*0.00*
	Ixh				*0*	*0.00*
	Ixi	*183*	*187*	*189*	*559*	*0.31*
Aquatic Graminoid Tundra	Iib	483	948	937	2,368	1.32
Water/Tundra Complex	Iid		549	567	1,116	0.62
Wet Sedge Tundra	IIIa	1,293	2,490	813	4,596	2.57
Wet SedgeTundra/Water Complex	IIIc		2,727	564	3,291	1.84
Moist Sedge, Dwarf Shrub Tundra/ Wet Sedge Tundra Complex		9,182	45,073	12,325	66,580	37.23
	IIId	*2,408*	*7,835*	*5,555*	*15,798*	*8.83*
	IIIe	*96*	*302*	*148*	*546*	*0.31*
	Iva	*6,677*	*36,936*	*6,622*	*50,236*	*28.09*
Moist Sedge, Dwarf Shrub Tundra		12,613	49,106	13,987	75,706	42.33
	Va	*11,720*	*38,263*	*13,130*	*63,112*	*35.29*
	Ve	*893*	*10,844*	*857*	*12,594*	*7.04*
Moist Tussock Sedge, Dwarf Shrub Tundra	Vb				0	0.00
Dry Dwarf Shrub, Crustose Lichen Tundra	Vc	2,782	3,229	3,010	9,020	5.04
Dry Dwarf Shrub, Fruticose Lichen Tundra	Vd		1,000		1,000	0.56
Dry Barren/Dwarf Shrub, Forb Grass Complex	Ixb				0	0.00
Dry Barren/Forb Complex	Ixc				0	0.00
Dry Barren/Grass Complex	Ixe				0	0.00
Dry Barren/Dwarf Shrub, Grass Complex	Ixf				0	0.00
River Gravels	Xa	41	781	49	870	0.49
Bare Peat, Wet Mud		715	1,000	693	2,407	1.35
	Xia	*715*	*1,000*	*693*	*2,407*	*1.35*
	Xic				*0*	*0.00*
Gravel Roads and Pads (and washouts)		0	0	0	0	0.00
	Xc				*0*	*0.00*
	Xe				*0*	*0.00*
Total		**29,715**	**113,158**	**35,979**	**178,852**	**100.00**

SUM = LENGTH (Units = Feet)

Obstruction of Flow

Impoundments can occur when drainage is impeded adjacent to roads or pads. Impoundments can be temporary, disappearing by mid-June, or they can persist through summer. Depending on the duration of seasonal impoundments, effects on vegetation range from minor to substantial. For the Point Thomson project, culverts will be placed during construction to prevent the formation of long-term impoundments adjacent to roads or pads. Additional culverts or other drainage structures could be installed after construction to drain any long-term impoundments that might form following initial gravel placement. Temporary impoundments probably will occur for brief periods (a week or less) during spring runoff; however, the overall effects of such impoundments on vegetation would be minimal.

Thermokarst

As described in Section 5.1.4, thermokarst is the settling or caving of the ground due to melting of ground ice (Muller 1947). Thermokarst is a natural process, even in undisturbed areas, and can be viewed as having both positive and negative effects. The process occurs whenever the heat absorption or exchange capacity of permafrost soils is altered. Thermokarst areas are typically found on the edges of gravel pads or roads, and are exacerbated by dust fallout or impoundment of water. Thermokarst also can result when the tundra mat is disturbed, often as a result of spill cleanup activities. Although visual and hydrologic effects of thermokarst are long-lasting (Lawson 1986), other ecological changes may benefit plant productivity and wildlife use (Truett and Kertell 1992). Physical and thermal changes may enhance organic matter decomposition, nutrient release, primary production, and nutrient concentrations in plant tissue (Challinor and Gersper 1975, Chapin and Shaver 1981, Ebersole and Webber 1983, and Emers et al. 1995). Thermokarst may increase habitat diversity, species richness, and plant growth on thin gravel fill (Jorgenson and Joyce 1994). Since the Point Thomson facility will be built on gravel pads to insulate ice-laden soils, thermokarst conditions are expected to be limited. Engineering techniques proven in over 25 years of working in permafrost areas on the North Slope will be used to further mitigate potential effects.

Dust Fallout

During the summer construction season, the gravel roads, pads, and airstrip will be graded and compacted. This activity, along with the movement of heavy equipment associated with the construction along the gravel roads, will generate dust. To a lesser extent, operational use of the roads will also create dust.

The effects of dust fallout (fugitive dust that lands on tundra downwind from gravel roads and pads) are most pronounced within 35 ft (11 m) of the source, constituting about 17,950,237 ft^2 (1.7 km^2) around the Point Thomson facilities. The magnitude of dust effects depends on traffic speed and intensity, distance from the source, and substrate acidity (Everett 1980, Walker and Everett 1987, and Auerbach et al. 1997). The effects of dust fallout within this zone could include (from Spatt 1978, Everett 1980, Spatt and Miller 1981, Werbe 1980, Klinger et al. 1983, Walker et al. 1985, Walker and Everett 1987, and Auerbach et al. 1997):

- Advanced snowmelt (up to two weeks) because of increased albedo
- Increased depth of seasonal thaw (to 20 inches (in) in ice-rich areas)
- Thermokarst

- Early green-up of plants
- Increased soil pH
- Reduced photosynthetic capacity of plants
- Lower nutrient levels,
- Decreases in acidophilous mosses (particularly *Sphagnum*) and some lichens (*Cladina* and *Peltigera*)
- Increases in other mosses
- Decreases in some prostrate shrubs (*Dryas* and *Ledum*)
- Barren patches of ground

Cotton-grass sedges, such as *Eriophorum* spp., are more tolerant of dust fallout, perhaps because they occur in wetter areas and are adapted to disturbed sites (Everett 1980).

Dust fallout associated with regrading and compacting of the gravel during the first summer construction phase will likely occur after spring thaw and will not affect snowmelt. Advanced snowmelt due to dust fallout adjacent to the roads, pads and airstrip could result from construction activities and infield traffic during operations. Watering the roads during the summer, an enforcing vehicular speed limits at all times will mitigate potential effects from dust fallout.

Snow Dumps and Snow Drifts

During the winter, snow that accumulates on pad, road, and airstrip surfaces will be plowed to the side. In some cases the snow will be pushed off of the gravel surface and will accumulate on the frozen tundra. In addition, drifted snow can accumulate adjacent to the gravel areas that are of higher relief than the surrounding tundra. The accumulated snow can result in delayed snowmelt and soil compaction. Impacts on vegetation may be long-term because of the chronically reduced growing season, soil compaction, altered moisture regime, and gravel fallout. Since large accumulations of snow are not anticipated for the region, the areas potentially affected by snow dumps and snowdrifts associated with the Point Thomson project are anticipated to be small. In addition, mitigation measures such as ensuring that the snow is stored on the gravel surface as much as possible and relocating snow dump areas from year to year will minimize any effects on vegetation.

Spills and Leaks

Contaminant spills associated with the Point Thomson project could affect plant communities in several ways. The most common accidental spills in the North Slope oil fields are fuels and vehicle/machinery lubricants, although a wide range of other chemicals are used in the industry and may be spilled accidentally (e.g., methanol, glycol). Impacts to vegetation range from minor to severe, depending on the toxicity of the product spilled and the measures taken to clean it up. For the most common spills in the oil field, predictable alterations in the plant community include decreased plant cover, decreased species richness, mortality of woody plants and herbaceous flowering plants, increased relative abundance of graminoid plants (grasses and sedges), and thermokarst and associated changes (ranging from increased to decreased hydrologic variability). The most common spills on the North Slope are relatively small and can be cleaned up with minimal impact on vegetation. Reasonably productive plant cover can be achieved within several years, with some rehabilitation effort. Impacts from large spills are considered in detail in Section 5.4.

5.2.2.2 Disturbance and Mortality Effects

While mortality of vegetation and disturbance to vegetation and wetlands will occur as gravel is placed on the tundra, these direct impacts are discussed in the context of habitat loss and/or alteration (see Section 5.2.2.1, above).

5.2.3 Fish

Potential effects of the Point Thomson Gas Cycling Project on fish species previously discussed in Section 4.8 of this ER are summarized in Table 5-2 and discussed in the following sub-sections.

5.2.3.1 Habitat Effects

Potential habitat effects could result from project activities that cause freshwater and marine fish habitat modification, loss, or decreased habitat value. Arctic cisco (*Coregonus autumnalis*), least cisco (*C. sardinella*), broad whitefish (*C. nasus*), and humpback whitefish (*C. pidschian*) are not known to overwinter or spawn in the Point Thomson area. The Canning River supports round whitefish (*Prosopium cylindraceum*) and Arctic grayling (*Thymallus arcticus*) populations (Section 4.8.3 of this ER). Round whitefish use the main stem of the Canning River, the delta area, and Canning River tributaries throughout their life cycle, but do not migrate extensively (Moulton and Fawcett 1984, WCC 1982). Dolly Varden char (*Salvelinus malma*) use the Canning River perennial warm-water springs for overwintering habitat (WCC 1982). Project activities are not planned close to these areas and, therefore, will not directly impact the overwintering and spawning habitats of these fish species.

Winter Construction

Gravel mining activities will take place during one winter season (i.e., removal of tundra overburden, blasting, and mining of the gravel). Ninespine stickleback (*Pungitius pungitius*) are the only documented freshwater fish known to reside in Point Thomson area streams (Section 4.8.3). Ninespine sticklebacks overwinter in deep tundra lakes and rivers. The closest freshwater body to the proposed gravel mine site is an unnamed stream to the east. Due to its small size and probability that is freezes solid during winter, it is unlikely to provide overwintering habitat for ninespine sticklebacks. Gravel mining activities are not anticipated to impact ninespine stickle back overwintering habitat.

Gravel placement for roads, pads, and airstrip could alter flow patterns of streams and wetlands, preventing fish access to some habitats and/or modifying fish habitat. There is rarely a defined channel from perched lakes to river channels; the connection is generally through low-lying wetlands. Perched lakes can provide overwintering and rearing areas for fish. Ninespine stickleback can be found in streams and rivers in the Point Thomson area (Section 4.8.3); however, there are no known perched lakes or streams deep enough to provide ninespine stickleback overwintering or spawning habitat in the project area (see Figure 3-19). Therefore, it is anticipated that gravel placement for roads, pads, and airstrip will not impact ninespine stickleback overwintering and spawning habitats.

Culverts and/or bridges will installed during winter construction at road stream crossings. The method of crossing selected streams will depend on the water-body width. Ninespine sticklebacks forage in freshwater tundra streams and brackish nearshore waters during the summer. These fish were caught along the coastline at stations in Lions Lagoon south of Flaxman Island throughout the openwater season during a 1999 Point Thomson fish study (LGL 2000b). Culverts will be designed to minimize sedimentation and subsequent blockage, and to meet the fish passage requirements of the Alaska Department of Fish and Game (ADF&G) as determined by site-specific conditions. Therefore, it is not anticipated that culverts and/or bridges will inhibit the passage of ninespine sticklebacks and other fish into area streams.

The dock will be constructed during the winter in the land-fast ice zone, and extend out to a water depth of 7-ft (2 m). Placement of gravel fill during the dock construction will eliminate 2 acres (<1 ha) of nearshore summer fish foraging habitat. Foraging habitat is not limited in the nearshore waters; therefore, it is anticipated that the loss of this small area compared to the total nearshore habitat in the Point Thomson area will not impact fish species that use the area during the open water season.

Ice within the land-fast ice zone is frozen to the bottom substrate from the shore to a depth of about 7 ft (2 m). The remaining ice in the land-fast ice zones is floating (from 7 ft to 50 ft [2 to 15 m] water depth). Placement of gravel during dock construction will increase turbidity in the under-ice water column. It is anticipated that sediments released to water under the ice in the land-fast ice zone will settle out close to the construction area due to the large grain size (gravel) of the particles, and the quiescent conditions expected under the ice (LGL et al. 1998). Therefore, fallout from the sediment plume during winter dock construction would not likely affect the integrity of the summer foraging habitat used by diadromous or marine fish in this zone.

Pipeline construction will be conducted during winter using onshore ice roads. Turbidity associated with reworking of channels due to placement of VSMs is expected to be temporary and timed with normal seasonal turbidity increases in streams associated with spring breakup. Gathering and export pipelines are not known to cross any waterbodies supporting fish freshwater overwintering habitat. Therefore, potential impacts on freshwater fish habitats along the pipeline route are not anticipated.

Summer Construction

Re-grading and compaction of gravel roads, pads, airstrip, and dock during the first summer construction period could cause dust and sediment to enter freshwater and marine fish habitats, thereby increasing turbidity in these waters. Watering of gravel surfaces and enforcement of vehicular speed limits will minimize the generation of dust. Potential effects due to re-grading and compaction activities are inferred to be short-term and similar to naturally occurring events in the freshwater and marine environments (e.g., disturbance from ice, river runoff from spring break-up, and storm induced waves). Therefore, any effects from dust and sediment drift to freshwater and marine waters are anticipated to be minimal.

Dredging offshore of the dockhead during the summer and disposal of the spoils at an offshore location will generate turbidity plumes (see Section 5.1.3.2 discussion). Studies have shown that diadromous and marine fishes tolerate waters with turbidity values up to 146 NTU, which equates to a visibility of approximately 2 inches (5 centimeters [cm]) (WCC 1997). It is anticipated that increased turbidity due to dredging and spoils disposal will be temporary and cause minimal effects since naturally occurring events also increase the turbidity of marine waters annually (e.g., disturbance from ice, river runoff from spring break-up, and storm induced waves).

Operations and Maintenance

Vehicular traffic and maintenance of gravel roads, pads, airstrip, and dock surfaces could cause dust to enter freshwater and marine fish habitats. Watering of gravel surfaces, low traffic volumes during operations, and enforcement of vehicular speed limits should minimize the generation of dust from operations traffic and gravel maintenance activities on fish habitat. Potential effects from dust and sediment drift to freshwater and marine waters are anticipated to be minimal and within naturally occurring turbidity variation in the freshwater and marine environments (e.g., disturbance from ice, river runoff from spring break-up, and storm induced waves).

5.2.3.2 Disturbance Effects

"Blockage" of fish movement by a dock does not normally occur due to the physical structure, but is a result of hydrographic changes (i.e., alterations of the distribution of water mass properties such as temperature and salinity) that might be induced by the structures. Potential hydrographic changes are highly dependent upon the location of a dock and the nature of the surrounding environment. In stratified nearshore waters, a wake eddy can cause high salinity/low temperature water to displace the nearshore band of water on the lee side of a dock (see Section 5.1.3.1 of this ER for further discussion). Some fish species are unable or unwilling to swim through such higher salinity areas and are therefore "blocked" from migrating through or foraging in that area.

Prey availability is not thought to be a limiting factor for North Slope diadromous and marine fish; however, the biomass of prey species in North Slope coastal waters has a patchy distribution and is variable between years due to climatic conditions (Craig 1989 and Colonell and Gallaway 1990). Therefore, the variable net worth of feeding habitat along the coastline provides an impetus for the coastal distribution of foraging diadromous and marine fish (Fechhelm et al. 1989).

The summer movement patterns of diadromous fish in the North Slope coastal region are also strongly influenced by wind patterns during the brief open-water season (Moulton 1989). Fechhelm et al. (1989) observed that the eastward dispersal of Arctic and least cisco from the Colville River was dependent on the prevailing wind patterns. The fish traveled in conjunction with westerly winds eastward through the barrier island lagoons, the greater the percentage of westerly winds in a given season the farther the eastward migration. Easterly winds inhibited the eastward movement of younger fish, but did not materially affect adult Arctic cisco. Fechhelm et al. (1989) also noted that dispersal was related to size, with larger, more powerful fish traversing distances quicker than smaller fish.

During the 1999 Point Thomson fish survey, adult diadromous fish from spawning stocks in the Colville River and/or Sagavanirktok River were caught in Lions Lagoon (LGL 2000b). Large numbers of adult least cisco were collected in Lions Lagoon throughout the summer, adult broad whitefish were collected at comparable rates to those previously reported from Prudhoe and Mikkelsen Bays, and adult humpback whitefish were more abundant than expected based on previous studies conducted in Prudhoe and Mikkelsen Bays (LGL 2000b).

Persistent easterly winds are more important than west winds because they assist the westward movement of small Arctic cisco from the Mackenzie River to the Colville River; therefore, interannual easterly wind variability influences the size of each year-class. During a 1999 Point Thomson nearshore marine fish study, young-of-the-year (YOY) Arctic cisco were first collected at the southern end of Mary Sachs Entrance on 7 August after a period of sustained easterly winds switched to a period of mixed east/west winds (LGL 2000b). Young-of-the-year Arctic cisco were found dispersed through out Lions Lagoon for the remainder of the summer.

Colonell and Gallaway (1990) cited numerous tagged fish studies that show Dolly Varden char are powerful swimmers with widespread coastal dispersal exploit to a variety of habitats during their summer foraging. Dolly Varden char are not restricted to warm low-salinity environments. They have been taken as far as 10 mi (16 km) offshore in tow-net surveys and are known to feed on *Apheruisa glacialis* a marine amphipod that concentrates along the underside of floating icepans (Colonell and Gallaway 1990).

Lions Lagoon typically exhibits unstratified marine conditions from breakup to freeze-up (i.e., the water column is uniform from top to bottom). Brackish water conditions prevail in the spring in nearshore areas due to increased freshwater input from streams and rivers. Salinity of the nearshore water gradually increases to marine conditions by mid-September (Section 4.5.3.1 of this ER). The proposed dock would provide an alternative mechanism by which localized upwellings could occur but would not appreciably enhance naturally occurring upwellings. Because the water column within Lions Lagoon in the area of the proposed dock tends to be uniform, both horizontally and vertically, formation of a wake eddy would typically mix waters with similar temperature and salinity characteristics and thus renders no net changes to hydrography (see Section 5.1.3.1 discussion).

The principal source of food for diadromous fish in North Slope nearshore waters is demersal macroplankton, mainly mysids and amphipods, which in turn feed on marine phytoplankton (Craig et al. 1984). These plankton species are of marine origin, demonstrating the importance of marine productivity to the nearshore waters. The upwelling of marine waters into nearshore waters are thought to be the primary factor involved in maintaining the trophic richness of the coastal ecosystem along the North Slope (Colonell and Gallaway 1990). Two channels, Mary Sachs Entrance and at the east end of Flaxman Island, allow marine waters and associated planktonic species to enter Lions Lagoon. The proposed dock location is not likely to block or alter natural marine water upwelling processes or impair the trophic productivity of the nearshore waters.

Both West Dock and Endicott causeways cause localized hydrographic changes. However, there are no significant data indicating Endicott and West Dock causeways impair Arctic cisco YOY migration to rearing and overwintering areas in the Colville and Sagavanirktok Rivers (Moulton 1985, Colonell and Gallaway 1990, and Bickham et al. 1992). Environmental monitoring conducted from 1981 to 1984 at the West Dock Causeway and environmental surveys conducted from 1985 to 1989 at Endicott Causeway have not shown any evidence that Dolly Varden seasonal coastal dispersal is affected by the physical presence or by hydrographic conditions that develop around these structures (Colonell and Gallaway 1990). It is not anticipated that the Point

Thomson dock will disturb fish migrations patterns or cause diadromous or marine fish species to avoid or be displaced from the marine habitats they use in Lions Lagoon.

5.2.3.3 Mortality Effects

Winter water removal for ice road construction could potentially affect freshwater fish overwintering habitat in deep tundra lakes. Under-ice dissolved oxygen concentrations in lakes on the North Slope decrease over the winter. Excessive water withdrawal during the winter could adversely affect overwintering fish populations in deep tundra lakes. Recent water use permits for North Slope developments have limited winter water withdrawal to 15% under-ice water volume in fish bearing lakes to minimize the potential for significant impacts to overwintering fish. It is inferred that permitted water withdrawal volumes are conservative and protective of fish species. Therefore, it is not anticipated that water withdrawal from identified potential water sources (see Figure 3-19) will have adverse effects on overwintering freshwater fish.

Sport fishing conducted by personnel in area streams and rivers and from the marine dock could cause mortality due to direct take of fish species. All personnel will be required to comply with applicable ADF&G sport fishing regulations.

Contaminant spills associated with construction/drilling operations could affect freshwater, diadromous, or marine fish species. It is not anticipated that construction/drilling operations will be conducted near important freshwater fish habitat and diadromous and marine fish are not present in the area during the winter. Minor spills associated with winter construction and drilling activities (e.g., fuel, produced water, and other drilling wastes) can be readily contained and cleaned-up. Contaminant spills associated with operations and maintenance are also expected to be minor. Personnel will be trained in spill prevention and cleanup procedures. It is not anticipated that freshwater or marine fish habitat will suffer long-term adverse effects due to minor contaminant spills. Section 5.4 discusses the risks and impacts of condensate spills in detail.

5.2.4 Birds

Table 5-2 summarizes the potential impacts from the Point Thomson Gas Cycling Project on waterfowl and water birds, tundra-nesting species, and predatory birds.

5.2.4.1 Habitat Loss and Alteration

Loss and/or alteration of bird habitat can be either long-term (i.e., due to burial by gravel placement for roads, pads, and airstrip) or temporary. Temporary loss and alteration of bird habitats could result from ice roads, dust fallout, snow dumps, persistent snowdrifts, thermokarst, impoundments, and contaminants.

Gravel Placement

Gravel placement and gravel mine development for the Point Thomson project would cause long-term alteration of 9,832,544 ft^2 (0.9 km^2) of habitats used by birds (Table 5-3). Mine development and pad, road, and airstrip construction will occur during winter. The most affected vegetation types would be moist sedge, dwarf shrub tundra/wet sedge tundra complex, and moist sedge, dwarf shrub tundra, which together comprise 79% of the project footprint.

Important bird habitats in the Point Thomson area are primarily those containing wet tundra and those with aquatic (ponds/lakes) components that provide food, shelter, and escape cover from predators (water, aquatic graminoid tundra, water/tundra complex, wet sedge tundra, and wet sedge tundra/water complex). Gravel coverage for all these types combined accounts for 779,037 ft^2 (0.07 km^2), about 8% of total acreage affected by gravel coverage and mine development. Salt marsh is another important, but rarer, vegetation type in the Point Thomson area, and is used by brood-rearing geese (brant and snow geese) and shorebirds. Gravel coverage for the Point Thomson development would cause long-term alteration of 136,744 ft^2 (0.01 km^2) of salt marsh, about 1% of total gravel coverage.

Although most bird species in the region exhibit fidelity to nesting areas, studies in the Prudhoe Bay oil field indicated that most birds who lost nests sites to gravel placement were not prevented from nesting in subsequent years, but shifted their nesting efforts to adjacent, undisturbed habitats (Troy and Carpenter 1990 and Troy 2000). In general, the amount of habitat lost due to the Point Thomson project will be small relative to regional habitat abundance. The impacts of long-term habitat loss for birds are anticipated to be minor because nesting habitat is not thought to be a limiting factor.

Ice Roads

Ice roads will be used during winter pipeline construction, and potentially on an occasional basis for pipeline maintenance throughout the life of the project. Ice roads do not melt until after most bird species begin nesting (late May–early June), thereby reducing the availability of nesting sites. In addition, compaction of standing dead vegetation reduces cover needed by most birds for nesting sites. The effects of temporary losses of habitat due to ice roads for the Point Thomson project are anticipated to be minor, as displaced birds would likely nest in adjacent, unaffected habitats. In addition, the effect would be limited to the summer after construction.

Water Removal

Withdrawal of water from lakes could potentially alter wetland community structure by changing the hydrologic regime. A change in regime could potentially affect bird use of waterbodies as nesting areas or as brood-rearing habitat. The changes could alter plant and invertebrate community structures, potentially decreasing the value of habitats used by waterbirds for cover or food. Waterbirds that nest on small islands within tundra lakes could be affected if spring recharge is insufficient to compensate for water withdrawn the previous winter. Potential lakes identified for ice road construction water use are identified in Figure 3-19. As described in Section 5.1.2.3, these lakes will be permitted and permit stipulations will likely limit the amount of freshwater withdrawal. It is assumed that permitted water withdrawal limits are conservative and protective of affected waterbodies.

Obstruction of Flow

Impoundments can occur when drainage is impeded adjacent to roads or pads. Impoundments can be temporary, disappearing by mid-June, or they can persist through summer. Depending on the duration of seasonal impoundments, the effects on bird habitats can range from minor to substantial. Water impounded by gravel roads and pads both displaces and attracts birds, depending on the species (Troy 1986, Kertell and Howard 1992, Kertell 1993, 1994, and Noel et al. 1996). Temporary impoundments preclude nesting by some species (Walker et al. 1987) but may be used by others (e.g., Pacific loon [Kertell 2000]; geese, loons, eiders [Noel et al. 1996]).

Troy (1986) found that some shorebirds and Lapland longspurs avoided a 330-foot-wide zone along the West Road in Prudhoe Bay, whereas other shorebirds and snow buntings (this species nests in pipeline supports) preferred this zone (habitat use exceeded availability). These changes were attributed to temporary impoundments adjacent to the road, early availability of some habitats because of the "dust shadow" produced by traffic, and reduced habitat availability from persistent snow banks created by snow removal and drifting (Troy 1986). For the Point Thomson project, culverts will be placed during construction to prevent long-term impoundments adjacent to roads or pads. Additional culverts or other drainage structures could be installed after construction to drain any long-term impoundments that might form following initial gravel placement. Temporary impoundments probably could occur for brief periods (a week or less) during spring runoff, potentially affecting (both positively and negatively) shorebird and waterfowl use. Population level effects on birds are not anticipated to result from potential impoundments associated with the Point Thomson Gas Cycling Project.

Thermokarst

Thermokarst is a natural effect as well as a potential project effect that can alter the tundra landscape, including changes in microrelief and soil moisture. Changes due to thermokarst can result in increased diversity of wet, moist, and dry habitats or, if severe, can result in the creation of large, deep waterbodies. Many of the ecological changes associated with thermokarst may benefit plant productivity and wildlife use (Truett and Kertell 1992). Thermokarst has been shown to result in increased nutrient concentrations in plant tissue (Challinor and Gersper 1975, Chapin and Shaver 1981, Ebersole and Webber 1983, and Emers et al. 1995). Among birds in the Point Thomson area, geese are strictly herbivorous and selectively graze plants of higher nutritional value and are regularly observed grazing in thermokarst terrain adjacent to facilities. However, the effects of tundra disturbance on secondary production are uncertain (Truett and Kertell 1992). In one study of habitat use by birds, severely disturbed tundra associated with a peat road had higher use (in relation to availability) than most other undisturbed habitats in the Prudhoe Bay area (Murphy and Anderson 1993). Overall, however, data are insufficient to assess the potential effect of thermokarst on wildlife populations (Truett and Kertell 1992).

Dust Fallout

Advanced snowmelt as a result of dust fallout has both positive and negative effects on wildlife. Advanced snowmelt often impounds runoff and causes early "green-up" of plant species (Makihara 1983 and Walker and Everett 1987). The resulting open water and early plant growth attract waterfowl and ptarmigan to habitats near roads and pads (Walker and Everett 1987 and Murphy and Anderson 1993). In the Lisburne Development Area of the Prudhoe Bay oil field, the snow-free areas near roads supported large numbers of foraging geese and swans during pre-nesting, although the birds moved away from roads to rest and sleep (Murphy and Anderson 1993). Troy (1986 and 1988) noted that dust benefited shorebirds within 150 ft to 300 ft (46 m to 91 m) of roads when traffic was relatively light because it melted snow and made habitats available earlier for nesting. However, at higher traffic levels, disturbance offsets these benefits, resulting in lower densities of nesting shorebirds (Troy 1988).

Dust fallout associated with regrading and compacting of the gravel during the first summer construction phase will likely occur after spring thaw and will not affect snowmelt. Advanced snowmelt due to dust fallout adjacent to the roads, pads and airstrip could result from construction activities and infield traffic during operations. Watering the roads during the summer, and enforcing vehicular speed limits at all times will mitigate potential impacts from dust fallout.

Snow Dumps and Snowdrifts

Snow dumps and snowdrifts adjacent to pads or roads that persist into the breeding season could displace nesting birds and may have other long-term effects on habitat quality for birds. Since large accumulations of snow are not anticipated for the region, the areas potentially affected by snow dumps and snowdrifts associated with the Point Thomson project are anticipated to be small (see Section 5.2.2.1). In addition, mitigation measures such as ensuring that the snow is stored on the gravel surface as much as possible and relocating snow dump areas from year to year will minimize any impacts on nesting habitat. In addition, because nesting habitat is not a limiting factor, population-level effects on birds are not anticipated.

Spills and Leaks

Contaminant spills and cleanup efforts can alter bird habitats in various ways. However, the most common spills are relatively small in quantity and affect small areas of tundra. The Point Thomson project is not anticipated to result in population-level effects attributable to habitat alteration by small contaminant spills. Impacts from large spills are considered in detail in Section 5.4.

5.2.4.2 Disturbance Effects

Potential disturbance effects include immediate behavioral responses of affected animals (including energetic or other costs associated with startle or fleeing responses), loss of habitats or degradation of habitat quality (by causing avoidance), and attraction of some species to areas of human activity (particularly predators/scavengers).

Winter Construction

Winter construction activities will occur from January to April for two seasons and will include ice road construction, gravel mining, gravel placement for roads, pads, airstrip, and dock, and pipeline installation. Because most birds are absent during winter months, these activities are unlikely to cause disturbance effects for most species.

Summer Construction

Summer construction activities planned for the Point Thomson project include grading and reshaping road, pad, airstrip, and dock surfaces, a nearshore dredging operation, and installing the modules. The majority of this activity will take place from mid-July to mid-August. During summer, it is likely that several helicopter and airplane trips from Endicott/Prudhoe will be employed each day for equipment and personnel transport. Vessels from Endicott/Prudhoe will be used to support summer construction, also from Endicott/Prudhoe. The dredging operation could employ one or two 12-in (30.5 cm) suction dredges operating in the nearshore area for several weeks, and barge trips to deeper waters to dispose of dredge spoils. One sealift (with approximately three barges) will transport large CPF modules to the Point Thomson Dock after dredging is accomplished. Vehicle traffic will occur on the infield roads as construction on the roads is completed. During summer facilities construction and installation activities, several trips per day can be expected on the infield gravel roads between the pads. Noise from these activities and the physical presence of the equipment both onshore and offshore, could disturb birds in the Point Thomson area.

Any turbidity plume resulting from dredging operations could have impacts on birds foraging or loafing in the nearshore waters affected by the plume. For example, long-tailed ducks occur in the nearshore waters near Point Thomson during the molting and post-molting periods (mid July-mid September; see Figure 4-4) and commonly feed on benthic invertebrates that may be temporarily unavailable if covered by a plume from dredging. Noise and visual disturbance from the dredging operation itself may temporarily displace birds from the area and reduce impacts of the plume on foraging.

The behavioral responses of birds to disturbance by construction and operations activities are well documented for existing oil fields (WCC 1985, Hampton and Joyce 1985, Troy 1986 and 1988, Anderson 1992, Anderson et al. 1992, Burgess and Rose 1993, and Murphy and Anderson 1993). Birds can be sensitive to noise disturbance during any life history stage. However, during nesting, birds are restricted to one site for 2 to 4 weeks, and disturbance during this period can lead to nest failure. The earliest nesting birds (waterfowl and loons) typically initiate nests sometime after 1 June, and all but a few species hatch by 15 July. Therefore, during this period the consequences of behavioral disturbance of birds may be most severe (i.e., loss of productivity). Following nesting, many birds typically move from nest sites to other locations and different habitats, and are generally capable of moving away from disturbance sources (e.g., airstrips or roads), if necessary.

Vehicles are the most ubiquitous source of oil field disturbance, but cause less severe reactions in birds than many other common disturbances, including humans on foot or predators (foxes or gulls). In general, the frequency of bird reactions to vehicles increases with traffic rate, although at higher traffic rates animals may become habituated and react to fewer individual vehicles. Even at higher traffic levels, reaction rates remain high to particularly large, noisy vehicles, and those with unusual profiles, such as boom cranes.

Reactions to traffic vary during the breeding season. In the Lisburne Development Area, birds reacted to vehicles most frequently during brood-rearing, but the strongest reactions were observed during pre-nesting, when birds were attracted close to roads by early snow-melt and green-up (Murphy and Anderson 1993). Most reactions by geese and swans occurred within 500 ft to 700 ft (152 m to 213 m) of roads and pads in the Lisburne area (Murphy and Anderson 1993). Approximately 10% of all vehicle passes elicited reactions from geese and swans (Murphy and Anderson 1993 and ABR, Inc. unpublished data). Birds reacting to vehicles primarily displayed brief alert (head-up) behavior, with a small proportion of birds walking, running, or (rarely) flying (Murphy and Anderson 1993).

Based on these findings, a small percentage of birds likely could show short-term alterations in their behavior. Minor effects on nesting success from Point Thomson project-related disturbance within 700 ft (213 m) of drilling pads (10,925,007 ft^2 [1 km^2]) and within 500 ft (152 m) (90,306,836 ft^2 [8.6 km^2]) of gravel access roads is also possible. Disturbance would be highest during construction, when traffic rates would be higher and larger, noisy vehicles would be more likely to use the infield roads. However, the majority of the construction activities involving ice road construction and gravel hauling and placement will take place in the winter when many of the bird species are not expected to be in the area.

Air traffic associated with the Point Thomson project also could result in behavioral disturbance of birds. Noise levels and potential for disturbance would be highest during takeoffs by large aircraft and helicopters. Based on United States Air Force data (OMEGA 10.8 noise model; Mohlman 1996 personal communication), the area affected by the highest noise levels during takeoff by a Boeing 737-200 (an aircraft that could use the Point Thomson airstrip) can be approximated by a zone extending to 6,300 ft (1,920 m) around the runway (193,888,526 ft^2 [18.4 km^2]), within which noise levels could reach or exceed 85 decibels (A-scale weighting, or dBA) as the engines reach maximum power. Noise levels during landings would be substantially lower than during takeoffs, although the aircraft would be at lower altitudes through a longer approach to the airstrip.

The effects of large fixed-wing aircraft on wildlife have not been thoroughly studied in the Arctic. Most studies of aircraft disturbance in the Arctic have focused instead on low-flying helicopters (LGL 1974, Barry and Spencer 1976, Simpson et al. 1980, and Derksen et al. 1992). Some waterbirds show startle responses to landings and take-offs by Boeing 737s near the Prudhoe Bay and Kuparuk airports, but responses are of short duration and the birds using the area appear to have habituated to the disturbance (ABR, Inc. unpublished data). In the Lisburne Development Area, birds were less habituated to infrequent disturbances than to constant (steady-state) disturbances (Murphy and Anderson 1993). Investigation of impacts of the airstrip at the Alpine Development Project suggests that nesting birds have not been negatively affected to a substantial degree (Johnson et al. 1999b and 2000). Preliminary results suggest that although nest densities varied annually, they did not decline with increasing levels of activity, and the distance of nests from the airstrip during two years of construction did not change from that observed during the pre-construction years. Nest densities were lower within 3,280 ft (1,000 m) of the airstrip as compared to greater distances, but no comparisons were available to indicate if this pattern existed prior to construction. Distance from the airstrip did not have a significant effect on nesting success, although it may have affected nest attentiveness. Birds in areas subjected to regular disturbance by aircraft exhibited habituation, with reduced frequency and intensity of reaction over time.

The siting of the Point Thomson airstrip could result in flight patterns over the offshore lagoon area that is used by thousands of molting and feeding birds during July–September (Noel et al. 2000 and Flint et al. 2001). Disturbance of molting long-tailed ducks, common eiders, and other birds in the lagoon may result from aircraft (particularly larger, noisier types) landing or taking-off from the airstrip and subsequently flying over the lagoon and offshore islands. Little information is available on the effects of aircraft on molting long-tailed ducks, but Petersen et al. (1999) found that flocks along barrier islands scattered and dove in response to high levels of disturbance such as low flying aircraft or boats within 0.6 mi (1 km). At Point Thomson, aircraft traffic is anticipated to be greater during winter construction efforts as compared to summer construction and the operations and maintenance phase. Project-related air traffic would be unlikely to measurably reduce nest abundance or nest success of birds near the airstrip.

Marine traffic at the proposed Point Thomson dock facility could disturb birds in lagoon and nearshore waters. Dock use and marine traffic would occur primarily during late summer (August–September). Marine traffic could have the greatest potential to disturb birds when long-tailed ducks and other ducks are most abundant in the lagoon, between approximately 20 July and 30 September (Noel et al. 2000). Dredging operations as described above could occur from the end of July to mid-August, increasing the potential for disturbance to the ducks. Petersen et al. (1999) found that long-tailed ducks were disturbed (dove or scattered) by boats approaching within 0.6 mi (1 km), but often returned to the same area after the disturbance had passed.

Operations

Operation of the Point Thomson Gas Cycling facility could require a few helicopter trips per week from Prudhoe Bay, and daily by other aircraft. During the open water season about four to five local barge trips can be expected annually. Several vehicle trips on infield roads between pads per day would likely occur during normal operations. Levels and duration of noise from operations equipment (such as compressors generators, and flares) proposed for the Point Thomson project have not yet been characterized, but could be a disturbance concern for birds in the area. Birds that are attracted to camp facilities could also be affected.

During operations, a consequence of both traffic disturbance and increased noise levels is that areas located adjacent to roads, airstrips, or pads could become less attractive, and therefore would be avoided by birds. For some species, high noise levels (e.g., near compression modules) could cause a long-term reduction of bird use in the immediate areas of constant disturbance. Early studies of noise effects on birds in the Arctic found that simulated compressor noise did not affect nesting Lapland longspurs (Gollop et al. 1974), but it decreased habitat use by fall-staging snow geese (Gollop and Davis 1974). More recently, increased noise at the Central Compressor Plant in the Prudhoe Bay oil field caused some water-bird species (spectacled eiders, pre-nesting Canada geese, brood-rearing tundra swans) to shift their distribution (averaging 1,600 ft to 2,000 ft [487 m to 610 m]) away from habitats close to the compressor plant, although most waterfowl species (including nesting Canada geese, brant, greater white-fronted geese, loons, ducks) habituated to the noise levels (Anderson et al. 1992). Wildlife near a new processing facility (CPF-3) in the Kuparuk oil field showed variable responses to disturbance (Hampton and Joyce 1985). Although nesting by waterfowl was significantly lower within 0.5 miles (mi) (0.8 km) of the facility, a brant nesting colony located approximately 0.5 mi (0.8 km) away has not been affected adversely by the constant noise emanating from the facility; the nesting colony has been used continuously since facility operation began (Stickney et al. 1994 and Anderson et al. 1995 and 1996). These studies suggest that some birds may be displaced from the immediate area, within 0.5 mi (0.8 km) surrounding the Point Thomson facilities. In general, the size of the displacement area will depend on the species and the nature of the noise generated by the facilities.

During operations, the marine dock facility at Point Thomson could displace molting long-tailed ducks, and perhaps other birds, that regularly use that area during late summer (Noel et al. 1999a and 2000). Noel et al. (1999a and 2000) found a mean numbers of between 1000 and 1400 long-tailed ducks in the Point Thomson area during aerial surveys along the coast in 1998 and 1999. Displacement of birds in late summer could be highest when boat traffic or Sealift operations are occurring. However, it is not known whether such displacement would be long-term.

Glaucous gulls and common ravens are attracted to garbage and food handouts at human settlements and camps. Although adequate historical records are lacking, biologists generally agree that the populations of these two species have increased because of the availability of these foods from the North Slope oil field operations. Ravens and some raptors are now known to nest on buildings (particularly ravens on processing facilities) and other structures in the existing oil fields, including elevated pipelines (Ritchie 1991 and ABR, Inc., unpublished data). Raptors, gulls, ravens, ptarmigan, songbirds, and shorebirds all perch on elevated pipelines, and snow buntings nest in VSM supports and buildings. The presence of the Point Thomson facilities may cause minor increases in populations of scavenging birds, if any edible garbage is available at the facility. Snow buntings, raptors, and ravens may nest or roost on new buildings and pipelines built for the Point Thomson Gas Cycling Project. Proper handling and disposal of camp solid wastes will serve to partially mitigate the attraction factor.

5.2.4.3 Mortality Effects

Strikes by vehicles (trucks and aircraft) and collisions with structures pose some risk to birds in the Point Thomson area. The risk of vehicle strikes is greatest during summer, when larger numbers of birds move into the area. Herbivores, such as geese and ptarmigan, can be attracted to roadside habitats by early green-up and higher nutrient forage. Although these animals gain access to nutritious forage, their exposure to traffic-related disturbance and risk of vehicle strikes also increases. Vehicle-caused mortality is poorly documented for the Kuparuk and Prudhoe Bay oil fields; however, the number of animals injured or killed by vehicles is thought to be low.

Waterfowl and other birds occasionally collide with oil field structures, including buildings and towers, guy-wires for antennas, and power poles and wires. Bird strikes are most common in areas where large numbers of birds aggregate or pass during migration, such as points of land along the coast, or lagoon molting areas. The incidence of bird strikes also increases during periods of low visibility due to fog or darkness. Anderson and Murphy (1988) studied bird strikes with powerlines in the Lisburne Development Area in Prudhoe Bay and found that most collisions apparently occurred under conditions when visibility was limited. Species in the Point Thomson area that could experience strikes with project facilities include long-tailed duck, common eider, and brant, all of which would be abundant in the area during molting or migration periods. Other species of waterfowl and shorebirds that migrate primarily along the coast could also be subject to occasional strikes. It is difficult to predict the likelihood of bird strikes at a particular site without having detailed knowledge of local bird movements. Although this information is lacking for Point Thomson sites, there is little potential for bird strikes to have population-level consequences for most species in the area. Mitigation measures to reduce bird strikes could include using a color scheme for the buildings and modules that allows them to stand out from the surrounding terrain or be more visible during foggy conditions. However, this measure is at odds with the potential need to reduce visual impacts of the facility for recreational users of the area (see Section 5.3.).

Mortality for birds, particularly during the flightless stage, could occur in the immediate vicinity of the flare. It is not known at this time how significant the heat increase at the base of the 100 ft (30 m) structure will be during flaring events. However, because the area immediately beneath the flare will be fenced, mortality of or injury to flightless or molting birds is unlikely. Flaring will be a relatively rare event and noise associated with the flaring will serve to keep birds with flight ability away from the area during an event.

Contaminant spills also have the potential to result in bird mortality. Contaminants can adversely affect birds through dermal contact, dermal absorption, ingestion, and inhalation. Dermal contact can affect the ability of feathers to insulate or to shed water. For small spills, the chance that birds would be oiled is limited due to the size of the spill, but seasonal timing of spill events and location relative to high-use habitats may increase chances that birds will contact spilled oil or petroleum products. The most common oil field spills (small volume spills of fuels and vehicle/machinery lubricants) are unlikely to have population-level impacts on birds. Impacts from large spills are considered in detail in Section 5.4.

Increased predator populations in the vicinity of oil field developments may increase predation on bird populations (Martin 1997). This impact is inferred from the higher numbers and productivity of foxes (Eberhardt et al. 1982, Burgess et al. 1993, and Burgess 2000), grizzly bears (Shideler and Hechtel 1995b and 2000), and gulls and ravens (Truett et al. 1997 and Day 1998) in the North Slope oil fields. Gulls, ravens, and foxes prey on bird eggs and young, and foxes can also take adult birds. Bears have been known to take bird eggs. Foxes and grizzly bears often cause the complete failure of goose colonies during some breeding seasons in the North Slope oil fields (Burgess and Rose 1993, Burgess et al. 1993, Stickney et al.1993, Johnson 1994 and 2000, and Noel and Johnson 2001a and 2001b). Failure of the Howe Island snow goose and brant colony in six of the last ten years has been attributed to the increased abundance of Arctic foxes and bears in the region (Noel and Johnson 2001a and 2001b). Common eiders are the most abundant colonial nesting species in the Point Thomson area and exhibit susceptibility to Arctic fox predation during nesting (Quinlan and Lehnhausen 1982).

It is anticipated that refuse control efforts, employee environmental sensitivity training, and enforced rules against animal feeding would minimize population-level effects on predators and scavengers, and avoid the potential for these animals to negatively affect populations of birds in the Point Thomson area.

5.2.5 Marine Mammals

Marine mammals that may be encountered at various times of the year in the Point Thomson area include cetaceans (whales), pinnipeds (seals) and polar bears (see Section 4.10). The following sections describe the potential impacts of winter and summer construction efforts and operations activities on the habitat, disturbance, and mortality of these mammals. The potential impacts are summarized in Table 5-2.

5.2.5.1 Habitat Effects

Long-term habitat effects (loss or alteration) on marine mammals are not expected due to winter or summer construction activities associated with the Point Thomson Gas Cycling Project. Increased turbidity from placement of gravel fill at the dock site is expected to be short-term. Habitat or denning sites for polar bears will not be impacted since the construction activities will avoid any active dens.

Short term alteration of the marine habitat from winter and summer construction and traffic noise is discussed as disturbance to marine mammals (see Section 5.2.5.2) rather than as a habitat effect. Impacts of operations on marine mammals are also expected to be related to disturbance. These impacts are discussed in the following sections.

5.2.5.2 Disturbance Effects

Winter Construction

The ringed seal is the principal pinniped species present in the region and the only one that would be expected in Lions Lagoon during the winter. Polar bears are known to den on land during the winter months in the project area. Cetaceans, including bowhead, beluga, and gray whales, will not be within the proposed project area during winter and, consequently, will not be affected by the winter construction efforts.

Disturbance to marine mammals present in Lions Lagoon and adjacent onshore areas (polar bears) during winter construction periods will likely occur due to noise from construction activities, drilling, aircraft and helicopter over-flights, and vehicle movement along sea ice roads. Construction activities that will generate noise include gravel extraction at the preferred gravel mine site, placement of gravel to construct roads, pads, and the airstrip, and placement of gravel fill in the nearshore area to build the Point Thomson dock. Increased suspended sediments under the ice from the dock construction probably will not affect marine mammals, which commonly inhabit turbid waters (Richardson et al. 1989). Therefore, the main concern is disturbance due to construction-related noise and activities.

Winter construction will occur from January to April for two seasons, with up to 450 people working with heavy equipment at any given time during this period (see Section 3.0). During winter construction and drilling efforts, numerous vehicle trips per day could take place on the sea ice road from Prudhoe/Endicott to the Point Thomson area. In addition, several helicopter and other aircraft trips could be required each day to support construction activities.

Pinnipeds

In winter and spring, ringed seals frequent land-fast ice and offshore pack ice. The highest densities of seals are usually found on stable shore-fast ice. Ringed seals maintain breathing holes throughout the winter in ice up to 6 ft (1.8 m) thick and dig multiple haul-out shelters and nursery lairs beneath the snow (Kelly 1988). It is possible that construction activities could impact individual seals using the area at the dock construction site. Pupping occurs in the spring, and it is unlikely that birthing lairs would be established by the time construction begins. The most likely impact to seals in the area would be displacement to other areas of shore-fast ice. Inupiat hunters continually stress that all marine mammals are sensitive to noise, and are careful to make as little extraneous noise as possible when hunting. Seals are also said to be cautious of any unusual visual stimulus, especially if the stimulus 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, 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 a qualified measure of this sensitivity to noise and other disturbance.

Seal reactions to construction activities are related to the noise of construction activities. Greene (1983) studied the underwater noise produced during construction of Seal Island. The island was built in 40-ft (12-m) of water compared to 0 to 12 ft (0 to 4 m) of water for the Point Thomson dock. He found that at 2.2 mi (3.6 km) from the Seal Island construction site, there was no evidence of propagation of noise components above 1000 Hertz (Hz), and little propagation of components below 1000 Hz (Greene 1983). Sea ice road construction in waters over 40 ft (12

m) deep produced potentially detectable low-frequency (<200 Hz) underwater noise as far as 2,624 ft (800 m) from the source (Greene 1983). Others have found that sound, especially at low frequencies, attenuates rapidly in shallow nearshore waters (Mi et al. 1987; Section 4.4 in Richardson et al. 1985). Thus, winter construction sounds only propagate a short distance waters as shallow as those at Seal Island (40 ft [12 m]), and would propagate even less well in the nearshore zone at the proposed site of the Point Thomson dock.

The ability of seals and other marine mammals to detect anthropogenic noise is influenced by natural background (ambient) noise levels. Ambient noise is influenced by sea surface noise associated with waves (Fairbridge 1966). Some limited measurements of ambient noise under the ice near the Liberty Development were obtained during February 1997 (Greene 1997). Noise levels as measured were well below the reference values for zero sea state at all frequencies between 25 Hz and 5000 Hz. This is typical for an area of stable fast ice. As one would expect, background noise, as influenced by sea state, is minimal under the ice.

The hearing abilities of these mammals are another factor affecting their potential responses to anthropogenic noise. The hearing abilities of ringed seals have not been measured at frequencies below 1 kiloHertz (kHz) (Terhune and Ronald 1975). Based on data from harbor seals, hearing sensitivity is expected to deteriorate with decreasing frequency to a threshold of about 96 decibels (dB) re 1 micro Pascal (μPa) at 100 Hz (Kastak and Schusterman 1995 and 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.

Green and Johnson (1983) found that seals apparently were displaced from the area within a few mi of Seal Island during the island construction in the winter of 1981-1982. Frost and Lowry (1988) similarly found seals avoiding areas within 2.3 mi (3.7 km) of artificial islands, and that avoidance was stronger, a 50 to 70 percent reduction in seal density, when island activity was high. However, more recent data described in LGL and Greeneridge (2001) showed that the construction of Northstar Island pipeline corridor and ice roads in late 19991 and early 2000 did not significantly affected the distribution or abundance of ringed seals. Seal densities in areas close to the Northstar development were similar to those found in non-construction impacted areas.

Since most of the Point Thomson construction effort is located on shore, there should be even less disturbance to seals from this project. Any minor displacements that occur as the dock is being constructed and dredged localized and short term. Overall effects on ringed seals from dock construction will likely be minor.

Polar Bears

Polar bear dens have been identified in the project area in the past (see Section 4.10.3). Females are occasionally found on land during the winter denning season. Construction and drilling activities can cause short-duration (one-or two seasons), but intense disturbances for polar bears denning near the center of activity. However, Amstrup (1993) found that 10 of 12 polar bears tolerated exposure to a variety of disturbance activities with no apparent effect on productivity. Polar bears may be more apt to abandon dens in response to disturbance early in the denning period (Amstrup 1993). Abandonment late in the denning period could have a greater impact. Amstrup and Gardner (1994) found that survival was poor for cubs that left dens prematurely due to movement of sea ice. It is apparently less costly for a bear seeking a den site to find an alternate location than for the bear to abandon a den and establish a new one elsewhere. Amstrup (1993) suggested that initiation of intense human activities during the period when polar bears seek den sites (October– November) could give bears the opportunity to choose less disturbed locations. All known areas of specific denning activity by polar bears have been avoided during design and siting of the project facilities and planned ice road routes.

Polar bears are thought to avoid loud noise sources, although there is no evidence that noise associated with construction or operations disturbs polar bears. Stirling (1988) reports that polar bears have commonly approached industrial sites in the Canadian Beaufort Sea region. Human/polar bear encounters have the potential to cause injury to both sides. Polar bears are curious and opportunistic hunters that have been known to approach facilities in search of food. As with grizzly bears and foxes, 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. All activities associated with polar bears in the region will be coordinated with the U.S. Fish and Wildlife Service (USFWS) and the ADF&G. Upon issuance of a Letter of Authorization from the USFWS, trained personnel have authority under Section 112(c) of the Marine Mammal Protection Act to haze/take polar bears under certain circumstances involving the protection of life.

Summer Construction

As described for winter construction, disturbance to marine mammals present in Lions Lagoon during summer construction periods will likely occur due to noise from construction activities, helicopter and fixed-wing aircraft overflights, and vessel movement in the nearshore and offshore areas. During summer, daily helicopter and other aircraft trips may be employed each day for personnel and equipment transport. Marine vessels will also be used to support summer construction throughout the open water construction season from Prudhoe Bay or Endicott. One sealift (two to three barges) will transport production and other modules to the Point Thomson area. Vehicle traffic will take place on the infield roads as construction on the roads is completed. During summer facilities construction and installation activities, daily vehicle trips can be expected on the infield gravel roads between the pads.

An open water dredging operation to create a 1,000 ft by 400 ft by up to 2 ft deep channel will take place off of the end of the marine dock. The dredging will be conducted using one or two 10 to 12 inch (25 to 30 cm) suction dredges. Barges will be used to transport spoils to an offshore permitted location. The dredging activity will likely begin as early as mid-July and could last until mid-August. The dredging and dumping of spoils must be completed by late summer to avoid any impacts to the fall bowhead whale migration.

Cetaceans

Spring migration of bowhead and beluga whales through the Western Beaufort Sea occurs from April to June at a considerable distance north of the barrier islands. Fall migration for bowheads begins in early to mid September, and a few bowheads could be expected to be offshore of Point Thomson as early as late August. Beluga whales are rarely seen offshore of Point Thomson in the summer. During their fall migration, small numbers of beluga whales could move into waters offshore of the project area. Details concerning the presence of these whales in the area can be found in Section 4.10.1 of this ER.

Whales are particularly sensitive to noise. Hunters stalking these mammals avoid making any sort of extraneous noise, and the loud and relatively constant noises associated with boat and air transport can cause whales (and other marine mammals) to avoid areas where such noise is audible to them. Dredging and re-grading of the dock and onshore summer construction activities (see Section 3.0) will generate noise during one season, but the sounds should not propagate far offshore due to the shallow waters of Lions Lagoon (see Section 5.2.5.2.1). The barrier islands that lie between the lagoon and the migration corridor used by the great majority of whales will also serve to block noise. In addition, LGL Greeneridge (2001) found that airborne sounds were not consistently detectable as far away as underwater sounds. The presence of boats near Northstar Island had the largest impact on the level of man-made underwater noise potentially perceivable to whales (LGL and Greeneridge 2001). For example, sounds from self-propelled barges were limited in frequency range but were faintly detected as far as 15 nautical miles (28 km) north of the island.

Therefore, while whales are sensitive to noise, they are either not expected to be found in the area during the majority of the summer construction and transportation efforts, or the majority of noise from these efforts is not likely to propagate to the whales' offshore migration corridor. Dredging activities and vessel movements outside of the barrier islands will be curtailed after September 1 so as not to impact the fall migration.

Pinnipeds

Disturbance to seals during summer construction will be similar to that discussed above for winter construction activities. However, other species of seal such as spotted and bearded seals could be present in Lions Lagoon during the summer months, and at higher densities. The nearshore dredging operation, along with vessel and air traffic does have the potential to disturb seals in the lagoon. Mitigation measures for vessels such as avoiding haul-out areas and limiting helicopter flights to routes over land can be enacted during summer construction. However, mitigation may not be possible for the dredging operations, and localized displacement of the seals is possible. Since this operation is short-term (about 1 month), population impacts are not expected. Additional mitigation measures are described below for operations and in Section 6.0.

Polar Bears

In the summer, polar bears will be casual visitors to the study area. Females with cubs and subadult males may come ashore for short periods of time. In the fall while open water is still found in the lagoon, polar bears moving along the barrier islands from the Canadian Arctic could be encountered on or near Flaxman Island. These bears could swim to onshore areas at Point Thomson, particularly if attracted by cooking odors or other human activities. As the pack ice recedes from coastal areas, polar bears for the most part move north with the ice where they remain offshore with the drifting ice during the summer months. Therefore, no impacts from summer construction are expected.

Operations

The majority of effects from Point Thomson operations and production activities on marine mammals will be in response to underwater and airborne noise. Operation of the facility will require transportation to the area by vessel and aircraft. In addition, the compressors, flares, and other equipment associated with condensate production will produce noise that could disturb marine mammals in the area.

Operation of the Point Thomson Gas Cycling facility could require a few helicopter trips per week and daily trips by other aircraft, from Prudhoe Bay. At present, an annual sea ice road to the facility is not planned once construction is completed. There will be daily trips by vehicles on the infield roads to each of the well pads during operations. During the open water season, annual barge trips can be expected. Levels and duration of noise from operations equipment (such as compressors, generators, and flares) would be expected to be similar to levels currently experience at Endicott where similar facilities are in operation. Impacts to deeper water should be even less then Endicott since Point Thomson facilities are located on shore and inland behind a barrier island and lagoon system.

Effects of operations of the proposed project and associated transportation on seals are expected to be limited to short-term and localized behavioral reactions by a small number of seals. Aircraft will avoid flying within 2 mi (3.2 km) of any identified spotted seal haul-out sites in or near the proposed project to mitigate potential effects of aircraft on these highly sensitive species. Overall, operations effects on individual seals or their populations will not be significant.

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. A polar bear interaction plan using the MMS guidelines for operation within polar bear habitats can be implemented if necessary (Truett 1993 and BPXA 1993a). All activities associated with polar bears in the region will be coordinated with the USFWS and the ADF&G. Trained personnel have authority under Section 112(c) of the Marine Mammal Protection Act to haze/take polar bears under certain circumstances involving the protection of life. This requires project-specific authorization from the USFWS.

The project will be operated in compliance with all applicable permits and regulations, which will further assure that the likelihood that impacts will occur to the species, stocks, and subsistence users of the species or stocks is minimized. During the summer, all helicopter operations will be conducted over land, to the extent practicable. If any spotted seal haul-out sites are identified, air traffic will be instructed to avoid these sites. As appropriate, activities will be coordinated with the relevant federal and state agencies (particularly the National Marine Fisheries Service, USFWS, National Biological Service, and ADF&G), 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).

Potential non-acoustic project related effects on marine mammals 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. Impacts from large spills are considered in detail in Section 5.4.

Effects of the proposed project operations and associated transportation on bowhead whales are expected to be minimal. Additional information concerning bowheads is provided in Section 5.2.7, Threatened and Endangered Species.

5.2.5.3 Mortality Effects

Mortality effects on marine mammals could be either direct due to construction or operations activities, or indirect due to attraction to predators that could then reduce populations of resident marine mammals. For the marine mammals expected in the Point Thomson area, only direct mortality of polar bears is possible. Hunting of seals, polar bear, and whales by project personnel will not be permitted. Vessels will avoid the presence of seals in the water; therefore, mortality due to collisions will be negligible.

Should a polar bear encounter occur, it may become necessary to kill a threatening bear. This is most feasible during winter construction and operations since polar bears are not likely to be in the area during the summer. Mitigation measures such as avoidance of known polar bear denning areas and managing wastes will help to reduce the possibility of this effect.

Regardless of the mitigation efforts, mortality to marine mammals may occur during project operation. Operations will be conducted under small take provisions, including either (1) Incidental Harassment Authorizations (IHA) 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.

5.2.6 Terrestrial Mammals

Table 5-2 summarizes the potential impacts of the project on terrestrial mammals. Impacts due to habitat loss and alteration, disturbance, and mortality have been identified and are discussed in the following sections.

5.2.6.1 Habitat Loss and Alteration

Impacts to habitats used by terrestrial mammals can be either long-term (i.e., burial by gravel placed for roads, pads, and airstrip) or temporary. Temporary loss and alteration of terrestrial mammal habitats could result from ice roads, dust fallout, snow dumps, persistent snowdrifts, thermokarst, impoundments, and contaminants.

Gravel Mining and Placement

Gravel mine development and pad and road construction will occur during winter. Gravel placement and gravel mine development will cause long-term alteration of 9,404,666 ft^2 (873,693 m^2) of habitats used by terrestrial mammals, excluding open water (Table 5-3). Vegetation types that will be most affected by construction are moist sedge, dwarf shrub tundra/wet sedge tundra complex, and moist sedge, dwarf shrub tundra (together comprising 79% of the project footprint). Although these are important habitats for some mammal species (including caribou and lemmings), they are also the most abundant habitats in the Point Thomson area. Riparian habitats that are used particularly by moose, muskox, and grizzly bears comprise less than 1% of the project footprint (dry barren /dwarf shrub, forb grass complex; dry barren/forb complex; and river gravels; see Table 5-3). Dry upland sites that are important to ground squirrels and denning Arctic foxes comprise less than 4% of the project footprint (dry dwarf shrub, crustose lichen tundra; dry dwarf shrub, fruticose lichen tundra; dry barren/dwarf shrub, forb grass complex; dry barren/ forb complex; dry barren/dwarf shrub, grass complex; and river gravels). In general, for all vegetation types affected the amount of habitat loss would be small relative to abundance in the Point Thomson area. In addition, the displacement of terrestrial mammals, such as caribou, due to loss of habitat does not coincide with any negative impact on population/growth rates and it does not appear to be absolute, as is evidenced by the sustained use of even the most heavily developed oil field areas (Maki 1992). Therefore, effects of long-term habitat loss due to gravel mine development and gravel road and pad construction for terrestrial mammals are anticipated to be minor.

Ice Roads

Onshore ice roads will be used during winter pipeline construction. Effects of ice roads on vegetation could include broken and abraded willows and mortality of lichens, both of which may have adverse consequences for terrestrial mammals. Shrub habitats are important for collared lemmings, voles, and large mammals such as moose, muskoxen, and caribou. However, the use of ice roads during winter pipeline construction is anticipated to have minimal impacts on terrestrial mammals because of the small area affected.

Obstruction of Flow

Impoundments can occur when drainage is impeded adjacent to roads or pads. Impoundments can be temporary, disappearing by mid-June, or persist through summer. Depending on the duration of seasonal impoundments, effects on terrestrial mammal habitats range from minor to substantial. Water impounded by gravel roads and pads can displace resident small mammals and inhibit grazing by large herbivores. For the Point Thomson project, culverts will be placed during construction to prevent the formation of long-term impoundments adjacent to roads or pads. Additional culverts or other drainage structures could be installed after construction to drain any long-term impoundments that might form following initial gravel placement. Therefore, potential effects due to the formation of impoundments associated with gravel roads and pads is anticipated to be minimal.

Thermokarst

As described previously, thermokarst is a natural effect as well as a potential project effect that can change the tundra landscape by creating changes in microrelief and soil moisture. Changes due to thermokarst can result in increased diversity of wet, moist, and dry habitats or, if severe, can result in the creation of large, deep waterbodies. Many of the ecological changes associated with thermokarst may benefit plant productivity and wildlife use (Truett and Kertell 1992). Thermokarst has been shown to result in increased nutrient concentrations in plant tissue (Challinor and Gersper 1975; Chapin and Shaver 1981; Ebersole and Webber 1983; Emers et al. 1995). Lemmings and caribou are the most abundant herbivorous mammals in the Point Thomson area, and both species groups may benefit from the availability of grazing plants with higher nutritional value (McKendrick 1981). However, the effects of tundra disturbance on secondary production are uncertain, and data are insufficient to assess the net effect of thermokarst on wildlife populations (Truett and Kertell 1992).

Dust Fallout

Advanced snowmelt due to dust fallout can have both positive and negative effects on terrestrial mammals. Advanced snowmelt along gravel roads often impounds runoff and causes early "green-up" of plant species (Makihara 1983 and Walker and Everett 1987), attracting caribou prior to calving (Lawhead and Cameron 1988).

Gravel roads, pads, and the airport runway will be regraded and compacted during the first summer construction phase. Regrading and compacting activities will occur after spring thaw has begun; therefore, associated dust fallout will not affect snowmelt.

During operations, early snowmelt due to dust fallout could attract some terrestrial mammals in the spring. Low anticipated traffic volumes during operations and dust control measures (e.g., watering of roads) and enforced traffic speed limits should minimize the effects of early snowmelt due to dust fallout.

Snow Dumps and Snowdrifts

Snow dumps and snowdrifts adjacent to pads or roads could displace small mammals and have localized effects on vegetation due to delayed snow melting. Areas affected by snow dumps and snowdrifts associated with the Point Thomson Gas Cycling Project are anticipated to be minimal due to the minimal footprint of the project. Potential effects on terrestrial mammal habitats due to snow dumps and snowdrifts are anticipated to be minimal.

Spills and Leaks

Contaminant spills and cleanup efforts can alter mammal habitats in various ways. However, the most common spills in the oil fields are relatively small and affect small areas of tundra. Small spills occurring during construction and/or operations at the Point Thomson facility are not anticipated to result in population-level effects attributable to habitat alteration. Impacts from large spills are considered in detail in Section 5.4.

5.2.6.2 Disturbance Effects

Potential behavioral disturbance includes immediate responses of affected animals (including energetic or other costs associated with startle or fleeing responses), loss of habitat or degradation of habitat quality (by causing avoidance), and attraction of some species to areas of human activity (particularly predator/scavengers). Point Thomson Gas Cycling Project activities could cause either behavioral disturbance or attraction of wildlife during construction and main operations. The potential impacts are discussed under the context of winter construction, summer construction, and operations activities.

Winter Construction

Winter construction activities will occur from January to April for two seasons and will include ice road construction, gravel mining, gravel placement for roads, pads, airstrip and dock, drilling, and pipeline installation. Few caribou, muskoxen, grizzly bears, moose, and wolves are likely to be present in the Point Thomson area during the winter. Grizzly bears are also unlikely to be denning in the vicinity of the proposed project. Arctic fox and Arctic ground squirrels could be disturbed by construction activities if they were present in the area. It has not been determined to what extent these species make use of habitat in the project area (Section 4.10.4 and 4.10.6). It is anticipated that any disturbance of small mammals present in the Point Thomson area during the winter will be minimal.

Summer Construction and Year-Round Operations

Noise generated due to onshore construction activities, the physical presence of equipment, and vehicle traffic during construction and operations has the potential to disturb terrestrial mammals in the area. Disturbance of muskoxen, grizzly bears, moose, wolves, and wolverines is anticipated to be minimal due to their infrequent use of the area (Section 4.10).

Disturbance by traffic, structures, and human activities can produce several effects on caribou behavior and movement. During and immediately after the calving season, female caribou with calves tend to avoid areas near active pads and roads. During and immediately after the calving season, female caribou with calves (up to 3 to 4 weeks old) tend to avoid areas within at least 1,500 to 3,300 ft (457 to 1006 m) of active pads and roads (Johnson and Lawhead 1989) and as far as 1 to 3 mi (1.6 to 4.8 km) (Dau and Cameron 1986; Lawhead 1988; Cameron et al. 1992; Cronin et al. 1994). The Central Arctic Herd has shifted its most concentrated calving areas several times over the last 20 years, with the most recent shift to an inland area southwest of the point Thomson area (Section 4.10.1.1). The Porcupine Caribou Herd does not calve near the Point Thomson area (Section 4.10.1.1).

During the insect season, harassment by insects overwhelms the avoidance response, and caribou of all ages and both sexes regularly approach and cross pipeline/road corridors while moving to and from insect-relief habitat located near the coast. The clearest behavioral impact of road traffic during insect season is reduced crossing success when caribou groups attempt to cross pipelines that are within 300 ft (91 m) of roads with high traffic rates (15 or more vehicles per hour) (Curatolo and Murphy 1986 and Cronin et al. 1994). Deflected movement and delays of up to several hours are common under these circumstances (Johnson and Lawhead 1989, Lawhead et al. 1993). Energetic stress during the insect season has been identified as a potential pathway by which human disturbance could affect caribou populations by decreasing body condition of females and reducing reproductive success in subsequent years (Cameron 1995, Cameron and Ver Hoef 1996, Murphy et al. 2000, and Murphy and Lawhead 2000).

To reduce disturbance impacts, research has focused on ways to facilitate free passage of caribou through the oil fields and standard mitigation measures have been developed (Cronin et al. 1994). The principal mitigative measure is to elevate pipelines to a minimum height of 5 ft (1.5 m). This often results in substantial lengths of pipe situated higher than 5 ft (1.5 m) as it crosses irregularities in the tundra surface. A pipeline constructed to the standard minimum height of 5 ft (1.5 m) above the ground surface (measured at the bottom of the pipe or vibration dampers, whichever is lower) does not impede caribou movements as long as a road with a high traffic rate is not located nearby (Curatolo and Murphy 1986, Cronin et al. 1994). Therefore, another standard mitigative measure is to assure adequate separation of elevated pipelines from adjacent gravel roads. A distance of 300 ft (91 m) has been identified as the minimum separation necessary to ensure that crossing success is not reduced (Curatolo and Reges 1986), but a greater distance (400 to 500 ft [122 to 152 m]) has been recommended to provide extra assurance of mitigation (Cronin et al. 1994). Elevated pipelines at or above 5 ft (1.5 m) and pipeline/road separations of 500 ft (152 m) at the Point Thomson Project will minimize the impacts of behavioral disturbance of caribou. Behavioral reactions to road traffic could occur for caribou groups encountering the Point Thomson access roads during the construction phase, but it anticipated to diminish to low levels during project operation as traffic rates decline. Disturbances have not resulted in population level changes for caribou due to the location of facilities and the availability of other suitable habitat in the Prudhoe Bay region. Similarly, no population level effects are expected in the Pt. Thomson region.

Foxes and bears are attracted to areas of human activity where they readily feed on garbage and handouts (Eberhardt et al. 1982, Follmann 1989, Follmann and Hechtel 1990, Shideler and

Hechtel 1993, and Truett 1993). Opportunistic predator/scavengers such as Arctic foxes and grizzly bears appear to benefit from increased food resources in the oil fields (Burgess 2000 and Shideler and Hechtel 2000). When organic refuse is abundant, attracted foxes experience increased survivorship and higher reproduction rates (Eberhardt et al. 1982 and Burgess et al. 1993), leading to long-term increases in population size. The density of active Arctic fox dens and fox numbers are greater in oil fields than in undeveloped areas (Eberhardt et al. 1982 and 1983, Burgess et al. 1993, and Burgess 2000). Grizzly bears in and near the oil fields also show better nutrition, greater adult weights, lower cub mortality, and are present in higher concentrations than elsewhere on the North Slope, presumably due to the accessibility of human refuse (Shideler and Hechtel 2000).

The potential for scavengers to be attracted to the Point Thomson area is greatest during construction, when human activity would be most intensive and wide-ranging. Lower levels of human activity during operations would have less potential to attract scavengers. Tight controls on the availability of organic refuse will also reduce the potential impacts on foxes and bears. Nonetheless, the Point Thomson Gas Cycling Project could attract numbers of foxes and bears throughout the year since artificial food sources are powerful attractants. It is anticipated that refuse control efforts, employee environmental sensitivity training, and enforced rules against animal feeding will minimize population level effects on Arctic foxes and grizzly bears.

5.2.6.3 Direct and Indirect Mortality

Strikes by vehicles could cause mortality of terrestrial mammals at the Point Thomson project facilities. Risks of vehicle strikes will be greatest during summer when large numbers of caribou and other mammals may move into the area. Arctic foxes could be present year-round and subject to vehicle strikes during all seasons. Although vehicle-caused mortality is poorly documented for the Kuparuk and Prudhoe Bay oil fields, the number of animals injured or killed by vehicles is thought to be low.

Under certain seasonal conditions, caribou are attracted to developed areas. During early spring, caribou may be attracted to roadside areas where dust fallout has caused vegetation to "green up" earlier. Although these animals gain access to nutritious forage, their exposure to traffic-related disturbance and risk of vehicle strikes increases. Caribou also may be attracted to developed areas where they seek relief from insect harassment (mid-July to mid-August) on elevated gravel roads and pads and in shaded areas under pipelines and buildings (Roby 1978 and Johnson and Lawhead 1989). The number of caribou engaging in this behavior at a specific location can range from one or a few individuals to several thousand. Thus, the risk of vehicles striking caribou is greatest during this period. At such times, caribou often are less cautious around vehicles than at other times of the year. The likelihood of vehicle strikes can be minimized through driver education and reduced speeds.

The habituation of Arctic foxes and grizzly bears to human activity not only increases the potential for animals to be struck by vehicles, but also increases the potential for animals to infect humans and other animals with rabies or other diseases, harm humans through aggressive behavior, and be killed as a control measure to protect human life and property. Fox control measures, such as trapping, have occasionally been undertaken in the Prudhoe Bay and Kuparuk oil fields to reduce the abundance of Arctic foxes.

Increased predator populations around oil field developments may increase predation on prey populations (Martin 1997). This impact is inferred from the higher numbers and productivity of foxes (Eberhardt et al. 1982 and Burgess et al. 1993, Burgess 2000), grizzly bears (Shideler and Hechtel 1995b and Shideler and Hechtel 2000), and gulls and ravens (Truett et al. 1997 and Day 1998) in the North Slope oil fields. There is little information on lemming and vole populations in oil fields adjacent to where Arctic foxes have increased in abundance. Arctic fox could also cause impacts on birds, their primary prey during periods of lemming scarcity (Section 5.2.4.3). Terrestrial mammalian prey of grizzly bears includes ground squirrels and ungulates (caribou, moose, and muskoxen), particularly ungulate calves. Although grizzly bears are known to prey on caribou in the region (Shideler and Hechtel 2000), the magnitude of mortality is difficult to quantify. Impacts to colonial bird populations from increased grizzly predation are also a concern (Section 5.2.4.3). It is anticipated that refuse control efforts, employee environmental sensitivity training, and enforced rules against animal feeding would minimize population-level effects on predators and scavengers and avoid the potential for these animals to negatively affect populations of lemmings or ungulates in the Point Thomson region.

Contaminant spills also have the potential to result in mortality of terrestrial mammals. Contaminants can negatively affect mammals through dermal contact, dermal absorption, ingestion, and inhalation. Dermal contact can include impacts on the ability of hair to insulate or to shed water. The most common oil field spills (small volume spills of fuels and fluids necessary for vehicle/machinery operations) are unlikely to have population-level impacts on terrestrial mammals. Impacts from large spills are considered in detail in Section 5.4.

5.2.7 Threatened and Endangered Species

As described in Section 4.14, one threatened species of birds (spectacled eiders) and one endangered whale (bowhead) may be found seasonally in the vicinity of Point Thomson. Steller's eiders, also a threatened species, are unlikely to make use of the Point Thomson area. Table 5-2 summarizes the potential impacts of the proposed facilities on these species.

5.2.7.1 Spectacled Eiders

The effects of the Point Thomson Gas Cycling Project on threatened birds is restricted primarily to the possible effects on the spectacled eider.

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 are expected to be applied more conservatively in areas supporting spectacled eiders versus other tundra-breeding birds in general, because spectacled eiders are currently listed as threatened under the Endangered Species Act. The USFWS 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 (0.16 km) of nest sites.
- Maintaining adequate access for birds to move from nest sites to brood-rearing areas.

Habitat Loss and Alteration

The proposed Point Thomson project will result in the long-term alteration of 915,781 ft^2 (0.8 km^2) of the more important spectacled eider habitats. These habitats include water (primarily lakes and ponds) and the following vegetation types: salt marsh, aquatic graminoid tundra, water/tundra complex, wet sedge tundra, and wet sedge tundra/water complex. The direct loss of habitat due to gravel placement for the airstrip, roads, and pads could have a potential impact on these eiders, since spectacled eiders prefer habitats in drained lake basins and wet coastal tundra for nesting and brood rearing. Spectacled eiders have been shown to readily use impoundments (Warnock and Troy 1992) and are not expected to suffer adverse impacts should small areas of surface hydrology be changed due to ponding. Similarly, impacts on spectacled eider habitat from snowdrifts, and other temporary changes to habitats resulting from Point Thomson construction or operation are expected to be minimal. Spectacled eiders could also occasionally use some other vegetation types in the Point Thomson project area, but the water and aquatic types are those most important to eiders during the breeding season.

Disturbance Effects

Behavioral disturbance of birds using habitats near the roads and pads and the types of potential effects are discussed in detail in Section 5.2.4.1. Similar responses are likely for any spectacled eiders that use habitats near facilities in the Point Thomson area during construction or operations. Indirect loss of habitat due to disturbance may occur near facilities generating noise in the Point Thomson area. Spectacled eiders did shift their distribution away from the Central Compressor Plant in the Prudhoe Bay oil field, presumably due to increased noise output when the facility was expanded (Anderson et al. 1992).

Some disturbance of spectacled eiders may result from helicopter and fixed wing flights during both summer construction and operations activities. However, aerial surveys of spectacled eiders indicate that they are tolerant of low altitude helicopter overflights (i.e., they exhibit low incidence of flushing) during regular census surveys (LGL et al. 1998). In general, the relative scarcity of spectacled eiders in the area will potentially limit population-level impacts due to disturbance or indirect habitat loss.

Direct and Indirect Mortality

Some potential for increased mortality of spectacled eiders may result during poor weather conditions from collisions of low-flying spectacled eiders with elevated structures. The potential for such impacts is likely to be limited because the Point Thomson area is at the eastern end of the species range on the Arctic Coastal Plain and movements of large numbers of spectacled eiders past Point Thomson are unlikely.

Increased predation levels from attraction of predators to the Point Thomson area may affect small numbers of breeding spectacled eiders. The number of breeding pairs observed in June is low (5 pairs) and only one brood of spectacled eiders has been reported in the area, near Point Sweeny located about 2 mi (3.2 km) east of the West Pad (see Section 4.14.3). Therefore, increased predation is unlikely to have a population-level effect on spectacled eiders.

As with other birds, the impacts of contaminants on spectacled eiders are dependent on the type of contaminant, season (i.e., when the spill occurs), and the number of birds that could be affected. Because the distribution of most spectacled eiders is located to the west of the main production area at Point Thomson, effects on spectacled eiders related to possible spills are most likely from the pipeline rather than from contaminants found on the drilling and production pads. Impacts from large spills are considered in detail in Section 5.4.

In conclusion, the direct and indirect effects of the Point Thomson project will be limited for spectacled eiders because of their relatively low numbers and limited distribution (primarily away from the road, airstrip, and pad locations) in the Point Thomson project area.

5.2.7.2 Bowhead Whales

Effects of operation of the proposed project 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 as ice and other conditions allow. Aircraft overflights of waters north of Flaxman Island will be avoided after 31 August until migration is complete, except for emergency situations. Dock construction and all major onshore construction and drilling will be conducted in winter, avoiding disturbance to whales. The details of these mitigation measures will be defined during the IHA and rulemaking processes.

5.3 SOCIOECONOMIC AND CULTURAL RESOURCES

Impacts of the project on the socioeconomic characteristics and cultural resources of the area can occur through a reduction or enhancement population, economy and income, land use and management, subsistence and recreational and visual resources. The consequences of disruption or displacement, restriction, and destruction are applicable to the land use and management, subsistence, recreation and visual and cultural resources.

5.3.1 Population

The Point Thomson Gas Cycling project is unlikely to significantly alter the population base of the local communities of the North Slope Borough (NSB) or the state of Alaska. The project is relatively small, requiring 75 personnel for operations, and during the temporary construction phase, 450 personnel. Workers will be housed on site at Point Thomson facilities for both construction and operations phases, avoiding the potential for significant impact to the relatively small village communities in the area. Additionally, this physical disassociation of workers from established local communities would also render it unlikely that incoming construction workers will settle in the NSB.

Addition of non-Alaskan Point Thomson personnel and their families would be a relatively minor factor in the NSB population of 7,345 (preliminary 2000 census count), and even more so within the population of the State of Alaska, diminishing the overall population impact.

5.3.2 Employment and Income

5.3.2.1 Local Communities

A direct positive economic effect should result from the Point Thomson project, with the creation of new jobs for construction and operations. It is expected that the benefit will take place mostly on the North Slope and in southcentral Alaska. In the short-term, the activity is projected to generate approximately 450 construction jobs and 75 long-term positions (for operating and maintaining the facility). The North Slope owners have historically made a commitment to hire Alaskan resident workers on the North Slope and within Alaska. Regarding long-term jobs in operations, local residents' need for seasonal flexibility to pursue subsistence activities and other factors may reduce the attractiveness of oilfield operations employment when other jobs (NSB) with greater flexibility are available. Relatively few village residents on the North Slope are currently employed by the oil industry for this reason, even though recruitment efforts are made and training programs are available. The Point Thomson Gas Cycling Project is not expected to change this pattern.

The short-term construction positions, however, are more seasonal in nature, and thus more likely to fit into a subsistence calendar, in particular those that take place during the winter phase of construction. There are local firms specializing in the construction of ice roads which could benefit from the project. In addition, many of the contractors hired for the Point Thomson project (design, construction, drilling, and operations) could be either Native Corporations, subsidiaries of such corporations, or otherwise affiliated with such corporations through joint ventures or other relationships. This would thus provide indirect benefit to the wider Native community, as well as to individual workers.

5.3.2.2 State of Alaska

The Oil and Gas Policy Council report estimated that $1 in direct oil industry expenditures can result in $1.9 to $2.9 in total output, when state revenues, Permanent Fund dividends, and all other factors are considered (Northern Economics, 1995). The range of values reflects different facility types. Of the sites described in the report, the Point Thomson Gas Cycling project resembles most closely the marginal and remote sites, and should have an output multiplier of 1.9 to 2.1. The owners estimate that total expenses will be in excess of $1 billion for the Base Case. In addition, the State of Alaska will benefit directly from capital expenditures (associated with purchase of services and materials) in the economy, leading to the creation of indirect employment.

5.3.3 Public Revenue and Expenditures

Oil and gas revenues support a variety of expenditures and have allowed the NSB to pursue significant capital improvement plans and health and social services. The increase in the NSB tax base through the addition of the Point Thomson facility will also indirectly benefit on employment in the region, as the NSB employs about 62% of the Borough's working population.

Over the estimated life of the project, additional benefits will accrue to the State of Alaska through the State of Alaska's share of the Federal royalty, income tax, and *ad valorem* tax, some of which will also accrue to the NSB. This benefit will occur at a time when State of Alaska and NSB revenue, heavily dependent on production from the large North Slope oil fields, could be declining. The Point Thomson project by itself will not offset these declines, but it could help mitigate the severity of any decline. The Point Thomson Project will add approximately $1 billion to the NSB and State of Alaska taxable property.

5.3.4 Subsistence and Traditional Land Use

The proposed action includes construction and maintenance activities that have the potential to affect local residents' patterns of subsistence use. However, in order for there to be a potential impact on subsistence activities, two conditions must be met: 1) the resource has to be present or expected in the area during the period of impact, and 2) subsistence use of the resource has to occur in the impact area.

Impacts on subsistence can be produced by direct or indirect actions on biological resources that result in a displacement or reduction in the animals important for subsistence. Other impacts that could potentially occur are:

- Changes in human behavior, which can include restricting access to a subsistence resource.
- Disruption of subsistence activities, resulting in a reduced harvest.
- Limited subsistence resource use due to the perception that the subsistence experience has been affected or that the resource has been tainted.

5.3.4.1 Winter Construction

The majority of winter construction activities at the Point Thomson project area will take place during February through May. The preparation for these activities, during November to January, will include the construction of an ice road to access the Point Thomson site from Prudhoe Bay. Polar bears and ringed seals are the only marine mammals expected to be within the proposed project area during winter construction. Winter construction activities occur during a season in which subsistence use of the project area is low to non-existent. Nuiqsut and Kaktovik hunters do not venture as far afield as the Point Thomson area in order to pursue their traditional subsistence activities.

Polar bear denning habitat could be encroached upon by onshore pipeline construction and associated ice roads, although a one-mile (1.6 km) avoidance stipulation protects the dens to a large extent (Section 5.2.5). Any subsistence hunting of polar bear in and near the project area would be primarily opportunistic and associated with fall whaling activities. Given the infrequency of polar bear harvest during the winter, potential effects on subsistence use will likely be negligible.

Some localized disturbance of seals is possible due to noise associated with winter construction activities, but overall population effects are not anticipated. Similarly, some localized displacement of seal hunting activities may also occur, but would be minimal in terms of the overall pattern of Nuiqsut seal hunting. As discussed in Sections 4.13.3.1 and 4.13.3.2, seal hunters from Nuiqsut have reported using the area offshore of Point Thomson in the past, but current harvest rates from the area are relatively low.

Subsistence hunters in the area tend to rely on caribou hunted closer to the village for their winter protein (see Sections 4.13.3.1 and 4.13.3.2). As indicated in previous reports (USACE 1999), the area around the Point Thomson project is not currently used as a winter harvest area for caribou for the local villages.

Whales will not be present in the proposed project area during winter construction. Similarly, potential winter construction effects on fish are judged to be negligible (see Section 5.2.3), and subsistence use of the area for fishing is infrequent and limited to summer.

Effects of winter construction efforts, including gravel extraction, on terrestrial subsistence resources and their use for subsistence would also be minimal. Use of the project area by subsistence hunters in general is low and is practically non-existent in winter, when trapping and hunting of fur bearers occurs closer to the communities (see Sections 4.13.3.1 and 4.13.3.2). As a result, onshore gravel extraction, placement of fill, and pipeline construction efforts in the winter would not be expected to reduce, restrict, or disrupt subsistence activities.

5.3.4.2 Summer Construction

Summer construction activities both on land and offshore have the potential to impact subsistence resources. Subsistence resources are likely to be present in the area during the summer and fall construction period (i.e., seals, whales, anadromous and freshwater fish, terrestrial mammals, and birds). However, use of the area by residents of Nuiqsut and Kaktovik is low (see Section 4.13.3.1 and 4.13.3.2). Most area use occurs in conjunction with the fall whale hunt, when hunters travel through or near the area in pursuit of whales, and hunt other resources on an opportunistic basis.

Whales are not expected to be directly affected by shore-generated noise, as their normal migration route (seaward of the barrier islands) is beyond the transmission range of the noise expected to be generated. The open-water offshore construction activities are all associated with dock construction (e.g., compaction, shaping armoring, and dredging). Offshore construction activities are scheduled to be finished by mid-summer, which should avoid impacting the fall whaling hunt. Because of the offshore distribution of most fall migrating whales, few, if any, are expected to encounter vessels within the project area. However, it is possible that supply vessels travelling between Prudhoe Bay and Point Thomson could encounter whales. If any such approaches do occur, a small number of whales may show short-term avoidance reactions that will be of no long-term significance. Encounters during the fall whale-hunting season would be most likely to affect subsistence activities; mitigation measures (see Section 6.0) should reduce any potential adverse impacts. Potential impacts to whaling could be mitigated through the establishment of restrictions to boat and air traffic during sensitive whaling periods.

It should also be noted that although the Point Thomson area falls within the extent of Nuiqsut and Kaktovik whaling areas, it is by no means the most important stretch of coastline for this activity. In the case of the Nuiqsut whalers, the core bowhead harvest areas centers on Cross Island, to the west (USACE 1999). The Kaktovik core area falls between Camden Bay and Griffin Point, to the east of the project area (Figures 4.19 and 4.20).

Summer construction activities are not anticipated to have any significant effects on diadromous, freshwater, or marine fish (Section 5.2.3). Fish species in the Point Thomson area were historically used by Native residents, but currently are not used much due to the area's distance from local communities. Therefore, overall subsistence use effects on fish resources are anticipated to be minimal (LGL et al. 1998).

The subsistence use of terrestrial mammals in the project area is minimal, primarily due to its distance from Nuiqsut and Kaktovik. There is a historical summer caribou hunting site for the Kaktovik village adjacent to the Point Thomson project area (USACE 1999), but it is currently seldom used. The potential for impact of the project on terrestrial mammals is also limited to the immediate vicinity of the project area, as the project is not planning to build overland transportation routes. During the summer, transportation will be via marine vessels or aircraft. Thus any potential disturbance of terrestrial mammals due to summer and fall construction should be strictly limited to the immediate locale of the Point Thomson project, and given the present use pattern of local Inupiat hunters, should not be significant.

5.3.4.3 Operations

Noise generated during operations is anticipated to be less than that produced during the construction phases. Disturbance effects on local wildlife are anticipated to be minimal and should not affect subsistence resource population levels. In order to mitigate the potential for adverse effects on wildlife in the area due to attraction of wildlife, personnel will be trained in measures to avoid attracting wildlife, and how to deal with human/wildlife interaction.

Another potential long-term effect of the project is competition for local subsistence resources due project personnel sport hunting and fishing. In order to mitigate the potential for project personnel to interfere with subsistence activities, hunting by personnel in the vicinity of the project will be prohibited. All personnel will be required to comply with applicable ADF&G sport fishing regulations.

A significant concern is the potential impact of a pipeline spill or well blowout on biological resources and related effects on subsistence activities in the Point Thomson area. The risks and impacts on biological resources associated with a large spill are discussed in Section 5.4. The impacts of a spill on subsistence activities may cause displacement or mortality of a wildlife resource, or restrict access of subsistence users to the resource. While direct effects of a product spill on terrestrial and/or marine subsistence resources could occur (see Section 5.4), the use of the area by subsistence hunters is low, so that any subsistence use effects are anticipated to be minimal.

The perception of contamination can also occur even if resources are not actually affected. 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 localized shellfish were contaminated), this pattern of reduced consumption persisted for at least a year. The cultural context of subsistence on the North Slope differs markedly from the *Exxon Valdez* area (in the Alutiiq cultural region), making it difficult to make specific comparisons. Direct, indirect, and perceived subsistence impacts can 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 on the size and location of the spill. Mitigation measures could include contamination testing in coordination with local residents to dispel such perceptions.

Oil-spill cleanup activities could also have effects on subsistence resources from vessel and aircraft traffic by causing temporary disturbance and possible displacement. The Final Environmental Impact Statement for Lease Sale 144 states that 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 with cleanup activities could (depending on the time of the spill and the cleanup) potentially displace seals, polar bears, and other marine mammals, increase stress, and reduce pup survival of ringed seals if operations occurred in the spring (MMS 1996). The potential impacts of large oil spill is discussed in Section 5.4.

5.3.5 Land Ownership, Use, and Management

5.3.5.1 Ownership

As described in Section 4.13.4.1 most of the land in the Point Thomson Gas Cycling Project area is patented to the State of Alaska. All project development will occur on these State Lands under the terms of existing State oil and gas leases. Most leases within the Point Thomson Unit are currently being held through Plans of Development that have been submitted and approved by the state on an annual basis.

Federal lands within the Arctic national Wildlife Refuge (ANWR) are located adjacent to the east of the development unit. A Native allotment application has been made on Flaxman Island and a location near Brownlow Point. However, the proposed project facilities will not be constructed in either of these areas and will not affect land ownership.

5.3.5.2 Land Use

As described in Section 4.13.4.2, historic and current land and water use of the Point Thomson area is primarily threefold. It includes oil and gas exploration, occasional traditional and subsistence use by Alaskan Natives, and occasional summer recreation uses along the Canning River within the ANWR border.

The proposed project is consistent with existing oil and gas exploration and production activities in and adjacent to the project area. In terms of the subsistence use of the area, impacts will be minimal (see Section 5.3.4), primarily due to the fact that the area is minimally used at present by the Kaktovik and Nuiqsut villages for subsistence. The greatest potential for disruption of subsistence habits would be to the annual fall whale hunt, and would consist of disruption to the whale migration pattern through noise or transportation interactions. The likelihood that these impacts would be significant is low (see section 5.2.5) and will be mitigated to some extent through project controls (see Section 6.0). There will be negligible competition for subsistence resources through additional access to the area for sports fishing and hunting. Project personnel will not be permitted to hunt in the area.

Recreational use in the area mainly occurs in the adjacent ANWR. Development of the Point Thomson facilities would affect use of surrounding areas for recreation activities to the extent that the presence of an industrial facility would interfere with that experience. See Section 5.3.7 for further discussion of recreation impacts. The project may distract from the visual aesthetics of the region in the eyes of residents and visitors. Mitigation measures, such as using natural coloring for facilities, will provide some amelioration of this effect.

5.3.5.3 Land Management

Section 4.13.4.3 describes the land management aspects of the Point Thomson area. The area has been unitized and is subject to specific agreements and state regulations governing activities within unitized areas. The unit is located within the boundaries of the NSB coastal zone. All development within the unit will adhere to the NSB Title 19 LMRs and the Alaska Coastal Management Program (ACMP). The Point Thomson unit is zoned as a Resource Development District, but any existing Master Development Plans for the area will require revisions.

The construction of the pipeline to connect the Point Thomson Unit with the Badami Unit requires rezoning of the area from a Conservation to a Resource Development District, as designated by the NSB LMRs. This requires the development of a Master Plan for the area, which must demonstrate that the project will not permanently and seriously impair the surrounding ecosystem, nor significantly affect subsistence resources and activities.

The project will be consistent with the existing policies and requirements specified in the various governing ordinances. Mitigation measures proposed in Section 6.0 will assist with compliance.

Development plans should receive approval, with likely conditions and stipulations for complying with responsible practices as directed under NSB and ACMP management.

5.3.6 Transportation

Impacts to transportation systems will occur since the project requires the movement of personnel, equipment, materials, and supplies by marine, highway, air, and overland routes for construction and operation. Although the project is not large in size, there will be an increase in movement, particularly during parts of the construction phase.

A one-time construction impact in the form of increased vessel traffic will affect annual sealifts, since project modules will be transported either to Prudhoe Bay and on to Point Thomson by barge, or directly to Point Thomson without a stop in Prudhoe Bay. However, this should create only minor effects on transportation systems and can be mitigated by planning.

Traffic on the Dalton Highway and within the Prudhoe Bay road system is not expected to see a large increase due to the Point Thomson project. A dock is proposed at the project site, so that major modules can be sealifted directly into the area and not have to be transported via ice or gravel roads from Deadhorse. The suction dredges needed to create a channel to the dock, smaller modules, and piping will be trucked to Prudhoe Bay, and then transported by ice road or barge to Point Thomson. A seasonal ice road will connect the project during the construction phase and potentially during operations; however the expected traffic from Point Thomson activities is unlikely to be significant.

Air and boat traffic in the immediate vicinity of the project, associated with the transport of supplies and personnel between the project site and Prudhoe Bay, will increase during the construction and operations phases. Impacts associated with disturbance of marine and terrestrial animals have been discussed in previous sections 5.2.5 and 5.2.6 of this ER. Due to Prudhoe Bay access restrictions, and lack of existing overland access to the site, an increase in public and charter service into Deadhorse related this project would be unlikely.

5.3.7 Recreation

As described in Section 4.13.6, recreational opportunities in the area include floating the Canning River and camping in ANWR. As the possibility of oil drilling in ANWR receives more public attention, the perceived impairment to recreational opportunities in the area may become an issue raised concerning the Point Thomson project development.

Currently, the US Fish and Wildlife Service estimates that 591 visitors are expected in ANWR during 2001. This figure represents visitors arriving with guided tours, but does not include individuals traveling to ANWR. Recreation activities occur during the summer, and would only be impacted by summer construction activities and regular operations. The project would provide no actual impediment to the recreational activities as currently practiced; however it may affect the quality of the recreation experience. During construction in particular, the Point Thomson area will be subject to a large number of transportation vehicles, including airplanes and boats, which may create visual and aural impacts, distracting from the recreational experience. Drilling may create a noticeable increase in noise for a limited time period; however, due to current restrictions, drilling is planned to take place during winter when recreation activities will be less likely to occur. Construction effects would last for one to two seasons, with the majority of impact occurring during dark and cold winter months. Noise associated with facility operation may be heard in the immediate vicinity throughout the life of the project. The Canning River takeout airstrip for guided float trips is located approximately 11 mi (18 km) south of the Point Thomson project area. Depending on activities and wind direction and speed, the noise associated with operations may not be audible by visitors at the Canning River takeout.

5.3.8 Visual Aesthetics

The long-term visual and aesthetic characteristics of the project during operation have the potential to affect both the local residents and visiting recreational users. Since the visual and aesthetic characteristics of the area (see Section 4.13.7) consist of a low relief, treeless landscape, oil field facilities, particularly those located at the East Well Pad, could be visible from within ANWR, or to people partaking in recreational activities on the Staines and Canning Rivers. While it is unlikely to be visible from the Kaktovik or Nuiqsut, the villagers could be affected by the project during subsistence activities conducted in the area and in particular during the whale-hunting season. Since the facilities will also have flares and lights, a glow could be visible in the area. Noise from the compressors and vehicles may be heard. These impacts may be perceived as intrusive to local residents who pass through the area, or as a reduction in the quality of the recreational experience for visitors for whom the visual and aesthetic value may be a key component. The presence of the oil field facilities and the accompanying limits to area access may be considered as a disruption to recreational use of the area. Tower-like structures such as flare stacks (100 ft [30 m]) and the microwave tower (300 ft [91 m]) will be part of the facility design. More massive structures such as modules and processing facilities are likely to be approximately 100 ft (30 m) tall. However, any impacts can be at least partially mitigated by choosing colors that are consistent with the natural landscape, reducing noise emissions, and reducing or redirecting light from the facilities.

5.3.9 Cultural Resources

The results of the cultural resources reconnaissance survey of the proposed Point Thomson development identified seventeen sites that are listed on the Alaska Heritage Resource Survey (AHRS) archaeological database. Five of these sites are also listed on the NSB's Traditional Land Use Information (TLUI) database (see Section 4.12 of this ER). The known sites in the project area are all located along the Beaufort Sea coastline.

Lobdell and Lobdell (2000) described the status of cultural resources in relation to proposed development of the Point Thomson Unit:

> *Given the extensive research that has taken place from early in this century through concentrated impact-related research beginning in the 1980s and intensifying in the 1990s, it is herein recommended that the Point Thomson Unit receive an area or unit clearance. There is no need for conducting additional cultural resources examinations. Unit operations should buffer and remove areas of all known cultural resources from any potential development or exploration activities. Additional protective measures and unit operating personnel education about the importance of the preservation of these historic sites should be included*

in HSE certification and personnel training. The sites may require periodic visitation to insure their integrity and the effectiveness of protective measures.

As Lobdell and Lobdell noted, the nature of the project area's landscape, specifically, the dynamic nature of Point Thomson area shorelines, and the expansive areas of low-lying wet tundra, reduces the archaeological sensitivity of the project area. Impacts to any identified or unidentified cultural resources of the area would be either through destruction and/or disruption of the site during construction activities, or through disruption of the artifacts by unauthorized visitors. Destruction could be defined as the physical obliteration of the site, while disruption could involve removal of the artifacts or other impacts to the integrity of site features or artifact locations. With effective protective measures in place, disruption and/or destruction of known cultural resources due to either winter or summer construction efforts are unlikely.

No surface sites or indications of buried cultural sites are identified within the project footprint. However, the previous citation notwithstanding, the proposed airstrip and mine site have not been systematically surveyed for cultural resources. It would be prudent to do so, particularly since the proposed airstrip footprint is located on a 25 ft (7.6 m) elevation contour, a geomorphological feature that should be examined for archaeological resources prior to construction.

If there are any unknown archaeological sites yet to be discovered, they may be inadvertently impacted through excavation at the proposed gravel mine site(s) or airstrip construction. However, given the environs elsewhere within the project area, direct impact to cultural resource sites is regarded as highly unlikely. The known archaeological sites are limited in area and well known. There should be no direct adverse effect to the physical remains present at these sites since they can easily be avoided. Mitigation measures of avoidance and sensitivity training of personnel would adequately counter any potential impacts during winter and summer construction activities (see Section 6.0 of this ER).

Systematic surveys including subsurface testing for deeply buried cultural resource sites in the Point Thomson area are not likely to produce any archaeological resources but may create unintended impacts to fragile permafrost. With the exception of the proposed airstrip and mine site area, further surveys are unlikely to produce cultural resources because of the reduced archaeological sensitivity of the project area. Similarly, the likelihood of submerged cultural resources being located in the area to be impacted by planned dock construction is a low. No shipwrecks are known from the locale (Tornfelt and Burwell, 1992), and no geomorphological features are present to indicate potential ancient buried sites.

However, should cultural resources be discovered during construction gravel mining activities, airstrip construction, any work that may damage these resources will be halted, and the State Historic Preservation Officer and the North Slope Inupiaq History, Language, and Culture Commission will be contacted. Following consultation, a decision will be made to avoid, protect, or remove the resource, utilizing appropriate scientific excavation, recording, or testing.

Secondary impacts to cultural resources include destruction or damage to cultural resources and the heritage resource record from unauthorized visitation to, increased pedestrian traffic upon, looting of, or contamination of cultural resources sites. Secondary impacts may occur to sites not directly in the path or footprint of a project, but in close enough proximity to be damaged by the aforementioned activities. The impacts could occur either during construction or operations activities. To mitigate any potential secondary impact, all project personnel will receive training on the importance of cultural resources and will be instructed to avoid these sites. The training will include a discussion of the penalties for disruption of any cultural site. The lack of a permanent access road along the pipeline route thereby restricting year-round access to the Point Thomson area will aid in mitigating secondary impacts.

5.4 PRODUCT SPILL RISK ANALYSIS

This section assesses product spills and their relative impact to environmental, cultural and socioeconomic resource areas that could result from development at Point Thomson. Spills, leaks, or blowouts at the Point Thomson facility could consist of mostly gas at the wellheads and gathering lines, and liquid condensate from the sales lines connecting to Badami. In addition, produced water which will be removed from the product stream at the CPF could also be spilled.

Predicting a spill is a matter of probability with uncertainty in the areas of spill volume, extent, location, and quantity as well as environmental conditions (i.e. season, wind, ice, water currents) at the time of a spill. A lack of substantial experimental data regarding the spill behavior of the Point Thomson gas/condensate product under the extreme conditions expected and its effects on the affected environment contribute to this uncertainty.

Assumptions must be made to analyze the effects of oil spills, including estimating information regarding the type of oil, the location, size, and distribution of a spill, the chemistry of the oil, how the oil will weather, how long it will remain, and where it will move. These assumptions are made based on project-specific engineering calculations, modeling results, statistical analyses, and professional judgement. After analyzing the effects of an oil spill, we must take into consideration the chance of an oil spill ever occurring. This section also discusses this probability based on historical oil spill records and prevention and response planning strategies.

An *Oil Discharge Prevention and Contingency Plan* (C-Plan), demonstrating effective oil discharge prevention, control, containment, cleanup, and disposal of a spill of any size, including the greatest possible discharge that could occur, is required by 18 AAC 75.425 (subject to AS46.04.020 and 09.020). In accordance with ADEC requirements, the C-Plan for Point Thomson will address specific conditions that might reasonably be expected to increase the risk of discharge, and actions taken to eliminate or minimize them.

5.4.1 Probability of an Oil Spill

Although much smaller, BP Exploration-Alaska's (BPXA) Badami facility has similar facilities as the proposed Point Thomson development. The history of spills at Badami reveals that most spills are small (in the 1 to 20 gallons [4 to 76 liters] category) and involve hydrocarbons (crude, glycols, motor oil, diesel, hydraulic fluid, etc.). Most spills are caused by leaking valves, failures of automatic shutoffs, and leaks from vehicles.

In its exploration and production history, Badami had three spills that were 55 gallons (gal) (209 liters) or more. These include one 150-gal (570-liter) turbine oil spill within a turbine enclosure, and two crude oil spills of 55 gal (209 liters) and 125 gal (475 liters) that were contained on a snow covered gravel pad.

Large spills, such as those associated with pipelines and well blowouts, tend to be more significant and of greater public concern. Fortunately, the rare occurrence of such spills can be attributed to the operators' implementation of comprehensive spill prevention procedures. ExxonMobil's policy is to prevent spills at the outset, through facility design and personnel training, including proper fuel transfer procedures, secondary containment, pipeline corrosion protection plan, remote or manually operated valves, and pipeline leak detection systems. Additionally, regular ground inspection or over-flights of the pipeline route will be conducted to inspect for potential pipeline spills. If a spill occurs, there are several resources at hand including qualified on-site personnel, the Mutual Aid organization of North Slope operators, and Alaska Clean Seas.

Spill data associated with ANS exploration and production (E&P) activites, including all North Slope oil wells, facilities, crude stabilization, and feeder pipelines (flowlines) available in Atlantic Richfield Corporation BPXA, and ADEC databases from 1977 until 1999 were analyzed as part of the Trans Atlantic Pipeline System (TAPS) Right Of Way renewal ER draft report (2001). This analysis found that there have been no large oil spills (using the typical MMS definition of a large spill as 1,000 barrels [bbl] or more) related to ANS E&P activities on record. The largest spill events associated with E&P activities include leaks on pads, well workover/maintenance spills, and loading/unloading spills at crude oil topping units. Most spills are relatively small; about 84% of crude spills and 92% of product spills are less than 2 bbl. The total volumetric spill rate was calculated at 0.86 bbl per million barrels throughput. Using a projected future (2004-2034) TAPS throughput estimate of 7.02 billion barrels, the total projected volume of E&P crude and product spills on the North Slope averages 202 bbl per year.

In a major pipeline leak, the full volume of the product contained between adjacent automated valves or high points in piping could be released. Theoretical spill volumes from a gas condense pipeline between Point Thomson and Badami have been studied using a 100% flow rate sized failure at the elevated throughput rates of the three-train case. For this worst-case scenario, the largest condensate spill volume from the pipeline is estimated at approximately 3,300 bbl, resulting from a significant rupture at the most critical location that is furthest from known valve locations (i.e. mainline valves only on each side of East Badami Creek and at the midpoint between there and the CPF were assumed). A significant rupture at any other point on the pipeline could result in a spill of 1,500 bbl. These worst-case spill volumes can be reduced as additional valves are considered and optimal valve locations are further examined.

For the Badami Pipeline, the reliable detection limit for a leak was estimated at 24 bbl. The minimum valve closure time is estimated at 20 seconds, with a conservative valve closure time of 30 seconds. Assuming a 75,000 barrels per day flow for 30 seconds provides a release volume estimate of about 26 barrels, for Pt. Thomson pipelines.

The risk of a worst-case spill event, such as that from a well blowout, actually occurring during the proposed activities at Point Thomson is extremely small. Worldwide, the chance of a blowout from development drilling is about one in 400. On the North Slope of Alaska, there is an even smaller chance of well control loss with about one blowout in 560 wells drilled (includes exploration and development drilling) (Mallory 1998). These statistics include "shallow gas" blowouts, which do not involve oil. Based on historical records from the U.S. Offshore Continental Shelf, there is a 95% or greater probability that future blowouts will not contain oil (S.L. Ross 1998). Several reports exemplify these probability calculations.

Mallory (1998) found that of the approximately 3,336 wells that were drilled on Alaska's North Slope between 1974 and 1997, there are six documented cases of secondary well control loss with a drilling rig on the well; two surface blowouts and four subsurface blowouts. No oil spills occurred in any of the events. This suggests a blowout probability of 0.0018 (1.8 blowouts in 1,000 wells drilled) on the North Slope.

S.L. Ross (1998) specifies blowout frequency from various operations: Blowout probability from offshore development drilling is 0.0025, blowouts from land based development drilling is 0.0011, and blowouts from production operations/workovers is 0.000065.

Fairweather (2000) differentiates between a well control incident and a blowout. A blowout was defined as an uncontrolled flow at the surface of liquids and/or gas from the wellbore resulting from human error and/or equipment failure. Fairweather found 10 blowouts, six that Mallory had previously identified and four that occurred prior to 1974. Of the 10 blowouts, nine consisted of gas and one was oil. The blowout of oil occurred in 1950, prior to the availability of blowout preventers (Fairweather 2000). The blowout prevention program and well control plan for the Point Thomson development will be consistent with the programs currently used at other facilities on the North Slope. These detailed procedures will be included in the Point Thomson C-Plan.

Worldwide, the chances of an extremely large (>150,000 bbl) and large (>10,000 bbl) well blowout from development drilling are about 0.0008 and 0.014 respectively. Over a 16-year production period, similar blowouts from production activities and workovers, the chances are 0.0017 and 0.0043 respectively. This is equivalent to one extremely large well blowout for every 9400 years of production and one large well blowout for every 3700 years of production. These predictions are based on worldwide oil well blowout data including blowouts that occurred in Mexico, Africa, and the Middle East, where drilling and production regulations tend to be less rigorous (S.L. Ross 1998). Even lower frequencies are expected for the Point Thomson project given that little oil would be expected to spill during a blowout from this natural gas field. Additionally, because of technology improvements, there have been no development drilling blowout spills larger than 10,000 barrels since 1980.

Despite the low risk, a blowout at Point Thomson is a significant concern to the public due to its proximity to the ANWR. For this reason, the behavior of a response-planning standard sized spill for a well blowout will be analyzed in the C-Plan. Additionally, the behavior and environmental effects of a low probability, large spill are addressed in the following sections.

5.4.2 Behavior of Spilled Oil

The chemical and physical characteristics and toxicity of oil spilled on water or on land undergo a progressive series of changes. Collectively, these processes are referred to as weathering or aging of the oil and, along with the physical oceanography and meteorology, the weathering processes determine the oil's fate. The major oil-weathering processes are spreading, evaporation, dispersion, dissolution, emulsification, microbial degradation, photochemical oxidation and sedimentation to the seafloor (Payne et al., 1987; Boehm, 1987). Weathering rates are usually higher in the first few hours of a spill and are highly dependent on the type of oil spilled. The lighter and more volatile components of the spilled oil are lost most rapidly. Consequently, the Point Thomson condensate product is expected to weather much faster than most crudes, which contain a smaller proportion of light fractions.

5.4.2.1 Characteristics of Point Thomson Condensate

The Point Thomson condensate is the hydrocarbon liquid that condenses from the natural gas stream as the stream is expanded from the high pressure, high temperature reservoir conditions to the lower pressure, cooler conditions in the surface production, gathering and processing facilities. It is a low-density, low-viscosity hydrocarbon liquid at standard conditions (i.e. atmospheric pressure and 60° F) with a tendency to emit hydrocarbon vapors similar to the volatility of kerosene. The export condensate is expected to be a cloudy to light brown liquid that contains a small amount of sediment and water (combined total volume less than 0.35%) and small amounts of other liquid hydrocarbon constituents.

The predicted compositions of the gas stream are in Table 5-5. The predicted chemical and physical properties of the Point Thomson export condensate (i.e. the sales quality condensate that will exist downstream) are listed in Table 5-6. The three-phase product in the gathering pipelines, prior to production and processing, contains gas, condensate (similar in composition to the export condensate) and produced water. As the pressure is dropped in the CPF, additional condensate condenses from the gas phase. The produced water may contain heavy metals, salts, and other constituents as listed in Table 5-7. The concentrations of sodium, chloride, and total dissolved solids (TDS) may exceed Alaska's water quality standards if spilled into the aquatic environment. Therefore, cleanup of any spilled produced water would be performed according to the applicable regulations.

The Point Thomson condensate has physical characteristics that are more similar to refined petroleum products like gasoline and kerosene than the crude oil produced at most other Alaska North Slope assets. Table 5-8 compares typical standard physical characteristics of the condensate with crude oils and other selected refined petroleum products.

Table 5-5 Expected gas stream compositions (Typical Mole Fraction)

CHEMICAL	PRODUCED GAS/CONDENSATE	INJECTED GAS	EXPORT CONDENSATE
Nitrogen, N_2	0.6231	0.650	0.000
Carbon Dioxide, CO_2	4.385	4.490	0.080
Methane, C_1	83.5878	86.940	0.120
Ethane, C_2	4.2057	4.270	0.300
Propane, C_3	1.7229	1.630	0.990
i-Butane, iC_4	0.3578	0.320	0.680
n-Butane, nC_4	0.6254	0.530	1.900
i-Pentane, iC_5	0.2476	0.200	1.510
n-Pentane, nC_5	0.2672	0.200	1.950
C_6	0.4699	0.240	6.810
n-Heptane, C_7	0.4478	0.170	8.040
Octane, C_8	0.474	0.130	9.880
Nonane, C_9	0.3561	0.070	8.040
Dodecane, C_{12}	1.2247	0.100	31.610
Heptadecane, C_{17}	0.6758	0.010	18.620
C_{27}	0.2807	0.000	7.810
C_{42}	0.0409	0.000	1.140
C_{65}	0.0069	0.000	0.190
C_{86}+	0.0007	0.000	0.020
Water, H_2O	0.000	0.050	0.310
Total:	100.000	100.000	100.000

Table 5-6 Export Condensate Physical and Chemical Properties (60 °F)

Vapor/Phase Fraction		0.0000
Molecular Weight		169.0
Molar Density	(lbmole/ft3)	0.3009
Mass Density	(lb/ft3)	50.86
Std Liquid Mass Density	(lb/ft3)	52.83
Molar Heat Capacity	(Btu/lbmole-F)	82.44
Mass Heat Capacity	(Btu/lb-F)	0.4878
Thermal Conductivity	(Btu/hr-ft-F)	0.07329
Viscosity	(cP)	1.400
Surface Tension	(dyne/cm)	19.69
Z Factor		0.6985
Molar Volume	(ft3/lbmole)	3.323
Watson K		11.54
Kinematic Viscosity	(cSt)	1.718
CP/Cv		1.115

Table 5-7 Composition of Produced Water (mg/l).

CHEMICAL	CONCENTRATION (mg/l)
Sodium	23,181
Potassium	230
Calcium	1620
Magnesium	225
Iron	0
Sulfate	0
Chloride	39,000*
Carbonate	0
Bicarbonate	842
Hydroxide	0
TDS	64,671

*Point Thomson sands contain 30,000 to 45,000 mg/l Chloride.

Table 5-8 Comparison of Typical Physical Characteristics of Condensate, Crude Oil, and Selected Refined Petroleum Products.

	SPECIFIC GRAVITY 15 °C	VISCOSITY cs (38 °C)	POUR POINT (°C)
Condensate	0.78 to 0.80	4 to 10	unknown
Crude Oil	0.8 to 0.95	20 to 1,000	-35 to 10
Gasoline	0.65 to 0.75	4 to 10	na
No. 2 Fuel Oil (diesel)	0.85	15	-20
Kerosene	0.8	1.5	na

5.4.2.2 Weathering

The physical properties of a hydrocarbon liquid (hereafter referred to as "oil"), the environment in which it is spilled, and the source and rate of the spill will affect how an oil spill behaves and weathers. The spreading of a slick, as well as the rates and extent of emulsification, evaporation, and biodegradation processes, are intimately related to the physical and chemical properties of the spilled liquid. These properties include specific gravity, surface tension, viscosity, pour point, and changes in these parameters with time. By convention, these properties are measured at a standard temperature and atmospheric pressure. However, the physical properties of an oil will vary depending on local environmental conditions and may deviate considerably from values reported for "standard" conditions.

The following is a general description of the significant physical properties that affect oil spills to provide a comparison between the known behaviors of crude and other oils with the Point Thomson condensate (Fingas et. al., 1979). The fate of a hypothetical worst-case spill, or well blowout scenario, at Point Thomson will be described in detail in the C-Plan.

- *Specific gravity*, or the ratio of the mass of the oil to the mass of an equivalent volume of water, affects its dispersion in water. Since the specific gravity of virtually all oil products is less than 1.0, they will float on water. Generally speaking, the condensate and other oils with low specific gravities, have low viscosities, low adhesion properties, and high emulsification tendencies.
- *Surface tension*, in conjunction with viscosity, affects the rate at which an oil spill spreads over the water or land surface, or into the ground. The lower the surface tension of an oil, the greater its potential spreading rate. Low surface tensions are characteristic of low specific gravity oils such as the predicted condensate at Point Thomson. As temperature decreases, surface tension increases, and consequently the rate of spreading of a slick will decrease.
- *Viscosity* is a measure of the flow resistance of a fluid; the lower the viscosity the easier it flows. Like other physical properties of oils, viscosity is also affected by temperature, such that viscosity is greater at cooler temperatures. The condensate is expected to have low viscosity and the spreading rate on water and penetration into unfrozen soil of a spill from Point Thomson will be similar to that of diesel fuel at low temperatures.
- *Pour point* of oil is the temperature at which it becomes a semi-solid or "plastic" and will not flow. This effect is the result of the formation of an internal microcrystalline structure and overrides the effects of viscosity and surface tension. Although the pour point for Pt. Thomson condensate had not yet been tested, lighter oils with low viscosites, such as the expected condensate, tend to have low pour points. If the pour point is lower than the coldest temperatures expected on the North Slope, the condensate is expected to remain a liquid and rapidly penetrate most unfrozen granular beach substrates and soils. If the pour point is higher than ambient temperatures, the condensate may become a semi-solid consistency and stay on top of the ground when spilled.

In summary, a large portion of the gas/condensate produced at Point Thomson is expected to rapidly volatilize under most conditions. The remaining spilled liquid is expected to have weathering characteristics more like light fuel oils than crude oil when spilled. When compared to crude oil, it is expected to have relatively low specific gravity, low surface tension, low viscosity, and low adhesion. These properties indicate that spilled condensate should volatize faster than crude oil and prior to volatilization, it may spread and emulsify more rapidly on water.

5.4.2.3 Environmental Fate

The Point Thomson project's focus is the recovery of hydrocarbon condensate from a high-pressure retrograde gas reservoir. To provide a better idea of the effects of a large spill (i.e. for a well blowout) of the Point Thomson product, this section describes the environmental fates of the produced gas/condensate's major constituents (Refer to Table 5-5).

Approximately 61% of the produced gas/condensate's mass (90% of the mole fraction) consists of light-end hydrocarbons (C_1 to C_3 and C_6), while about 23.6% of the mass (3% of the mole fraction) consists of the heavy-end hydrocarbons (C_8 and above) with carbon dioxide making up most of the remaining fraction. This section summarizes a risk assessment performed by Zelenka and Steinberg (2001) where exposures to maximum one-hour concentrations of the major constituents provide conservative estimates of acute effects from exposure to them. This analysis assumes there is no snow or ice cover and that methane, ethane, and propane do not persist in the environment and do not exhibit chronic effects on humans, animals, or vegetation.

Light-End Fraction (C_1 to C_3 and C_6)

The largest fraction of the produced gas/condensate's composition consists of methane, ethane, and propane (C_1 to C_3). A conservative risk of benzene was used, where 100% of the C_6 portion of the condensate is considered benzene. Zelenka and Steinberg (2001) provide a summary of relevant physical/chemical properties for methane, ethane, propane, and benzene that are included in Table 5-9.

The environmental fates of these hydrocarbon gases were reported by Zelenka and Steinberg (2001) as fates in atmospheric, terrestrial, and aquatic environments and summarized here. In the ambient atmosphere, all four of these hydrocarbon gases are expected to exist entirely in the vapor phase, based on their calculated vapor pressures at 25 °C (77 °F). Methane, ethane, and propane are not expected to undergo direct photolysis in the atmosphere. And, direct photolysis should not be an important degradation process of benzene. Methane is expected to be unreactive towards ozone molecules. Vapor phase reactions with photochemically produced hydroxyl radicals in the atmosphere have been shown to occur for ethane and propane. Vapor-phase benzene is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals in air, the half life for which is about 13 days at 25 °C (77 °F).

In soils, photolysis or hydrolysis of methane, ethane, and propane is not expected to be important. Biodegredation and, to a lesser extent, adsorption of methane, ethane, and propane may occur in soil, but volatilization is expected to be the dominant fate process. Methane is calculated to have low mobility in soils and its high vapor pressure suggests that this gas may permeate through soil; however, under ambient conditions methane is a gas and therefore is expected to rapidly volatize from surface soils. Ethane and propane are characterized as having medium mobility in soils and should rapidly volatilize from most surface soils. Benzene has high mobility in soil. Significant volatilization of benzene from moist soil surfaces and also potential volatilization from dry soil is predicted. Based on a study in a base-rich para-brownish soil, benzene is expected to biodegrade. However, anaerobic degradation of benzene in soil is not expected to be an important loss process based on various studies (Zelenka and Steinberg 2001).

Table 5-9 Relevant Physical/Chemical Properties for Methane, Ethane, Propane, and Benzene

CHEMICAL NAME	METHANE	ETHANE	PROPANE	BENZENE
CAS RN	74-82-8	74-84-0	74-98-6	71-43-2
Molecular Formula	CH_4	C_2H_6	C_3H_8	C_6H_6
Appearance/State (760mmHg & 25°C)	Odorless, Colorless gas	Odorless, colorless gas	Odorless, Colorless gas	Colorless to light-yellow liquid
Molecular Weight	16.042	30.069	44.096	78.11
Boiling Point (°C)	-161.49	-88.63	-42.07	80.1
Melting Point (°C)	N/A	N/A	N/A	5.5
Flash Point (°C)	-187.78	-135.0	-183.27	-11
Flammability Limits (lower %)	5	3	2.1	1.2
Vapor Pressure (mm Hg)	30,400 @ -80.3°C	31,459 (calc.) @ 25°C	7,162 @ 25°C	94.8 @ 25°C
Vapor Density @ 25°C (Air = 1)	0.55	1.04	1.56	2.77 (@ 20°C)
Water Solubility	Very slight	Insoluble	Slight	Slight
Odor Threshold	303 mg/m^3	185-1106 mg/m^3	1800-36,000 mg/m^3	4.8 - 38.4 mg/m^3
Conversion Factors	1 ppm=0.66 mg/m^3 1 mg/m^3=1.515 ppm	1 ppm=1.23 mg/m^3 1 mg/m^3=0.813 ppm	1 ppm=1.80 mg/m^3 1 mg/m^3=0.555 ppm	1 ppm=3.25mg/m^3 1 mg/m^3=0.31ppm

In aquatic environments, methane, ethane, and propane are not expected to undergo significant photolysis or hydrolysis. Methane and propane are only slightly soluble and ethane is insoluble in water. Methane may permeate through organic matter contained in sediments and suspended materials, while ethane and propane may partition from the water column to these materials. Benzene is not expected to adsorb to sediment and suspended solids in water.

Biodegradation of these hydrocarbon gases may occur in aquatic environments to a limited degree, but volatilization is expected to be more significant. Rapid volatilization from environmental waters is predicted. A volatilization half-life from a model river is estimated to be 1.17 hours for methane, 1.5 hours for ethane, 1.9 hours for propane, and 1 hour for benzene. The half-life from a model environmental pond, which considered the effect of adsorption, was estimated to be about 14 hours for methane, 1.9 days for ethane, 2.3 days for propane, and 3.5 days for benzene. The half-life of benzene in seawater was reported to be about 5 hours.

__Heavy-End Fraction (C_8 and above)__

The assessment of a blowout at the Point Thomson gas condensate field indicates that octane and higher molecular weight paraffin droplets are likely to settle on the ground before evaporating. Therefore the environmental fate and effects of the heavy-end fraction (C_8 and above) are provided. Table 5-10 summarizes relevant physical/chemical properties for the C_8 to C_{27} hydrocarbons (EPIWIN model, USEPA version 3.04).

In the atmosphere, rapid oxidation (half-life 15.5 hours or less) is expected for paraffins C_8 and above. Based on Log K_{oc} values, moderate adsorption to soil or sediment is expected for C_8 to

C_{12} paraffins and high adsorption to soil or sediment is expected for C_{17} to C_{27} paraffins. Low water solubility is estimated for paraffins C_{12} and above. Based on Henry's Law Constant, rapid volatilization from water is expected for paraffins C_8 and above. In general, the heavy-end hydrocarbons (C_9 to C_{27}) have a low potential for bioconcentration (BCF < 1000), with the exception of octane (C_8), which has high bioconcentration potential.

Table 5-10 Relevant Physical/Chemical Properties for Paraffins $\geq C_8$.

PROPERTY	OCTANE C_8	NONANE C_9	DODECANE C_{12}	C_{17}	C_{27}
Log K_{ow}	5.18*	4.76	6.10*	8.69	13.60
Water Solubility (mg/L @ 25 °C)	1.152	2.329	0.1099	2.938e-4	2.834e-9
Henry's Law Constant (atm-m^3/mole)	3.21*	3.40*	8.24*	38.5	655
Atmospheric Oxidation, Hydroxyl Radicals Half-Life (hours)	15.493	13.236	9.210	6.111	3.653
Half-Life from Model River (hours)	1.091	1.156	1.332	1.582	1.991
Half-Life from Model Lake (hours)	101.5	107.6	124.0	147.3	185.3
Log K_{oc}	2.705	2.971	3.768	5.097	7.756
Bioconcentration Factor	1,944	92.51	314.1	9.876	3.162

*measured value; other values estimated (source EPIWIN model USEPA version 3.04).

Table 5-11 is based on the EQC model (version 1.01 May 1997) which is primarily the work of Mackay et al. (1996). This table shows that C_8 to C_{12} paraffins will partition largely to air. The C_8 to C_{12} paraffin droplets that settle on the ground will evaporate, for the most part. Table 5-10 shows that a C_{16} paraffin will partition predominantly to air and to soil. It is expected that paraffins partitioning to soil will biodegrade over time. Most experiments provide optimistic biodegredation rates (i.e. 83% of C_{13} in 28 days) that were performed at temperatures higher that those anticipated for most of the year at Point Thomson (EBSI 1996). While biodegradation is expected, it will occur at a slower rate.

Although half-lives of 1 to 2 hours are estimated for a river and half-lives of 101 to 147 hours are estimated for a lake (C_8 to C_{17}, Table 5-10), Table 5-11 shows that an insignificant amount of C_8 and above paraffins will enter water. Although octane has a high potential for bioconcentration, Table 5-10 shows that an insignificant amount of octane will partition into water or fish.

Table 5-11 EQC Level I Environmental Partitioning of Paraffins $\geq C_8$.

Compartment	Octane C_8	n-Nonane C_9	Dodecane C_{12}	Iso-Hexadecane C_{16}	n-Hexadecane C_{16}
% Air	99.8	99.2	93.3	68.4	24.5
% Water	0.012	0.015	4.37e-3	3.41e-4	5.26e-4
% Soil	0.0196	0.768	6.569	30.9	73.8
% Sediment	4.35e-3	0.017	0.146	0.687	1.639
% Suspended Sediment	1.36e-4	5.33e-4	4.56e-3	0.021	0.051
% Fish	1.11e-5	4.33e-5	3.71e-4	1.75e-3	4.16e-3

5.4.3 Spill Effects

There is considerable evidence that the nature of biological damage resulting from an oil spill is also directly related to the oil type. The capacity of an oil to smother and dislodge organisms is determined by its physical characteristics, while toxicity is more closely related to its chemical composition. For example, spills of heavy fuel oils and some crude oils may result in damage to intertidal organisms due to smothering or displacement from shoreline surfaces. On the other hand, light fuel oils have a higher proportion of aromatic hydrocarbons than heavy fuel oils and are generally more toxic to aquatic organisms (Fingas et al. 1979). Effects to organisms in a spill situation vary depending on a number of factors including

- time of year (species present),
- oil type (viscosity and composition),
- volume, extent, and location of the spill,
- local weathering conditions,
- sensitivity of species and life history stage present,
- exposure time of organisms,
- success of containment or cleanup, and
- time to detection.

This section describes the potential effects of a Point Thomson produced gas/condensate spill on organisms expected in the development area. Zelenka and Steinberg (2001) provided the information regarding the effects of methane, ethane, propane, and benzene that are summarized in this section. For this hazard assessment, it was assumed that there was no snow or ice cover. Due to the lack of sufficient experimental data regarding the effects of the condensate product on specific local species, the focus of this analysis is on known effects from exposure to the condensate's constituents. The estimated concentrations at which these various effects occur may vary somewhat. Since the light end, hydrocarbon gas fraction (C_1 to C_3 and C_6) do not persist in the environment, they do not exhibit chronic effects on humans, animals, or vegetation. Similarly, C_8 to C_{12} paraffins deposited on the ground will evaporate over time and C_{16} paraffins and above that adsorb to soil are expected to biodegrade over time. For this reason, acute effects are the focus of this discussion. Refer to Section 4 for a description of the potentially affected animal and plant species. Effects upon subsistence are discussed in Section 5.3.

5.4.3.1 Human Health Effects

Methane, ethane, and propane all present a flammable hazard, act as asphyxiates by displacing oxygen in air, and cause Central Nervous System (CNS) depression, or narcosis, at high concentrations. Each of these gases are considered asphyxiates at a concentration of 140,000 parts per million (ppm). Methane is predicted to induce CNS effects at 300,000 ppm, but since it displaces oxygen in air at 140,000 ppm it is considered to be a simple asphyxiant. Ethane and propane are thought to induce narcosis at 130,000 ppm and 47,000 ppm respectively, indicating these gases are fast-acting agents of narcosis, with symptoms of loss of judgment, disorientation, dizziness, and light-headedness. CNS effects are expected to occur in less than 15 minutes (min) following inhalation exposures to these gases. However, this occurs at concentrations above their lower explosive limits (LEL) of 50,000 ppm methane, 30,000 ppm ethane, and 21,200 ppm propane therefore these gases present a low hazard potential overall. Due to the normal physical state of methane, ethane, and propane it is unlikely that humans will experience oral or dermal exposure. However, contact with ethane and propane in compressed liquid from can cause frostbite injury to the skin or eyes (Cavender 1994).

Under the proposed revised Carcinogen Risk Assessment Guidelines, benzene is characterized as a known human carcinogen for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies (USEPA 1998). Benzene toxicity is well studied and its effects are highlighted below. However, it should be noted that the benzene concentration in the Point Thomson condensate is highly unlikely to approach the levels assumed for this report.

Inhalation of benzene in concentrations of 300 ppm can be endured for up to an hour, after which it is thought that acute CNS effects including vertigo, drowsiness, headache, and nausea may occur. Exposure to concentrations of 20,000 ppm can be fatal in 5 to 10 min (Gerarde 1960). Unspecified high concentrations can also lead to cardiac arrhythmia and ventricular fibrillation. As a liquid, benzene may be ingested, and its oral toxicity is considered relatively low. It has been estimated that a concentration of 10 milliliters (ml) would be a lethal dose in humans (Thienes and Haley 1972). Although benzene is not thought to have acute dermal toxicity, caution should be considered since dermal contact with benzene could contribute to the total dose received.

Most research on the chronic toxicity of benzene has involved its propensity to cause leukemia in humans. Studies suggest that benzene exposures of 35 to 100 ppm can result in a 4 to 20 fold increase in the risk of leukemia. Benzene may have a unique effect on acute myelogenous leukemia and its variants, rather than all leukemias (EBSI 1996). In contrast, chronic lymphocytic leukemia is a predominant leukemia cell type in the population at large. There is conflicting data regarding the hematologic effects of benzene exposure. However, it appears that benzene exposure does show some effects on cytopenias, especially of white and red blood cells at exposures down to 35 ppm.

5.4.3.2 Effects on Animals

Available data regarding CNS effects from inhalation of methane, ethane, and propane on animals is limited to a study in rats exposed to high concentrations of propane (290,000 ppm) where rats exhibited severe CNS effects including ataxia and loss of righting within 10 min (Clark and Tinston, 1982). Methane and ethane are simple asphyxiants and can cause suffocation by displacement of oxygen from breathing atmosphere below the critical level of 16% oxygen required to maintain life. Ingestion and dermal exposure to methane, ethane, and propane is considered unlikely under normal conditions due to their gaseous states, hence no toxicity data for these exposure routes is readily available. Overall, the potential acute toxicity for these gases is considered low.

Acute exposure of animals to high levels of benzene by all routes produces CNS effects including loss of righting reflex, ataxia, tremors, coma and death. Table 5-12 summarizes the key toxicological effects on animals from inhalation of methane, ethane, propane, and benzene. The oral toxicity of benzene has been studied by (Cornish and Ryan 1965 and Wolf et al. 1956) and it was found that, in rats, the oral LD_{50} to benzene is between 930 to 5,600 milligrams per kilogram (mg/kg) (equivalent to ppm). The dermal LD_{50} (rabbits) to benzene is greater than 2,000 mg/kg (Roudabush et al. 1965).

Chronic effects of long-term exposure to benzene have been studied in rats and mice and found to produce cancer of the hematopoietic system, particularly lymphomas. Additionally, it is thought that significant effects from chronic exposure to benzene in animals includes bone marrow and immunological effects. Genotoxicity of benzene was reviewed and it was determined that, in the absence of metabolic activation, benzene did not produce mutations in most of the standard short-term tests.

Table 5-12 Summary of Acute Toxicity Of Methane, Ethane, Propane, And Benzene in Animals.

HC GAS	EFFECTS				
	CONCENTRATION (ppm)	SPECIES	DEFINITION	TIME OF ONSET	REFERENCE
Methane	870,000	Mouse	Asphyxiation		Hathaway et al., 1991; Low et al., 1987
	900,000	Mouse	Respiratory arrest		
Ethane	150,000-900,000	Dog	Cardiac arrhythmia		Krantz et al.,1948
Propane	LC_{50} = > 800,000	Rat		15 min.	Clark and Tinston, 1982
	100,000-200,000	Monkey	Respiratory depression	15 min.	Aviado, 1975
	24,000-29,000	Guinea pig	Irregular breathing	5 to 120 min.	Low et al., 1987
	47,000-55,000	Guinea pig	Tremors	5 to 120 min.	
	25,000	Dog	Changes in blood pressure		Aviado et al., 1977
	33,000	Dog	Changes is BP, heart stroke rate/volume, pulmonary vascular resistance		
	100,000-200,000	Dog	Cardiac arrhythmia (17% of the time) Multiple ventricular beats (58% of the time)	5 min.	Reinhardt et al., 1971
	EC_{50} = 180,000	Dog	Cardiac arrhythmia to epinephrine	5 min.	Kirwin and Thomas, 1980
	EC_{50} = 100,000	Mouse	Cardiac arrhythmia to epinephrine	5 min.	Aviado, 1975
	EC_{50} = 280,000	Rat	CNS depression	10 min.	Clark and Tinston, 1982
Benzene	LC_{50} = 13,700	Rat		4 hr.	Drew and Fouts, 1974
	LC_{50} = 9,980	Mouse			Lewis, 1996

Limited data is available regarding the environmental toxicity of the individual heavy-end hydrocarbons (C_8 and above), which is summarized in Table 5-12. Some of the toxicity values reported in this table are above the estimated water solubilities of the hydrocarbon. Octane (C_8) is shown to be toxic to aquatic organisms (LC_{50} or EC_{50} ranges from 0.001 to 0.9 milligrams per liter [mg/L] or ppm). However, since an insignificant amount of octane will partition into water (refer to Table 5-11), toxicity effects of octane on fish are considered insignificant.

Nonane had LC_{50} or EC_{50} values of 0.2 mg/L for two species of aquatic invertebrates. No acute toxicity was observed for another aquatic invertebrate (mysid) exposed to nonane. No acute toxicity was observed for three species of aquatic invertebrates exposed to C_{10} to C_{14} paraffins.

An insignificant amount of C_8 paraffins and above is expected to enter water. It is not anticipated that the exposure concentrations and durations that resulted in adverse effects in the laboratory will occur in receiving waters due to advection and dilution. For terrestrial animal exposure, C_8 to C_{12} paraffins deposited on the ground will evaporate over time and C_{16} and above paraffins that absorb into soil are expected to biodegrade over time. Therefore, long-term exposure to these hydrocarbons is not expected.

Table 5-13 Environmental Toxicity of Paraffins $\geq C_8$

SPECIES	COMMON NAME	EXPOSURE	ENDPOINT	VALUE	REFERENCE
Daphnia magna	Water flea	48 hours	EC_{50} Immobilization	0.2 mg/L* n-nonane 0.3 to 0.4 mg/L* octane	Adema & Bakker 1987
Chaetogammarus marinus	Amphipod	96 hours	LC_{50} Mortality	0.2 mg/L* n-nonane 0.3 to 0.9 mg/L* octane	Adema & Bakker 1987
Mysidopsis bahia	Mysid	96 hours	LC_{50} Mortality	Acute toxicity > water solubility of n-nonane 0.3 to 0.4 mg/L* octane	Adema & Bakker 1987
Daphnia magna *Chaetogammarus marinus* *Mysidopsis bahia*	Water flea Amphipod Mysid	48 hours 96 hours 96 hours	EC_{50} Immobilization LC_{50} Mortality LC_{50} Mortality	Acute toxicity > water solubility of n-decane, n-dodecane, n-tetradecane	Adema & Bakker 1987
Daucus carota *Helianthus annuus*	Wild carrot Common sunflower	7 hours	Leaf damage indicated by change in conductance, when 2 ml n-nonane, n-dodecane, or n-hexadecane added to 5 g of excised leaves	No effect	Boyles 1976 (study on C9 + only)
Lactuca sativa	Lettuce	14 days	EC_{50} growth	> 1,000 μg/g soil decane	Hulzebos et al. 1993 (study on C9 + only)

Table 5-13 (Cont.) Environmental Toxicity of Paraffins ≥ C_8

SPECIES	COMMON NAME	EXPOSURE	ENDPOINT	VALUE	REFERENCE
Lycopersicon esculentum	Tomato	14 to 42 days	Leaf and bud damage following application of 0.05 to 0.10 M dodecane	No effect	Tucker 1975 (study on C9 + only)
Artemia salina	Brine shrimp	24 hours	LC_{50} mortality	3.5 mmol/m^3 octane	Abernethy et al. 1986 (study on octane only)
Mytilus edulis	Blue mussel	< 1.7 hours	EC_{50} feeding behavior	0.10 to 0.13 mg/L octane	Donkin et al. 1989 (study on octane only)
Skeletonema costatum	Diatom	9 hours	EC_{50} physiology	0.001 mg/L octane	Brooks et al. 1977 (study on octane only)
Crassostrea gigas	Pacific oyster	48 hours	mortality	3,500 mg/L octane	Legore 1974 (study on octane only)
Oncorhynchus kisutch	Coho salmon	96 hours	Mortality	100 mg/L octane	Morrow et al 1975 (study on octane only)
Tetrahymena pyriformis	Ciliate	24 hours	Mortality	3.9 mmol/m^3 octane	Rogerson et al. 1983 (study on octane only)
Squalus acanthias	Spiny dogfish	72 hours	Mortality	10 mg/kg octane	Guarino et al. 1976 (study on octane only)
Avena sativa Brassica rapa	Common oat Bird rape	14 days	EC_{50} Growth	> 1,000 mg/kg octane	Kordel 1984 (study on octane only)
Daucus carota Helianthus annuus	Wild carrot Common sunflower	7 hours	Leaf damage indicated by change in conductance, when 2 ml n-octane added to 5 g of excised leaves	No effect octane	Boyles 1976 (study on octane only)
Lactuca sativa	Lettuce	14 days	EC_{50} growth	> 1,000 µg/g soil octane	Hulzebos et al. 1993 (study on octane only)

*analytical verification

It should be pointed out that the toxicological experiments shown in Tables 5-12 and 5-13 were performed under laboratory conditions on laboratory animals. For this reason, the study results might not be considered applicable to the local species expected in the Point Thomson project area (Refer to Section 4 for a description biological resources). However, the range of species tested and the high exposures required to exert toxic effects on these species provide assurance that significant toxic effects on local species from a condensate spill would be minimal.

5.4.3.3 *Effects on Vegetation*

Based on available literature, no significant adverse effects due to a release of Point Thomson gas/condensate are expected for terrestrial vegetation unless volumes of material are sufficient to smother plants. The volume of gas/condensate required to smother vegetation has not been studied. Experiments on plant-growth dynamics containing a mixture of methane, ethane, and propane were performed to study the effect on the ultrastructure of the plant photosynthetic apparatus for maize (*Zea mays*) and ryegrass (*Arrhenetherum elarius*). The study concluded that only after high doses or prolonged exposure of the gases, irreversible damage of the plant cell ultrastructure and even plant death may occur and overall, maize and raygrass exhibited high resistance against the action of these substances (Buadze and Kvesitadze 1997). Environmental toxicity of paraffins C_8 and above is summarized in Table 5-13. No adverse effects were observed in five species of plants exposed to octane and four species of plants exposed to C_9 to C_{16} paraffins.

In summary, based on the known properties of the gas/condensate and limited experimental laboratory data available, the Point Thomson gas/condensate is expected to have a low hazard potential overall. This is due to the expected gaseous physical state of methane, ethane, and propane and the predicted rapid volatilization of the heavy-end hydrocarbons. Any liquid light-end fraction or heavy-end paraffins that do not immediately volatilize and are deposited on the ground are expected to evaporate and degrade in a relatively short amount of time, limiting the risk exposure of these components. The light-end hydrocarbons, as a gas, are considered a fire hazard and may cause asphyxia in humans and animals at high concentrations. Benzene is considered to be the component of primary concern and has been shown to have acute toxic effects in humans and animals via all exposure paths. These include CNS effects including vertigo, drowsiness, headache, and nausea as well as chronic effects such as cancer of the hematologic system (lymphoma) caused by long-term exposure.

Lacking sufficient data regarding the effects of natural gas/condensate on Arctic animal and plant species, it cannot be assumed that a large spill of Point Thomson gas/condensate would have the same or fewer effects as the relatively well known consequences caused by a crude oil spill. However, the range of species tested and the high exposures required to exert toxic effects on these species provide assurance that significant toxic effects on local species from a gas/condensate spill would be minimal. Furthermore, the probability of a large oil spill from a gas field such as Point Thomson is extremely low, which provides additional assurance that the hazard potential is low.

This page intentionally left blank

6.0 MITIGATION MEASURES

Mitigation measures are specific controls integrated into the project design and operations. The measures are intended to alleviate potential impacts to the physical, biological or human environment that could occur due to the (project) construction and/or operations. This section describes potential mitigation measures that could be considered in the design of the proposed Point Thomson Gas Cycling Development Project. Potential mitigation measures organized by environmental issues are summarized in Table 6-1. The table also discusses the anticipated effect or benefit of each measure.

Primary construction mitigation measures include:

- Access to site by a local dock and airstrip eliminate construction of an access road from the existing road system (Endicott & Prudhoe Bay Unit) located 40 miles to the west
- Separation of roads and elevated pipelines by sufficient distances to minimize obstruction impacts on wildlife,
- Avoidance of high value wildlife habitats (salt marshes, lagoon, etc.) in siting of structures
- Reuse of existing gravel pads where practicable.

To minimize environmental impact, all construction involving on-tundra activities will take place during winter. These activities include pipeline construction from ice roads and ice pads, access to and development of the gravel mine site, and construction of the pads, airstrip, and in-field access roads. While placement of gravel for the dock is proposed for winter, associated dredging will occur in the summer.

By conducting major construction activities in winter, disturbance to wildlife will be minimized, and impacts to tundra, other than those specifically authorized by permit, will also be minimized. Minor displacement of some breeding birds is anticipated as a result of construction of the pads and roads. Noise and other disturbances associated with the drilling and production operations will occur at the production sites; however, these changes are not expected to influence either breeding success or population dynamics of the species involved (see Troy and Carpenter 1990).

Similarly, caribou may be displaced from some areas of the project site; however, experience from the North Slope oil fields indicates that caribou will use gravel pads and other facilities as insect relief habitat because insect abundance is often lower on gravel pads compared to undisturbed tundra (LGL 1993b and Pollard and Noel 1994).

Measures used for protecting air and water quality, and for managing wastes during construction, will be continued as appropriate through project operation. These measures are also summarized in Table 6-1.

Table 6-1 Potential Mitigation Measures

ISSUE/RESOURCE	POTENTIAL MITIGATION MEASURE	EFFECT
General	1) Maintain continual on-site environmental presence during construction and operation following ExxonMobil Operation Integrity Management System (OIMS) guidelines 2) Strictly enforce speed limits within project areas; train personnel in interactions with wildlife 3) Establish an environmental/cultural awareness and training program 4) Conduct permit compliance training 5) Conduct periodic health, safety and environmental compliance audits	1) Assure compliance with permit requirements and all applicable federal, state, and local laws 2) Reduce potential for impacts on wildlife, reduce accidents and spill potential on tundra, sea ice, and marine environment 3) Both 1) and 2) above 4) Same as 1) 5) Independent performance assessment
Air Quality	1) a) Design uses natural gas fired turbines as drivers for compressors, and thus minimizes diesel-fired sources b) Reduce emissions of nitrous oxide (NO_x) through Best Available Control Technology (BACT) turbine selection c) Plan construction activities to stagger tasks and minimize concurrent sources d) Implement operational scenarios that minimize concurrent source operation e) Use of BACT (as per New Source Performance Standards) f) Design tanks with pressure/vacuum release devices and vapor recovery g) Water gravel surfaces to reduce dust generation h) Strictly enforce minimal speed limits 2) a) Minimize plume overlap by avoiding alignment of significant sources of NO_x in a NE/SW direction b) Where diesel fuel is necessary, use low sulfur grade where available c) Orient all equipment stacks vertically with no obstructions such as rain caps d) Design stacks 20 feet (6m) above rooftop and taller than tallest structure (may be incompatible with visual impacts mitigation). e) Utilize a halon-free fire suppression system	1) Reduce the volume of air emissions 2) Reduce the impact of air emissions

Table 6-1 (Cont.) Potential Mitigation Measures

ISSUE/RESOURCE	POTENTIAL MITIGATION MEASURE	EFFECT
Water Quality	1) a) Conduct gravel mining and construction during winter b) Locate pads, roads, and airstrip to minimize blockage of natural surface water drainage c) Locate gravel mine to minimize impacts to freshwater resources d) Use culverts and berm breaks to restore natural surface water drainage e) Limit water removal under ice in fish bearing water sources so as not to exacerbate low dissolved oxygen levels in winter	1) Minimize impacts due to construction/presence of facilities
	2) a) Eliminate operational discharges to the greatest extent possible by using injection wells as the primary disposal route b) Design facilities to minimize and control stormwater/snowmelt surface drainage c) Design and construct a wastewater treatment system for wastewater discharge should primary injection become unavailable d) Develop and implement treatment, and best management practices for all wastewater streams and stormwater discharges e) Manage snow removal	2) Minimize impacts due to permitted discharges
	3) a) Conduct continual-improvement employee training in proper refueling methods and use of authorized locations following ExxonMobil OIMS b) Provide proper storage locations for fuels and other fluids designed with appropriate secondary containment systems c) Limit refueling tasks to pre-defined locations that have appropriate secondary containment systems	3) Minimize impacts of spills and leaks

Table 6-1 (Cont.) Potential Mitigation Measures

ISSUE/RESOURCE	POTENTIAL MITIGATION MEASURE	EFFECT
Tundra/Wetlands	1) a) Minimize gravel pad footprints to meet operational needs b) Utilize Extended Reach Drilling directional drilling techniques (up to 20,000 ft [6,000 m]) c) Minimize infrastructure and infield road distances by selecting direct routes while minimizing encroachment to salt marsh d) Relocating East Well Pad to less optimal position to avoid impacts to salt march on point which would have been farther north e) Minimize infield access road crown width; use 2:1 slope f) Reuse Point Thomson #3 pad g) Do not build a gravel road connecting Point Thomson to oil fields located to the west h) Use ice roads for construction and seasonal access i) Reuse gravel from existing pads where possible	1) Reduce acres of tundra physically covered by gravel
	2) a) Conduct major construction efforts in winter for infield roads, pads, pipeline and airstrip b) Use of ice roads for seasonal access c) Based on hydrological studies, optimize siting of gravel mine, roads, stream crossings, and minor drainages to reduce alterations in surface water drainage patterns d) Design facilities to minimize impacts to drainage and permafrost e) Identify potential culvert requirements for infield roads to reduce alterations to surface water drainage patterns f) Prevent icing/blockage of culverts manual removal of ice when required; inspect to assure proper flow is occurring g) Utilize dust control measures such as applying water to roads and enforcing speed limits h) Institute and enforce environmental sensitivity training for construction and operations personnel i) Design emergency response and containment procedures in case of a spill j) Rehabilitate and re-seed any impacted areas and monitor restoration	2) Reduce tundra disturbance

Table 6-1 (Cont.) Potential Mitigation Measures

ISSUE/RESOURCE	POTENTIAL MITIGATION MEASURE	EFFECT
Fish and Fish Habitat (including anadromous, marine, and freshwater)	1) a) Do not use streams for water source in winter b) Limit work in streams in known spawning areas and prevent work during fish spawning runs, if any. c) Winter construction for gravel mining, infield roads, pads, pipeline, airstrip, and dock d) Prevent obstructions to fish migration due to roads e) Limit winter water withdrawal in fish bearing water sources, if any in area, to 15% of available water under ice.	1) Minimize direct impact/mortality of fish
	2) a) Based on hydrological studies, optimize siting of gravel mine, roads, and river crossings to reduce alterations to surface water drainage patterns b) Minimize stream crossings and construction activities in streams. c) Utilize arch or box culverts or bridges in larger streams d) Limit winter water withdrawal in any fish bearing water sources to 15% of available water under ice. e) Do not use streams for water source in winter f) Mine gravel for roads and pads during winter only and according to approved mining plan g) Conduct major construction efforts in winter for infield roads, pads, pipeline, airstrip and dock h) Do not cut stream banks for access, use ice or snow ramps i) Use appropriate means to stabilize banks j) Review and summarize existing data on nearshore oceanographic and hydrographic conditions and potential alterations due to construction of a dock in Lion's Lagoon (See Section 4.2 of this Environmental Report) k) Assure normal ice breakup by removing blockages in culverts and breaching ice roads as needed. l) Institute and enforce environmental sensitivity training for construction and operations personnel m) Only cross streams (tundra travel) where solidly frozen.	2) Maintain optimal fish habitat

Table 6-1 (Cont.) Potential Mitigation Measures

ISSUE/RESOURCE	POTENTIAL MITIGATION MEASURE	EFFECT
Wildlife and Habitat	1) Caribou and Muskoxen a) Use 5 ft (1.5m) high pipelines b) Design infield road and pipeline with a 500 ft (152.4m) separation c) Conduct major construction efforts in winter for infield roads, pads, pipeline and airstrip d) Route helicopters to minimize wildlife disturbance -- consultation with United States Fish and Wildlife Services (USFWS) e) Institute and enforce environmental sensitivity training for construction and operations personnel f) Strictly enforce speed limits within project area g) Institute a no hunting policy for site workers h) Prepare wildlife interaction plan	1) Minimize disturbance to migrating caribou and musk oxen
	2) Birds a) Where practicable, locate and avoid flyways, molting, and nesting areas. b) Review historical data and conduct baseline studies of use within the project area to optimize project siting and design c) Properly manage wastes and garbage d) Prohibit feeding by personnel e) Strictly enforce speed limits within project area f) Proper siting of culverts to minimize creation of temporary impoundments g) Limit water removal from freshwater lakes h) Limit aircraft to specific routes i) Prepare wildlife interaction plan	2) Minimize impacts to tundra nesting, waterfowl and predatory birds
	3) Other mammals including grizzly bear and fox a) Properly manage wastes b) Prohibit feeding by personnel c) Institute and enforce environmental sensitivity training for construction and operations personnel d) Strictly enforce speed limits within project area e) Use bear-proof dumpsters	3) Minimize impacts to these mammals

Table 6-1 (Cont.) Potential Mitigation Measures

Issue/Resource	Potential Mitigation Measure	Effect
Marine Mammals	1) Cetaceans a) Minimize construction noise especially during whale migration periods by using and maintaining high quality mufflers and sound proofing where available b) During fall and spring migration route vessel traffic inside the barrier islands and limit helicopter flights to overland routes to minimize disturbance to migrating whales c) Institute and enforce environmental resource sensitivity training for construction and operations personnel	1) Minimize disturbance to migrating whales
	2) Pinnipeds a) Minimize construction noise during all seasons by using and maintaining high quality mufflers and sound proofing where available b) Minimize offshore impacts by using the shortest possible dock, minimize barge trips by carrying full loads as much as possible c) Institute and enforce environmental resource sensitivity training for construction and operations personnel d) Avoid haul-out areas should any be identified in the transportation corridor e) Limit helicopter to overland flight routes f) Build sea-ice road on grounded ice (not seal habitat) g) Begin sea-ice road construction as early as possible	2) Minimize disturbance to pinnipeds, both long and short term residents in Lions lagoon
	3) Polar Bears a) Develop and implement polar bear interaction plan b) Partner with USFWS in yearly polar bear surveys and studies c) Conduct major construction efforts in winter for infield roads, pads, pipeline and airstrip d) Utilize facility design that minimizes polar bear and human interactions e) Locate and avoid historic polar bear denning areas f) Avoid dens by 1 mile g) Use forward-looking infrared (FLIR) technology to locate densities along ice road routes h) Ensure appropriate set back from denning areas i) Report any den encountered j) Manage wastes to avoid attracting polar bears k) Institute and enforce environmental sensitivity training for construction and operations personnel l) Prepare polar bear interaction plan m) Use bear-proof dumpsters	3) Minimize disturbance to denning polar bears in the project area.

Table 6-1 (Cont.) Potential Mitigation Measures

ISSUE/RESOURCE	POTENTIAL MITIGATION MEASURE	EFFECT
Threatened and Endangered Species	1) Spectacled and Steller's Eiders a) Coordinate with USFWS on Spectacled eider surveys b) Conduct major construction efforts in winter for infield roads, pads, pipeline and airstrip c) Institute and enforce environmental resource sensitivity training for construction and operations personnel 2) Bowhead whales a) Conduct major construction efforts in winter for the nearshore dock b) Minimize offshore impacts by using the shortest possible dock and efficient transportation methods c) During fall and spring migration route vessel traffic inside the barrier islands and limit helicopter flights to overland routes to minimize disturbance to migrating whales d) Institute and enforce environmental resource sensitivity training for construction and operations personnel	1) Protect these endangered/threatened species 2) (Same as 1)
Subsistence	1) a) Identify subsistence use and areas potentially affected by the project b) Conduct major construction efforts in winter for infield roads, pads, pipeline, and airstrip c) Prohibit hunting by construction and operations. Only allow fishing with required State license and following State regulations d) Route vessel traffic inside the barrier islands to minimize disturbance to subsistence activities. e) Institute and enforce subsistence resource sensitivity training for construction and operations personnel f) Obtain and respond to community input g) Coordinate offshore activities such as barge traffic with subsistence communities h) Develop conflict avoidance agreement for marine mammals, if needed	1) Minimize disturbance to subsistence resources and activities

Table 6-1 (Cont.) Potential Mitigation Measures

ISSUE/RESOURCE	POTENTIAL MITIGATION MEASURE	EFFECT
Cultural Resources	1) Archeological Sites a) Locate and avoid archeological sites b) Obtain and incorporate local information about important historical sites c) Maintain confidentiality of site locations d) Institute and enforce cultural resource sensitivity training for construction and operations personnel	1) Protect cultural resources in the Point Thomson area
Cultural Values	1) a) Obtain and respond to community input 2) a) Minimize visual impacts such as lights and structural profile b) Facility design to include no permanent road connecting project to state road system and other facilities and therefore no direct connection to other communities c) Institute and enforce cultural resource sensitivity training for construction and operations personnel d) Use local resources for construction and development labor	1) Ensure community input to project design and operations 2) Minimize impacts to local culture or ensure that impacts will be positive

Table 6-1 (Cont.) Potential Mitigation Measures

ISSUE/RESOURCE	POTENTIAL MITIGATION MEASURE	EFFECT
Spill Prevention	1) a) Design facility for zero discharge of drilling wastes b) Utilize corrosion resistant alloy for gathering lines c) Provide leak detection, monitoring and operating procedures for the gathering and sales lines. d) Use on-site fuel gas for power when it becomes available. Note: diesel will always be available for backup 2) a) Ensure adequate spill response equipment and personnel are available to respond b) Build spill controlling berm strategies into pad c) Locate pipeline route south of infield road so that road provides containment in case of a leak d) During construction, locate fuel storage and transfer locations away from river crossings and wetlands e) Use secondary containment at all fuel storage locations f) Train personnel in acceptable refueling procedures and allowed locations for refueling g) Use drip pans and liners during refueling and vehicle maintenance procedures	1) Reduce risk of spills/leaks 2) Reduce effect of spills; improve ability to respond/clean up spills
Recreational and Visual Effects	1) a) Utilize fuel gas for generator fuel, , energy efficiency , and emission controls b) Reduce indirect lighting as much as possible c) Reduce structural profile where practical. Highest structure is the microwave tower at approximately 300 feet. d) Use natural color schemes that blend with environment	1) Minimize emissions and visibility impacts

7.0 CUMULATIVE EFFECTS

A cumulative effect analysis is a requirement of the National Environmental Policy Act (NEPA). The Council on Environmental Quality (CEQ) regulations for implementing NEPA define cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7).

7.1 CUMULATIVE EFFECTS ANALYSIS OBJECTIVES

This Environmental Report (ER) is a pre-NEPA tool, following CEQ guidelines, with an objective of providing information to assist in determining the magnitude and significance of cumulative effects at a later date.

7.2 CUMULATIVE EFFECTS APPROACH

A well-designed cumulative effect analysis uses a procedure that is logical and reproducible. The cumulative effects procedure in this ER:

- Defines a spatial and temporal framework;
- Describes the potential direct and indirect effects of the Point Thomson Gas Cycling Project;
- Identifies external actions (e.g., human controlled activities and natural phenomena) that could have additive or synergistic effects;
- Uses a matrix process to screen effects that are potentially cumulative in nature;
- Identifies potential cumulative effects using criteria appropriate to the resource category in question; and
- Discusses the reasoning and assumptions used during the analyses.

The CEQ guidelines set forth 11 steps for analyzing cumulative effects that can be classified into four basic stages: scoping, organizing, screening, and evaluating (CEQ 1997). Table 7-1 summarizes how the Point Thomson Gas Cycling Project cumulative effects analysis was adapted to parallel the CEQ guidelines. The four stages are discussed below.

7.2.1 Scoping

Potential direct and indirect effects of the proposed project activities were identified using the project description (Section 3 of this ER) and affected environment information (Section 4 of this ER), Environmental Impact Statements (EIS) from other oil and gas projects, North Slope resource studies, and peer reviewed literature.

Two spatial or geographic areas were used in the cumulative effect analysis (Figure 7-1). The first is defined as a spatial area of interest from the Colville River east along the coastal plain to Kaktovik, from the coastal plain south to the Brooks Range, and seaward of the barrier islands to the north. This spatial area was used for the following resource categories:

- Fish
- Cetaceans (whales)
- Caribou (area modified, western boundary moved east to the Sagavanirktok River)
- Subsistence Issues
- Socioeconomic Issues (includes some North Slope Borough and statewide effects)

Table 7-1 Point Thomson Gas Cycling Project Cumulative Effects Analysis

RECOMMENDATIONS FROM CEQ (1997)	APPROACH USED IN POINT THOMSON ANALYSIS
A. Scoping: Identify Issues, Actions, and Boundaries	
1. Identify the significant cumulative effects issues associated with the proposed action [and alternatives], and define the assessment goals.	1. Review information provided in Sections 3.0 and 4.0 of the ER. Summarize predicted direct and indirect effects of the Point Thomson Gas Cycling.
2. Establish the geographic scope for the analysis.	2. Geographic scopes are defined in Section 7.2.1 of the ER.
3. Establish the time frame for the analysis.	3. The time frame is established as 1980 through 2020.
4. Identify other actions affecting the resources, ecosystems, and human communities of concern.	4. Review environmental impact statements, reports, resource studies, and peer-reviewed literature. Confer with expert contributors to the ER to identify other actions and issues of concern.
B. Organizing: Characterize and Consolidate Issues	
5. Characterize the resources, ecosystems, and human communities identified during scoping in terms of their response to change and capacity to withstand stresses.	5. Identify and characterize potentially affected resources and delineate the component parts/species of each resource category (organized into resource categories in Section 4 of the ER).
6. Characterize the stresses affecting the resources, ecosystems, and human communities and their relation to regulatory thresholds.	6. Evaluate all of the potential direct and indirect effects of the Point Thomson project on the specified resource categories (Section 5 of the ER).
7. Define a baseline condition for the resources, ecosystems, and human communities.	7. The baseline condition is defined as current Y2001 conditions.
C. Screening: Identify Potential Cumulative Effects	
8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.	8. Screening and matrix analyses for identified resource categories.
D. Evaluating: Rank by Magnitude and Probability	
9. Determine the magnitude and significance of cumulative effects.	9. A qualitative determination of identified cumulative effects was conducted.
10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.	10. The Point Thomson project could incorporate appropriate additional mitigation measures following NEPA review.
11. Monitor the cumulative effects of the selected alternative and adaptive management.	11. Monitoring and adaptive management would be conducted as needed.

The second spatial area of interest is from the Badami Facility east to the Canning River, north to the barrier islands, and to the southern boundary of the Point Thomson Unit. This spatial area was used for the following resource categories:

- Physical and Chemical Resources
- Marine Benthos
- Vegetation and Wetlands
- Birds
- Pinnipeds (seals)
- Polar Bears
- Moose, Grizzly Bear, Muskoxen, and Arctic Fox
- Threatened & Endangered Species
- Cultural Resources

The temporal timeframe for the cumulative effect analysis is established as 1980 through 2020. This timeframe allows for the incorporation of potential effects from previous exploratory oil and gas activities in the Point Thomson Unit and reasonably foreseeable future oil and gas development in the Point Thomson, Sourdough, Badami, and Slugger Units.

Potential external actions were identified using EISs from other oil and gas projects, North Slope environmental assessments, North Slope resource studies, and peer-reviewed literature. Expert contributors to this ER also assisted in identifying potential external actions. Potential external actions for physical, chemical, biological, cultural, and socioeconomic resources were identified. The external actions were placed into past, present, and reasonably foreseeable categories.

7.2.2 Organizing

Potentially affected resources were identified and characterized in Section 4 of this ER. Resource categories were defined and component parts of each resource category were described. For example, under the biological resources, fish were identified as a resource category with the component parts being freshwater, diadromous, and marine fish species. Potential direct and indirect effects of the proposed project on identified resources were evaluated in Section 5 of this ER. The baseline condition for the cumulative effect analyses was defined as the current (2001) physical/chemical, population, and socioeconomic conditions in the defined geographic areas and current (2001) subsistence use areas.

7.2.3 Screening

The screening process for the cumulative effect analyses consists of the following steps.

- Using Section 5 analyses, bring forward project actions with the potential to affect a given resource.
- Identify potential effects on a given resource from past external actions remain. Determine if there are lingering effects on the resource.

- Identify potential effects on a given resource from present and reasonably foreseeable actions.
- Analyze collectively project actions, lingering effects from past actions, and present and reasonably foreseeable actions to determine if a cumulative effect exists.
- Use matrices as the organizational structure in the cumulative effect analyses. The matrices provide a visual representation of the analytic process and help assure that the analysis is methodical.

7.2.4 Evaluating

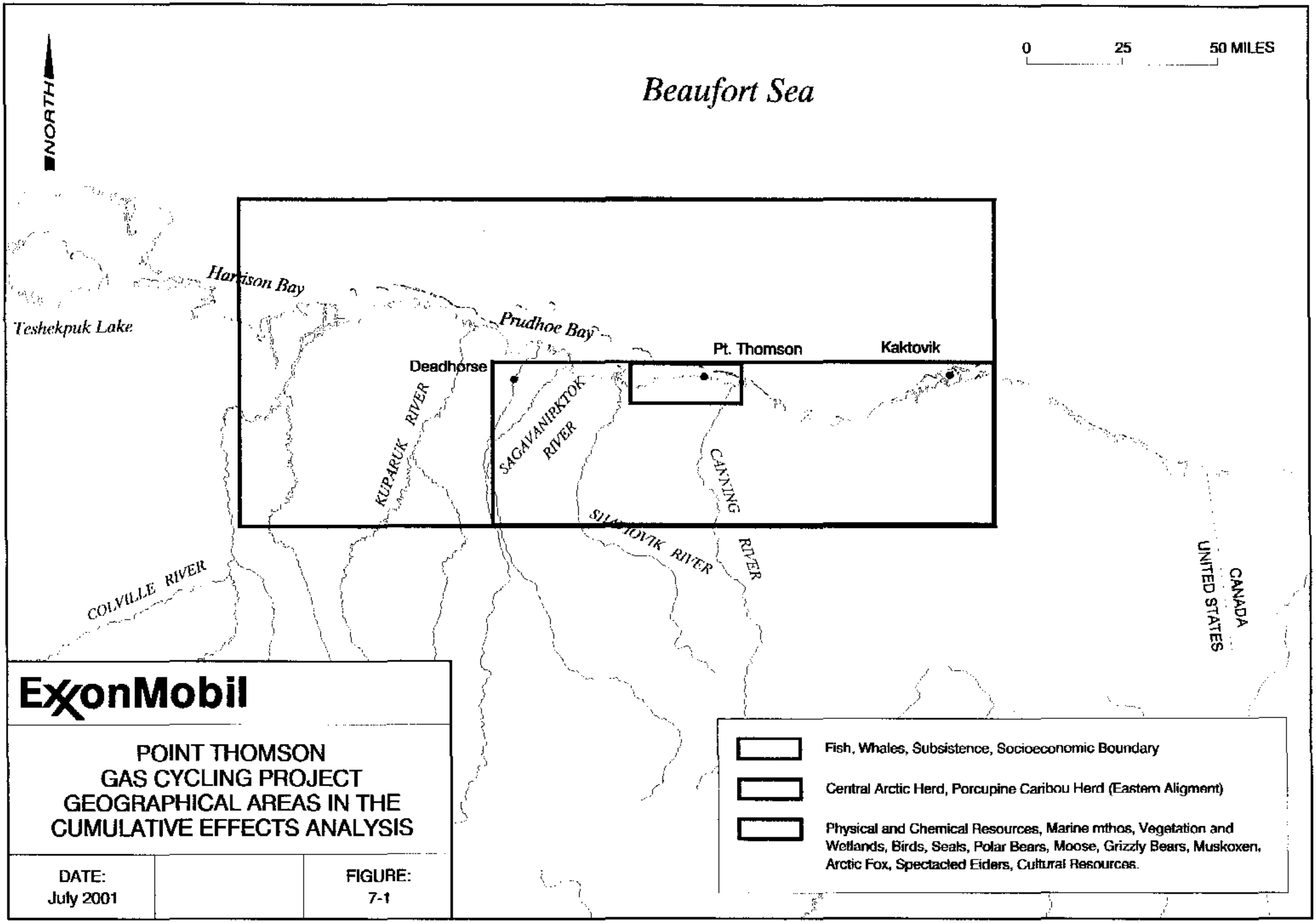
Physical/chemical resources were evaluated to determine if potential project and external effects would be long-term despite mitigation. For biological resources, the evaluation considered whether population level effects would occur. For socioeconomic characteristics, the evaluation criteria varied by resource as follows:

- Population and employment: potentials for a moderate increase in regional and state levels.
- Contribution to Borough and State revenues: particularly as they offset currently decreasing levels from order facilities.
- Potential effects on subsistence resources, disruption of harvest activities, and decreases in harvest levels: particularly with regard to culturally important species such as the bowhead whale.
- Major changes in land use and potential for creating land use conflicts.
- Transportation facilities and traffic levels: demands on facility capacity and changes in traffic levels.
- Recreation: level of recreational use and quality of recreation experience.
- Potential visual and noise effects from project activities and facilities were evaluated from the perspective of visitors and residents.

For all resource categories potential project effects were identified and qualitatively rate as follows:

- NS – not significant, assigned when it was determined that potential effects would not exceed evaluation criteria for a given resource.
- S – significant, assigned when it was determined that potential effects would exceed evaluation criteria for a given resource.

Lingering influences from past actions, and from present and reasonably foreseeable external actions were identified, but not rated for significance. Cumulative effects were identified and the likelihood that a cumulative effect could have significant impact on the resource was rated as low or high.



ExxonMobil

POINT THOMSON
GAS CYCLING PROJECT
GEOGRAPHICAL AREAS IN THE
CUMULATIVE EFFECTS ANALYSIS

DATE:		FIGURE:
July 2001		7-1

fig7_1.dgn

7.3 CUMULATIVE EFFECTS ANALYSES

As discussed in Section 7.0, a cumulative effect analysis takes into account the impact of the proposed action when added to other past, present, and reasonably foreseeable future actions external actions. It should be noted that development of the Point Thomson Gas Cycling Project could facilitate the development of other oil and gas resources in the immediate area, including several Brookian formation accumulations (i.e., Sourdough, Slugger, Flaxman). These accumulations are in the same Brookian formation from which Badami produces, and are believed to underlie portions of both the Point Thomson and Slugger Units. Construction of the Point Thomson dock, airstrip, and export pipeline could be used to support future development of these Brookian prospects and improve their development feasibility by reducing costs through shared facilities. For the purpose of this analysis, it is assumed that the proposed location of the Point Thomson dock, airstrip, and export pipeline are suitable to provide support to development in the Point Thomson Unit area.

Potential external actions identified during the cumulative effects scoping process are presented in Table 7-2. The external actions in Table 7-2 are first categorized by type, either "Human Controlled External Actions" or "Natural Events," and then as occurring in the past, present, or reasonably foreseeable future. A brief description of the external actions presented in Table 7-2 is as follows:

Human Controlled Actions

- Oil and Gas Exploration and Development: Includes past exploratory and Badami development, Badami operations, and reasonably foreseeable future exploration and development. Reasonably foreseeable includes exploration and/or development for which technical work is currently in progress or where Point Thomson Gas Cycling development might improve development feasibility. These foreseeable future projects are not part of the proposed action and would require authorization under a separate local, state, and federal permit process.
- Scientific Research and Surveys: past, present, and future oceanographic and biological and cultural survey work conducted within the geographic scope of the analysis having the potential to impact identified biological resources.
- Industrial Pollutants: past, present, and future global industrial air pollutants (including North Slope) and global industrial pollutants with the potential to affect North Slope resources.
- Subsistence Activities: past, present, and future potential impacts to identified resources.
- Borough and State Tax and Royalty Revenues Generated by the Petroleum Industry: Past, present, and future potential North Slope Borough (NSB) and State of Alaska tax and royalty revenues generated by petroleum industry projects
- Commercial Fishing: past, present, and future potential impacts to identified resources.
- Tourism and Recreation: past, present, and future potential impacts to identified resources.
- Military: past, present, and future potential impacts from the Bullen Point Distant Early Warning (DEW) Line Station.

Natural Events

- Disease: present and future viral infections affecting long-tailed ducks.
- Weather/Seasonal: past, present, and future ice scour; increased turbidity due to breakup, storms, and wave actions; and foggy weather.

Table 7-2. Potential External Actions

POTENTIAL EXTERNAL ACTIONS	PAST	PRESENT	REASONABLY FORESEEABLE
Human Controlled External Actions			
Oil and Gas Exploration and Development	• West Dock Causeway • Endicott Causeway • Endicott Onshore Road • Badami • Exploratory drilling pads • Seismic exploration	• West Dock Causeway • Endicott Causeway • Endicott Onshore Road • Badami • Flaxman Island Remediation	• Far West Pad • Sourdough • Slugger • Gas Sales Point Thomson • Seismic Exploration
Scientific Research and Surveys	• Oceanographic • Biological	• Oceanographic • Biological	• Oceanographic • Biological
Global Industrial Pollutants	• Bioaccumulation • Air Quality	• Bioaccumulation • Air Quality	• Bioaccumulation • Air Quality
Subsistence Activities	• Hunting • Trapping • Fishing • Whaling • Sealing • Traveling	• Hunting • Trapping • Fishing • Whaling • Sealing • Traveling	• Hunting • Trapping • Fishing • Whaling • Sealing • Traveling
Sport Hunting and Fishing	• Brooks Range • Kaktovik • ANWR	• Brooks Range • Kaktovik • ANWR	• Brooks Range • Kaktovik • ANWR
Commercial Fishing	• Colville River • Whaling	• Colville River	• Colville River
Tourism and Recreation	• Flight Seeing • Floating the Canning River • Arctic National Wildlife Refuge (ANWR)	• Flight Seeing • Floating the Canning River • ANWR	• Flight Seeing • Floating the Canning River • ANWR
Military	• Distant Early Warning Line Station	• None	• None
Tax Revenues Generated by the Petroleum Industry	• North Slope Borough (NSB) • State	• NSB • State	• NSB • State
Natural Events			
Disease	• None documented	• Viral infection in long-tailed ducks	• Viral infection in long-tailed ducks
Weather/Seasonal	• ice scour • increased turbidity due to breakup, storms, and wave actions foggy weather	• ice scour • increased turbidity due to breakup, storms, and wave actions foggy weather	• ice scour • increased turbidity due to breakup, storms, and wave actions foggy weather

Table 7-3 is an example of a cumulative effect matrix for a biological resource (bimos). Proceeding from left to right across the table, the screening procedure is as follows.

- Columns ❶ and ❷. This information is based on the discussions presented in Section 5 of the ER.
- Column ❸ asks if there is any lingering effect from a past external influence. This information is based on the results of the past external action screening (see Section 7.2.3).
- Columns ❹, "Human Controlled, and ❺, "Natural Events", are combined under the present and potential future external effects heading. In these columns, each external effect is screens to determine if it has a potential contribution to the project actions listed.
- Column ❻ asks if there is a cumulative effect. The determination of a cumulative effect result from identifying an additive or synergistic effect between a project impact (in this case, the Point Thomson Gas Cycling Project) and one or several external actions (in this case, actions associated with external human controlled activities and/or natural events).
- Column ❼ rates the likelihood that an identified cumulative effect could be significant.
- Column ❽ presents the assumptions and rationale used when rating the potential likelihood of a given cumulative effect in Column ❼.

The following sub-sections present the results of the cumulative effects analyses for each of the ER resource categories. Tables within each sub-section summarize the results of the cumulative effect analyses.

This page intentionally left blank

Table 7-3 Example Cumulative Effect Analysis Matrix

❶ POTENTIAL IMPACT	❷ Potential Project Effects?	❸ Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS — ❹ Human Controlled: Badami[3]	Far West Pad	Flaxman Island Rem.	Sourdough Dev.	Slugger Dev.	Gas Sales PTU[4]	Global Pollution	Scientific Research & Surveys	❺ Natural Events: Foggy Conditions	Disease	❻ Cumulative Effect?	❼ Likelihood That CE Could Be Significant	❽ Assumptions/Rationale
HABITAT LOSS AND ALTERATION	Y(NS)[1]	N[3]	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	Y	LOW	• Pt. Thomson project has minimal contribution to CE • Nesting habitat not limiting • Any new developments will minimize footprint and mitigate impacts to birds
DISTURBANCE	Y(NS)[2]	N	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	Y	LOW	• Pt. Thomson project has minimal contribution to CE • Any new developments will minimize and mitigate impacts to birds • Disturbance severe enough to create population level effects is not expected
MORTALITY	Y(NS)	N	Y	Y	Y	Y	Y	Y	Y[5]	Y	Y[6]	Y[7]	Y	LOW	• Mortality from Pt. Thomson project and other oil/gas development activities expected to have minimal contribution • Mortality from subsistence hunting and scientific surveys is controlled to minimize population level impacts • Disease not expected to have population level impacts in non-threatened species.

NOTES:
Y = Yes
N = No
NS = Not significant
N/A = Not applicable
Dev. = Development
Rem. - Remediation
CE = Cumulative Effect

Footnotes:
[1] Onshore nesting habitat not limited.
[2] Short-term impacts could occur due to construction noise; however, noise would be greatest during winter construction when most birds are not present.
[3] Potential effects if existing Badami facilities are expanded.
[4] If larger pads/roads are needed for gas sales equipment.
[5] Documentation of contaminants in Alaskan birds is poor; however contaminants could adversely affect bird populations.
[6] Foggy conditions contribute to incidence of bird strikes.
[7] Long-tailed ducks in waters found off of Flaxman Island suspected to have succumbed to a virus (ADN, June 27, 2001).

7.3.1 Physical/Chemical Resources

The cumulative impact analysis for physical and chemical resources of the Point Thomson area is summarized on Table 7-4 and described in the following sections.

7.3.1.1 Internal Project Effects

The physical and chemical resources of the Point Thomson area include air, freshwater, and marine water quality, marine circulation, surface hydrology, and permafrost/soils. As described in Section 5.1, project actions such as the placement and/or removal of gravel, emissions, discharges, and spills of materials to the environment, the removal of water from area lakes, and offshore dredging operations have the potential to impact these resources.

Air Quality

As described in Section 5.1, effects on local air quality will occur during project construction and operations. The project will produce emissions from vehicles, aircraft, machinery, generators, and compressors. Impacts may also include effects of minimal generation of dust during gravel mining and placement. Dust will also be generated by vehicles using gravel roads.

While air quality impacts will occur, construction and operations emissions will be regulated and monitored. In addition, long-term impacts due to dust generated during construction and operations are not anticipated (see Section 5.1.1.1 and 5.1.1.2). There fore, it is expected that the Point Thomson project will not significantly degrade air quality in region. This conclusion is depicted as Y (NS) [Yes, Not Significant] on Table 7-4.

Surface Hydrology

Impacts to drainage patterns and surface hydrology can occur when placement of gravel for roads, pads, or the airstrip diverts, impedes, or obstructs flow in stream channels or wetlands (see Section 5.1.2). As described in Section 5.1.2.1, impacts can be minimized with the proper siting of roads, pads, and the airstrip. In addition, the use of culverts and berm breaks can further minimize any blockage effects.

Surface hydrology can also be impacted by water removal for ice road construction and project operations (see Section 5.1.2.3). Impacts can be temporary if recharge is sufficient or longer term if areas are drained. Therefore, lakes used for this purpose will be carefully chosen and removal volumes in fish-bearing waters will likely be limited by permit. Melting ice roads during breakup could cause obstructions to typical water flow patterns or provide additional water in normally drier areas.

Therefore, while impacts can occur due to project actions, proper mitigation will decrease their significance. Table 7-4 indicates a Y (NS) under potential project effects related to surface hydrology changes.

Freshwater Quality

Water quality impacts to freshwater lakes and streams can occur due to obstruction of flow (see Section 5.1.2.1), and discharges and spills, water removal, and gravel removal (see Section 5.1.2.2 through 5.1.2.4). It is likely that direct project impacts such as increased turbidity during construction and discharges of wastewater during project operations will be mitigated. Also, in the case of small spills, proper mitigation will decrease their significance. While water withdrawal issues and their impact on freshwater quality could occur due to inadequate recharge, withdrawal volumes will be likely limited by permit requirements in fish-bearing water bodies. Any construction-related turbidity increases will be due to the timing of construction (most occurring during winter) or short-term. Therefore, while a potential project effect is identified for impacts to freshwater quality, any effects are expected to be not significant. The conclusion is depicted as Y (NS) on Table 7-4.

Marine Water Quality

Impacts to marine water quality could occur due to increased turbidity during dock construction and dredging, or due to the long-term presence of the dock itself. Sections 5.1.3.1 and 5.1.3.2 describe the potential impacts on water quality. Winter placement of gravel for dock construction is expected to create a minimal and short-term impact. A suspended sediment plume will be generated during summer dredging activities related to the 1,000-foot (ft) (305 meters [m]) channel. However, the effects will be temporary and generally restricted to lagoon waters within the project area. It may be necessary to transport dredge spoils to a location seaward of the 20-ft (6-m) isobath. It is anticipated that the affects related to ocean dumping would be similar to dredging effects (i.e., increased short-term turbidity).

Hydrographic effects due to the presence of the dock itself are anticipated to be minimal compared to naturally occurring, wind-driven upwelling. Therefore, while impacts to marine water quality can occur due to project actions, they are expected to be short-term and in the case of small spills, proper mitigation will decrease their significance. Table 7-4 indicates a Y (NS) under potential project effects related to marine water quality degradation.

Marine Circulation

Solid-filled structures, including marine docks, influence the alongshore movement of water immediately adjacent to the structure, resulting in variations in the current velocity (i.e., speed and direction), and introduce local vorticity (i.e., wake effects such as eddies and secondary flows). The Point Thomson dock would provide an alternative mechanism by which upwellings could occur, but would not enhance naturally occurring upwellings. Because the water column within Lions Lagoon in the area of the proposed dock tends to be uniform (URS 2000), both horizontally and vertically, formation of a wake eddy would mix waters with similar temperature and salinity characteristics, and thus have no perceptible effect on hydrography (see Section 5.1.3.1). Accordingly, the impact of the dock on marine circulation is rated as not significant, and this is depicted on Table 7-4 under potential project effects as Y (NS).

Permafrost and Soils

As described in Section 5.1.4, the dominant ice-rich permafrost soils in the project area, if allowed to thaw, will slump and release melt water that could then pond. In addition, there could be loclaized degredation of permafrost in the area of the gravel mine. The placement of 5 ft (1.5 m) of gravel on the tundra surface for roads, pads, and airstrip provides adequate insulation to prevent the degradation of the permafrost. Therefore, impacts of the Point Thomson facility of permafrost in the area will be minimal. The conclusion is depicted as Y (NS) on Table 7-4.

7.3.1.2 Past External Impacts

Past activities in the Point Thomson area could have had impacts on physical and chemical resources. Past external actions in the area include:

- Military operations, particularly at the Bullen Point DEW line station
- Oil and gas exploration, seismic investigations and drilling in the Badami and Point Thomson Units
- Construction and operation of the Badami facility
- Global pollutants/Arctic haze – contaminants that reach the Arctic through long-range atmospheric transport
- Natural Events - spring flooding and storms and wave action could have caused impacts to marine and freshwater quality.

The following sections describe the potential for lingering impacts from these past external actions on the physical and chemical resources of the Point Thomson area. As discussed in Section 7.2.4, lingering influences from past actions were identified but not rated for significance.

Air Quality

The incidence of arctic haze can be considered as a lingering influence from past external actions either on the North Slope or due to global pollution. This is depicted as Y on Table 7-4 under the "Lingering influence from past external actions?" column.

Surface Hydrology and Freshwater Quality

Past oil and gas exploration and development and military actions in the area that have included placement of gravel, removal of water, and gravel mining, could have impacted surface hydrology and/or water quality in localized areas. For example, the former gravel mine sites at Badami and Point Thomson have accumulated freshwater and could be used as water sources. While significant lingering impacts are unlikely on a large scale, localized areas (such as in the vicinity the old exploration pads or the DEW line station) may exhibit changes in surface hydrology conditions or degraded freshwater quality. Therefore, a remaining effect from past external actions for these impact categories is identified. Table 7-4 depicts these conclusions as Y in the lingering influence from past external actions column for both changes in surface hydrology and degradation of freshwater quality.

Marine Water Quality and Marine Circulation

There have been no industrial actions that could have contributed to lingering impacts on marine water quality and circulation in Lions Lagoon. Boats and barges passing through the area might have had accidental discharges of fuels or other materials. These contaminants, along with increased turbidity due to wind and wave action or spring river flooding, would likely be short-term and not have a lingering influence on marine water quality. Table 7-4 depicts these conclusions as N in the lingering influence from past external actions column for both changes in marine circulation and degradation of marine water quality.

Permafrost and Soils

Past oil and gas exploration and development, and the Bullen Point DEW line facility in the area that have included placement of gravel for construction of facilities on the tundra and gravel mining. These activities are likely to have impacted permafrost and soils in localized areas. While significant lingering impacts such as slumping, thermokarsting or tundra scars are unlikely on a large scale, localized areas may exhibit these impacts. Therefore, a remaining effect from past external actions is identified, and Table 7-4 depicts this conclusion as Y in the lingering influence from past external actions column.

7.3.1.3 Present and Potential Future External Actions

The following external actions, both human controlled and natural phenomena, have been identified as potentially contributing to impacts on physical and chemical resources of the Point Thomson area:

- Badami – future expansion of onshore facilities could be required to support development in the Slugger Unit. Impacts to surface hydrology, freshwater quality, and permafrost could be realized due to additional gravel placement or gravel mining.
- Far West Pad, Slugger Exploration and Development, and Sourdough Exploration and Development – impacts to surface hydrology, freshwater quality, and permafrost could be realized due to placement of gravel for development of these areas. Exploration activities could impact freshwater resources due to water withdrawal for ice roads and pads. Effects on the marine environment could occur if it became necessary to dredge offshore of either the Badami or proposed Point Thomson dock. Potential marine impacts include increased short-term turbidity and changes to hydrography.
- Gas Sales at Point Thomson - impacts could occur to surface hydrology, freshwater quality, and permafrost if additional or enlarged gravel pads are required or to the marine environment if the proposed Point Thomson dock would be dredged.
- Spring Flooding and Storms and Wave Action - could cause impacts to marine and freshwater quality.

Individually, many of these external factors could cause impacts to physical and chemical resources of the area. They are shown as Y, N, or N/A Table 7-4. However, while the potential for an impact from these actions is identified, the significance of an impact from any given action is not rated (see Section 7.2.4).

7.3.1.4 Cumulative Effects

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Facility, in conjunction with impacts from present and potential future external actions, it has been determined that cumulative effects on the physical and chemical resources of the area could occur. This is shown in the "Cumulative Effects?" column for each potential impact. However, the likelihood that any of the potential cumulative effects could be significant is low (see Table 7-4 "Likelihood that CE Could be Significant" column). The rationale for determining that the likelihood of significance will be low is based on the following assumptions (see "Assumption/ Rational" column):

Air Quality

- Other projects in the area will fall under New Source Performance standards protecting the air quality of the region.
- Impacts could occur, but mitigation will decrease their overall significance.
- Point Thomson project construction and operation is not expected to significantly contribute to arctic haze.

Surface Hydrology

- Other projects in area will be constructed with minimal footprint.
- Impacts could occur, but mitigation will decrease significance.
- Point Thomson contribution to cumulative effects is expected to be minimal.

Freshwater Quality

- Other projects in area will also be held to water withdrawal limitations as per permit requirements.
- Impacts could occur, but mitigation will decrease the significance.
- Turbidity impacts due to natural causes are expected to be short-term .
- Turbidity impacts will be minimized by winter construction efforts.
- Point Thomson contribution to cumulative effects is expected to be minimal.

Marine Water Quality and Circulation

- Point Thomson contribution to cumulative effects is expected to be minimal.
- Short-term increases in nearshore turbidity are not expected to be significant and are likely to be within range of natural perturbations.
- Region-wide climatic processes drive currents; development of other reasonable foreseeable facilities is unlikely to affect marine circulation in Lions Lagoon.

Permafrost

- Point Thomson contribution to cumulative effects is expected to be minimal.
- Other projects will be constructed to minimize impacts to permafrost.
- Majority of construction impacts on permafrost will be minimized due to timing (winter construction).
- Degradation of permafrost in the area of the gravel mine will be localized and minimal.

This page intentionally left blank

Table 7-4. Physical and Chemical Resources Cumulative Effects Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS: Human Controlled: Badami[1]	Far West Pad	Sourdough Exp. & Dev.[1]	Slugger Exp. & Dev.[1]	Global Pollutants/ Arctic Haze	Gas Sales PTU[2]	Natural Events: Breakup Spring Flooding	Storms Wave Action	Cumulative Effect?	Likelihood That CE Could Be Significant	Assumptions/Rationale
DEGRADATION OF AIR QUALITY	Y(NS)[3]	Y[5]	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	LOW	• Other projects in area will also fall under NSP standards • Impacts could occur, but mitigation will decrease significance • Pt. Thomson not expected to contribute significantly to arctic haze
CHANGES IN SURFACE HYDROLOGY	Y(NS)[5,7]	Y[8,9]	Y[5]	Y[5]	Y[5]	Y[5]	N/A	Y[5]	Y	N/A	Y	LOW	• Pt. Thomson contribution to CE expected to be minimal • Other projects in area will be constructed with minimal footprint • Impacts could occur, but mitigation will decrease significance
DEGRADATION OF FRESHWATER QUALITY	Y(NS)[5,6,7]	Y[8]	Y[5,6]	Y[5,6]	Y[5,6]	Y[5,6]	N/A	Y[5,6]	Y[7]	N/A	Y	LOW	• Pt. Thomson contribution to CE expected to be minimal • Other projects in area will also be held to water withdrawal limitations as per permit requirements • Turbidity impacts due to natural events will be short term • Majority of construction impacts on turbidity minimized due to timing (winter) • Impacts could occur, but mitigation will decrease significance
DEGRADATION OF MARINE WATER QUALITY	Y(NS)[7]	N	Y[1]	Y[1]	Y[1]	Y[1]	N/A	Y[1]	Y[7]	Y[7]	Y	LOW	• Pt. Thomson contribution to CE expected to be minimal • Short-term increases in turbidity not expected to be significant and likely within range of natural perturbations
CHANGES IN MARINE CIRCULATION	Y(NS)[10]	N	N	N	N	N	N/A	Y	Y	Y	Y	LOW	• Pt. Thomson contribution to CE expected to be minimal • Region- wide climatic processes drive currents; development of other facilities unlikely to affect marine circulation in Lions Lagoon
CHANGES IN PERMAFROST/ SOILS	Y(NS)[5]	Y[8]	Y[5]	Y[5]	Y[5]	Y[5]	N/A	Y[5]	N	N/A	Y	LOW	• Pt. Thomson contribution to CE expected to be minimal • Majority of construction impacts on permafrost minimized due to timing (winter) • Degredation in the area of the gravel mine will be localized and minimal • Other projects will be constructed to minimize impacts

NOTES:

Y = Yes NS = Not significant

N = No CE = Cumulative Effect

N/A = Not applicable

Dev. = Development

EXP = Exploration

Footnotes:

[1] If existing Badami or proposed Pt Thomson facilities are expanded or area offshore of docks is dredged

[2] If larger pads/roads and additional equipment are needed for gas sales

[3] Construction and operations emissions will be regulated and monitored, dust from construction not expected to be significant

[4] Arctic Haze

[5] Impacts could occur, but mitigation should decrease significance of impact;

[6] Includes potential impacts due to water withdrawal for ice roads and other project needs; will be mitigated by water use permit limits

[7] Potential short-term increases in turbidity

[8] Potential for localized impacts in vicinity of old exploratory pads or within the Badami facility; likely to be small scale

[9] Former gravel mine sites at Badami and Pt. Thomson have created new freshwater sources

[10] Wake eddy could be present, but effects will not be significant

7.3.2 Biological Resources

The following sections describe the analysis of cumulative impacts on biological resource. The resources considered are marine benthos, vegetation and wetlands, birds, marine mammals, terrestrial mammals, and threatened and endangered species.

7.3.2.1 Marine Benthos

The cumulative effect analysis for marine benthos is summarized on Table 7-5 and described in the following paragraphs.

Internal Project Effects

As described in Section 5.2.1, the development actions associated with the Point Thomson Gas Cycling Project can impact the benthic community of Lions Lagoon. The impacts can be seen as causing habitat loss and mortality and/or habitat alteration and disturbance. The following project actions have been identified as potentially contributing to these impacts:

Habitat Loss and Mortality

- Placement of gravel to construct the 750-ft (230-m) dock.
- Dredging operations to create a 1,000-ft (305-m) by 400-ft (122-m) channel from the end of the dock.
- Disposal of approximately 30,000 cubic yards (cy) (23,000 cubic meters [m^3]) of spoils outside of the barrier islands.

Habitat Alteration and Disturbance

- Creation of temporary turbidity plumes associated with dock construction and maintenance, dredging operations, and spoils disposal.
- Alteration of local circulation patterns, and thus the deposition (or erosion) of sediment and organic material in the vicinity of the dock.
- Tug and barge movement that could disrupt bottom sediments, thereby increasing turbidity.

Section 5.2.1 determined that impacts on marine benthos due to habitat loss and mortality and/or habitat alteration and disturbance associated with these project actions would be minimal. Habitat is not considered to be a limiting factor for benthic organisms in the grounded or land-fast ice zones. The area is characterized by regular disturbance and recolonization. Further offshore the community is considered to be more stable (see Section 4.5) and the disposal of the spoils could impact an as yet undetermined area of this community depending on disposal location. However, while numbers of non-motile organisms may be subject to burial, recolonization is likely to occur after a short period.

Two areas of kelp beds have been identified offshore of Lions Lagoon (see Section 4.5). Turbidity impacts associated with dredging and dredge spoils are not expected to impact the kelp since the dredge and disposal areas would be located away from known kelp beds. For these reasons, project impacts on the benthic community of Lions Lagoon are rated as not significant.

These determinations are depicted as Y (NS) on Table 7-5 under the "Potential Project Effects" column.

Past External Impacts

There have not been any previous offshore projects in Lions Lagoon or in the immediate vicinity of the Point Thomson Project. The Badami dock extends about 1,000 ft (305 m) into the nearshore zone of Mikkelsen Bay. The nearshore zone is subject to natural disturbance and recolonization events and habitat is not a limiting factor for these benthic organisms. Therefore, it has been determined that there are no lingering influences on the benthic community within the defined geographic area (Lion Lagoon). These conclusions are depicted as N in the "Lingering Influences from Past External Actions" column in Table 7-5.

Present and Potential Future External Actions

The following external actions, both human controlled and natural events have been identified as potentially contributing to marine benthic habitat loss and mortality and/or habitat alteration and disturbance in the vicinity of the Point Thomson project:

- Far West Pad, Slugger Development, Sourdough Development, and/or Gas Sales at Point Thomson – effects on the benthic environment could occur if it became necessary to dredge offshore of either the Badami or proposed Point Thomson dock to support development of these facilities. Potential impacts include benthic habitat loss and/or alteration and mortality of benthic organisms.
- Ice Scour – annual scoring of the nearshore benthic habitat by grounded sea ice or land-fast ice ridges prevents most species from overwintering in this zone. The area is characterized by opportunistic species that quickly recolonize the disturbed habitat

Individually, these external factors could impact the Benthic community. They are shown as Y on Table 7.5. However, due to the opportunistic nature of the benthic community, and the community's ability to adapt to natural disturbance and quickly recolonize new or previously disturbed areas, the significance of an impact for any given external action is likely to be not significant.

Cumulative Effects

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Facility, in conjunction with impacts from present and potential future external actions, it has been determined that cumulative impacts on the benthic community in Lions Lagoon and westward to Badami could occur (shown as Y in "Cumulative Effect?" column in Table 7-4). However, the likelihood that any of the potential cumulative effects could be significant is low (see Table 7-4). The rationale for determining that the likelihood of significance will be low is based on the following assumptions:

- Availability of benthic habitat is not limiting in Lions Lagoon.
- The area is characterized by opportunistic species that are regularly impacted by natural events.

Table 7-5. Marine Benthos Cumulative Effects Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS					Cumulative Effect?	Likelihood that CE could be Significant	Assumptions/Rationale
			Human Controlled				Natural Events			
			Far West Pad [1]	Sourdough Dev.[1]	Slugger Dev.[1]	Gas Sales PTU[1]	Ice Scour			
HABITAT LOSS AND MORTALITY HABITAT ALTERATION AND DISTURBANCE	Y(NS)[2]	N[2]	Y	Y	Y	Y	Y	Y	LOW	• Availability of benthic habitat is not limiting in Lions Lagoon • The area is characterized by opportunistic species regularly impacted by natural events • Kelp beds found in the offshore zone would not be impacted by increased turbidity; these organisms are likely adapted to turbidity from natural sources such as river input • Increased opacity of sea ice due to turbidity from dredge spoils disposal would not likely impact kelp since dredging will occur in summer. • Organisms are expected to quickly recolonize disturbed areas • Population/community effects not expected

NOTES:
Y = Yes
N = No

N/A = Not applicable
NS = Not significant
Dev. = Development
CE = Cumulative Effect

Footnotes: [1]Only if existing dock at Badami or proposed dock at Point Thomson is dredged for use by one of these other projects.
[2]Habitat not limiting to these opportunistic species which are affected by natural events such as ice scour each winter.

- Kelp beds found in the offshore zone would not be affected by increased turbidity; these organisms are likely adapted to changes in turbidity from natural sources such as river input.
- Increased opacity of sea ice due to turbidity from dredge spoils disposal would not likely impact kelp since dredging will occur in summer and resulting turbidity plumes from dredging and disposal will have dispersed prior to freeze-up.
- Organisms are expected to quickly recolonize any disturbed areas.
- Population/community effects are not expected for marine benthos.

7.3.2.2 Vegetation and Wetlands

The cumulative impact analysis for vegetation in the Point Thomson area is summarized on Table 7-6 and described in the following sections.

Internal Project Effects

As discussed in Section 5.2.2, potential effects of the Point Thomson Gas Cycling Project on vegetation and wetlands are primarily from habitat loss and alteration. While mortality and disturbance of plants including wetland species will occur as gravel is placed on the tundra, these direct impacts are considered in the context of habitat effects. The following project actions have been identified as potentially contributing to habitat effects:

Habitat Loss and Alteration

- Removal of vegetation at the gravel mine site, and burial of vegetation due to placement of gravel to construct facility roads, pads and airstrip. About 9,832,545 square feet (ft^2) (nearly 1 square kilometer [km^2]) of vegetation habitats would be impacted due to gravel mining and placement (see Section 5.2.2.1)
- Potential obstruction of surface flow due to improper or unmitigated placement of gravel, thereby creating impoundments, or conversely, unnaturally drier areas of tundra.
- Establishment of ice roads to support winter construction efforts; effects include areas of persistent ice and delayed "green-up" in those areas.
- Water removal from tundra lakes for ice road construction, dust control, and camp operations, potentially altering wetland community structure.
- Facilities-induced thermokarst areas can provide preferred habitat for certain plant species or conversely less attractive habitat for others.
- Dust fallout due to construction and operations along roadways, and near pads and the airstrip, which can cause earlier snowmelt and subsequent earlier green-up, reduce photosynthesis, increase soil pH, lower nutrient levels, and promote changes in plant community structure.
- Snow dumps and snow drifts that can result in delayed snowmelt and soil compaction. Impacts on vegetation may be long-term, because of the chronically reduced growing season, soil compaction, altered moisture regime, and gravel fallout.

Section 5.2.2 determined that the impacts of gravel cover are long term and vegetation recovery is slow following remediation. However, only about 8 percent (%) of total acreage affected by gravel coverage and/or removal consists of high value bird habitat and less than 2% of the area covered would alter high value salt marsh (see Section 5.2.4.1). In general, for all vegetation types affected, the amount of habitat loss would be small relative to regional abundance.

Impacts to vegetation from dust fallout, snow dumps and drifts, rare emergency flaring events, and small operational spills are also anticipated to be minimal and can be further minimized by mitigation measures. For these reasons, project impacts on vegetation due to habitat loss or alteration are considered to be not significant. This determination is depicted as Y (NS) under the "Potential Project Impact" column on Table 7-6.

Past External Effects

Past activities in the area of consideration for vegetation and wetlands could have had impacts on the habitat or created additional disturbance or mortality (see Table 7-2 for a list of potential external actions). Past external actions in the area that have had the potential to impact vegetation and wetlands include:

- Military operations particularly at the Bullen Point DEW line station – impacts to habitat due to gravel placement.
- Oil and gas exploration, seismic investigations, and drilling in the Badami and Point Thomson Units - impacts to habitat due to gravel placement, dust fallout, impoundments, snow accumulations, and thermokarst associated with existing facilities.
- Construction and operation of the Badami facility – loss and alteration of habitat due to gravel placement, disturbance and mortality due to construction and operations activities and presence of facility buildings.

Previous oil and gas exploration and development and military activities in the region contributed to loss of habitat due to mining and placement of gravel to support the developments. Gilders and Cronin (2000) report that approximately 10,900 acres (4400 hectares [ha]) of habitat have already been lost to gravel placement and mine sites on the North Slope. This impact is shown as a Y on Table 7.6 under the "Lingering Influence from Past External Actions" column since the vegetation impacts associated with gravel placement and removal can be considered permanent. However, the relative area of impact is small relative to the habitat available in the defined geographic scope of this analysis (exploration pads, small footprint for the Badami facility and only one military site at Bullen Point about 14 miles (mi) [23 km] to the west of the proposed Central Processing Facility (CPF). In addition, habitat is not considered to be a limiting factor for the bird and mammal populations present in the area, and any lingering impacts on habitat are likely to be not significant.

Present and Potential Future External Effects

The following external actions, both human controlled and natural phenomena have been identified as potentially contributing to loss or alteration of vegetation and wetlands in the vicinity of the Point Thomson project:

Table 7-6 Vegetation Cumulative Effects Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS					Cumulative Effect?	Likelihood that CE Will be significant	Assumptions/Rationale
			Badami[1]	Far West Pad	Sourdough Dev.	Slugger Dev.	Gas Sales PTU[2]			
HABITAT LOSS and/or ALTERATION	Y(NS)[3]	Y[4]	Y	Y	Y	Y	Y	Y	Low	• Pt. Thomson project has minimal contribution to CE • Habitats affected are not limiting for wildlife species in the area • Future development s will minimize footprints and mitigate impacts
DISTURBANCE[5]	NA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MORTALITY[5]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTES:

Y = Yes
N = No
N/A = Not applicable
Dev. = Development
NS = Not significant

Footnotes:
[1]Only if existing additional gravel were to be placed at Badami to support development in Slugger or other projects.
[2]Only if additional gravel were to be placed in the Point Thomson area to support gas sales.
[3]Total areas effected are small, rare habitat types and are not affected, habitats are not limiting for wildlife in the Point Thomson Development area.
[4]Former exploration drill sties and DEW line site
[5]Disturbance and mortality effects are considered as habitat loss

- Badami – future expansion of onshore facilities could be required to support development in the Slugger Unit. The effect would occur as vegetation habitat loss due to gravel placement.
- Far West Pad – if this pad is developed, an additional 968,054 ft^2 (less than 0.1 km^2) of vegetation would be covered.
- Slugger Development, Sourdough Development, and Gas Sales at Point Thomson – additional effects to vegetation would occur if additional gravel is needed for pad and road construction or expansion.

Individually, any of these external factors could impact vegetation. They are shown as either Y or NA on Table 7-6. However, while the potential for an impact from these actions is identified, the significance of an impact from any given action is not rated (see Section 7.2.4).

<u>**Cumulative Effects**</u>

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Facility, in conjunction with impacts from past, present, and potential future external actions, it has been determined that cumulative impacts on the vegetation in the analysis area could occur. However, the likelihood that any of the potential cumulative effects could be significant is low (see Table 7-6). The rationale for determining that the likelihood of significance will be low is based on the following assumptions:

- Habitats likely to be affected by gravel placement are not limiting for wildlife species in the area.
- Any new developments will minimize footprint and mitigate impacts to vegetation.
- Habitat lost due to placement of gravel for the Point Thomson and other oil/gas development activities in the vicinity (Far west Pad, Slugger and Sourdough developments) expected to have minimal contribution to overall cumulative effects.

7.3.2.3 Fish

The geographic scope for fish ranges from the Colville River east to Kaktovik. Cumulative impact analysis for freshwater, diadromous, and marine fish is summarized in Table 7-7 and described in the following paragraphs.

<u>**Internal Project Effects**</u>

As described in Section 5.2.3, potential effects of the Point Thomson Gas Cycling Project are modified and/or decreased value of nearshore foraging habitat, disturbance, and mortality of freshwater, diadromous, and marine fish. The following project actions have been identified as potentially contributing to these effects:

<u>*Habitat*</u>

- Placement of gravel to construct the 750-ft (230 m) dock causes loss of nearshore foraging habitat.

Disturbance

- Wake eddy at the tip of the dock could disturb nearshore fish movements.
- Dredging operations to create a 1,000-ft (305 m) by 400-ft (122 m) channel at the end of the dock would cause a short-term increase in turbidity.
- Disposal of approximately 30,000 cy (23,000 m^3) of spoils outside of the barrier islands would also cause a short-term increase in turbidity.

Mortality

- Winter water withdrawal for ice road construction could affect freshwater fish overwintering habitats in deep water sources.
- Sport fishing conducted by project personnel in streams, rivers, and Lions Lagoon could cause direct mortality of fish.

Section 5.2.3.1 evaluations determined that the proposed project is not anticipated to have any effects on spawning or overwintering habitat of freshwater, diadromous, or marine fishes. Habitat loss due to construction of the proposed dock would eliminate a small area (2 acres [< 1 ha]) of nearshore summer foraging habitat compared to the total nearshore foraging habitat available in Lions Lagoon. In addition, the proposed dock would not block or alter natural marine upwelling processes that play a roll in the trophic richness of the nearshore waters (Section 5.2.3.1). Therefore, project impacts on nearshore fish foraging habitat are rated as not significant, and depicted as Y (NS) on Table 7-7 for habitat in the "Potential Project Effects?" column.

The project is not anticipated to disturb fish migration due to dock wake eddy effects (Section 5.2.3.2). The potential effects from project actions are limited to disturbance due to increased turbidity from dredging activities, and disposal of dredge spoils offshore. Increased turbidity from dredging and disposal of dredge spoils will be short term. Due to fish tolerance of naturally caused turbid conditions, it is anticipated that a short term, localized increase in nearshore and offshore turbidity will not disturb fish. Accordingly, these project actions are rated as not significant, and depicted as Y (NS) on Table 7-7 for disturbance in the "Potential Project Effects?" column.

Recent State permits for North Slope development limit winter water withdrawal in fish bearing water sources for ice road construction. It is assumed that State withdrawal rates are conservative and protective of fish populations. All sport fishing conducted by project personnel will be required to comply with applicable State sport fishing regulations. The project is anticipated to have minimal fish mortality effects (Section 5.2.3.3). Therefore, project actions with the potential to cause fish mortality are rated as not significant, and depicted as Y (NS) on Table 7-7 for mortality in the "Potential Project Effects?" column.

Past External Effects

Past external actions pertinent to identified potential habitat, disturbance, and mortality effects for fish were as follows:

Habitat

Section 5.2.3.1 evaluations determined that the proposed project is not anticipated to have any effects on spawning or overwintering habitat of freshwater, diadromous, or marine fishes; however there could be nearshore fish foraging habitat effects. Therefore, from the perspective of this ER, past external actions with the potential to impact only nearshore foraging habitat of freshwater, diadromous, and marine fish in the geographic area of concern were selected from the list presented in Table 7-2.

- West Dock Causeway – foraging habitat loss due to gravel placement.
- Endicott Causeway – foraging habitat loss due to gravel placement.
- Badami Dock – foraging habitat loss due to gravel placement.

Disturbance

- West Dock Causeway – wake eddy and associated upwelling of cold saline water during prevailing easterly winds.
- Endicott Causeway - wake eddy and associated upwelling of cold saline water during prevailing easterly winds.
- Badami Dock – wake eddy and assumed associated upwelling of cold saline water during prevailing easterly winds.

Mortality

- Badami - potential effect on overwintering freshwater from winter water withdrawal for ice road construction.
- Sourdough and Slugger Exploration and Development - potential effect on overwintering freshwater from winter water withdrawal for ice road/pad construction.
- Scientific Research and Surveys – fish killed during fish surveys.
- Subsistence Fishing – direct take of fish.
- Commercial Fishing – direct take of fish.
- Sport Fishing – direct take of fish.

There are no significant data indicating that nearshore foraging habitat loss due to the construction of West Dock and Endicott Causeways and Badami dock has affected freshwater, diadromous, or marine fish at the population level (Colonell and Gallaway 1990). Therefore, it is assumed that there are no lingering influences on nearshore foraging habitat for freshwater, diadromous, or marine fish in the ER fish geographic scope. This determination is depicted as N on Table 7-7 for habitat in the "Lingering Influence From Past External Action?" column.

Summer migration and foraging distribution of many diadromous fish in the North Slope coastal region are influenced by wind generated currents (Colonell and Gallaway 1990). Although wake eddies and associated upwellings are present at West Dock and Endicott Causeways and the Badami Dock, there is no significant evidence that fish migration and foraging patterns have been disturbed due to the presence of docks in the nearshore waters (see Section 5.2.3.2 of this ER for further discussion). Therefore, it is assumed that there are no lingering influences causing disturbance to freshwater, diadromous, or marine fish migration or summer movements. This determination is depicted as N on Table 7-7 for disturbance in the "Lingering Influence From Past External Action?" column.

It is assumed that winter water withdrawal for past ice road/pad construction was in accordance with habitat protection stipulations. It is inferred that the water withdrawal levels set in State permits are conservative and no impact occurred due to past winter water withdrawal in fish bearing lakes. Direct fish kills due to scientific research and surveys and subsistence, commercial, and sport fishing have occurred in the past. During the 1999 fish survey conducted at Point Thomson less than 1% of the total catch over the openwater season resulted in moralities (LGL 2000b). State and Federal agencies monitor subsistence, commercial, and sport fishing. Direct kills from scientific research and surveys and subsistence, commercial, and sport fishing are small relative to fish populations and are not thought to have caused lingering population level effects. Therefore, it is assumed that there are no lingering influences from freshwater, diadromous, or marine fish mortality at the population level. This determination is depicted as N on Table 7-7 for disturbance in the "Lingering Influence From Past External Action?" column.

Present and Potential Future External Actions

Present and potential future external actions pertinent to identified potential habitat, disturbance, and mortality effects for fish were as follows:

Habitat

No known expansions of Badami or West Dock and Endicott Causeways are planned. Therefore, no present or reasonable foreseeable fish foraging habitat loss was identified due to gravel placement in the nearshore environment..

Disturbance

- Badami – potential effects of maintenance dredging for support of Badami facility.
- West Dock Causeway - potential effects of maintenance dredging for support of current and potential future development.
- Endicott Causeway - potential effects of maintenance dredging for support of Endicott facility.
- Sourdough and Slugger Exploration and Development - potential effects of dredging if Badami dock or proposed Point Thomson docks are used during development.

Mortality

- Badami – potential effect from winter water withdrawal for ice road construction.
- Sourdough and Slugger Exploration and Development - potential effect from winter water withdrawal for ice road construction.
- Badami – potential effects of maintenance dredging for support of Badami facility.
- West Dock Causeway - potential effects of maintenance dredging for support of current and potential future development.

- Endicott Causeway - potential effects of maintenance dredging for support of Endicott facility.

Short-term increases in turbidity due to dredging could cause minimal disturbance of fish nearshore movements. This is depicted as Y in Table 7-7 under the Badami, West Dock Causeway, Endicott Causeway, Sourdough and Slugger Exploration and Development columns for disturbance.

Excessive water withdrawal during the winter could adversely affect overwintering fish populations in deep tundra lakes. Overwintering habitat is a limiting factor for freshwater and diadromous fish on the North Slope (Craig 1989). Direct fish kills occur due to scientific research and surveys and subsistence, commercial, and sport fishing. Potential mortality due to these external actions is depicted as Y under the Badami, Sourdough and Slugger Exploration and Development, Scientific Research and Surveys, Subsistence Fishing, Commercial Fishing, and Sport Fishing columns in Table 7-7 for mortality.

Cumulative Effects

Habitat loss due to construction of the proposed dock would eliminate a small area (2 acres [< 1 ha]) of nearshore summer foraging habitat compared to the total nearshore foraging habitat available in Lions Lagoon. There are no significant data indicating a lingering influence from past nearshore foraging habitat loss due to the construction of West Dock and Endicott Causeways and the Badami dock. There are no external actions within the geographic scope that could cause present or reasonably foreseeable loss of nearshore fish foraging habitat. Therefore, a cumulative effect for fish nearshore foraging habitat was not identified. This is depicted as N under the "Cumulative Effect?" column in Table 7-7 for habitat.

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Project, in conjunction with potential impacts from past, present, and potential future external actions, it was determined that cumulative effects on fish populations in the analysis area due to disturbance and mortality could occur. This is depicted as Y in Table 7-7 under the "Cumulative Effect?" column for disturbance and mortality.

The likelihood that these cumulative effects could be significant is rated as low (Table 7-7). The rationale for determining the likelihood of significance is based on the following assumptions.

Disturbance

- Maintenance dredging activities are conducted on an as needed basis and are of short duration.
- Turbidity increases from maintenance dredging activities are short term.
- Fish in nearshore waters of the Beaufort Sea are tolerant of turbid waters.

Mortality

- State permit winter water withdrawal rates are thought to be conservative and protective of overwintering fish species in deep tundra water sources.

- Direct fish kills during scientific research and surveys are small. During the 1999 fish survey conducted at Point Thomson less than 1% of the total catch over the openwater season resulted in fish morality (LGL 2000b).
- Direct fish kills from fishing activities both commercial and subsistence are minimal compared to overall fish populations, and are monitored by State and Federal agencies.

Table 7-7 Fish Cumulative Effects Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS — Human Controlled: Badami	West Dock Causeway	Endicott Causeway	Sourdough Exp. & Dev.	Slugger Exp. & Dev.	Scientific Research & Surveys	Subsistence Fishing	Commercial Fishing	Sport Fishing	Cumulative Effect?	Likelihood That CE Could Be Significant	Assumptions/Rationale
HABITAT[1]	Y (NS)	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	• No known expansions are planned for Badami dock or West Dock and Endicott Causeways.
DISTURBANCE[1]	Y (NS)	N	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	Y	LOW	• Limited to potential effects from maintenance dredging. • Turbidity increases short term. • Fish in nearshore waters are tolerant of turbid water.
MORTALITY	Y (NS)	N[2]	Y[2]	N/A	N/A	Y[2]	Y[2]	Y[3]	Y[3]	Y[3]	Y[3]	Y	LOW	• State permit water withdrawal rates are conservative and protective. • Fish mortality from fishing and scientific surveys is small relative to overall population levels. • Sport fishing is regulated by the State.

NOTES:

Y = Yes NS = Not significant
N = No CE = Cumulative Effect
N/A = Not applicable
Exp. = Exploration
Dev. = Development

Footnotes:

[1] = Effect is limited to nearshore foraging habitat for freshwater, diadromous, and marine fish.
[2] = Limited to potential effect on overwintering freshwater fish due to winter water withdrawal in fish bearing lakes for ice road/pad construction.
[3] = Adds to potential mortality from project actions.

7.3.2.4 Birds

The cumulative impact analysis for birds is depicted on Table 7-8 and described in the following paragraphs.

Internal Project Effects

As described in Section 5.2.4, development actions associated with the Point Thomson Gas Cycling project can impact waterfowl, tundra-nesting birds, and predatory birds that use the Point Thomson area for feeding, breeding, molting and/or nesting. Nearly all bird use of the area occurs in the summer months when snow free nesting habitats, forage, and open water are available (see Section 4.8). Only a few species remain in the area during the winter when food resources are scarce.

Potential project impacts on bird species in the area can occur due to habitat loss and alteration, behavioral disturbance, and/or mortality. The following project actions have been identified as potentially contributing to these impacts:

Habitat Loss and Alteration

- Burial due to placement of gravel to construct facility roads, pads, and airstrip.
- Potential obstruction of surface flow due to improper or unmitigated placement of gravel, thereby creating impoundments, or conversely, unnaturally drier areas of tundra. This could have positive or negative effects on bird habitat.
- Establishment of ice roads to support winter construction efforts; effects include areas of persistent ice and delayed breakup in those areas potentially causing temporary loss of habitat.
- Water removal from tundra lakes for ice road construction, dust control, and camp operations needs potentially causing loss of preferred habitat if recharge is inadequate.
- Facilities-induced thermokarst areas can provide preferred habitat for certain species or conversely less attractive habitat for others.
- Dust fallout due to construction and operations along roadways, and near pads and the airstrip which can cause earlier snowmelt and provide habitat for migrating birds that would normally not be available until later in the season.
- Snow dumps and snow drifts that persist into the breeding season rendering nesting habitat potentially unsuitable.

Section 5.2.4.1 determined that project impacts on bird habitat would be minimal since most habitats preferred by birds for nesting are not limited in the area. The amount of habitat anticipated to be lost due to gravel placement and gravel mine development will be small relative to regional habitat abundance. Habitat impacts from dust fallout, snow dumps and drifts, and small operational spills are also anticipated to be minimal and can be further minimized by mitigation measures. In addition, birds are known to regularly utilize abandoned gravel pads for resting and feeding. For these reasons, project impacts on bird habitat are considered to be not significant. This determination is depicted as Y (NS) under the "Potential Project Impacts" column on Table 7-8.

Disturbance

- Generation of noise and visual disturbance from activities associated with onshore and offshore construction during the summer when the majority of the birds are expected to use the area (i.e., construction equipment, vessels, airplanes, helicopters, and vehicles; drilling noise is not expected to create an impact on most birds since at present drilling is only allowed during the winter months).
- Longer-term, but likely of less magnitude, generation of noise associated with operation of the facility. This could consist of generators, compressors and other machinery, flaring events, and regular and maintenance-related vehicle traffic.

Section 5.2.4.2 concludes that a small percentage of birds could show short-term alterations in behavior due to noise associated with summer construction activities. However, the disturbance would be highest during winter construction efforts (gravel mine blasting, gravel hauling) when the majority of bird species are not present in the Point Thomson area. Vessel, air, and vehicle traffic effects during construction will be short-term. During operations, traffic and facility equipment noise could make areas adjacent to roads and pads less attractive to birds. However since habitat is not a limiting factor for birds, this displacement is expected to have minimal impacts. Therefore, project-related disturbance to area bird populations is considered to be not significant. This determination is depicted as Y (NS) on Table 7-8 under the "Potential Project Effects" column.

Mortality

- Strikes by vehicles and construction equipment.
- Collisions with structures and aircraft.
- Flare heat-related impacts, particularly for flightless or molting birds caught under the flare tower during flare events.
- Ingestion of spilled fuels and other operations-related materials.
- Increased predator populations (i.e., fox) due to attraction to oil field facilities (feeding by employees, or incorrectly handled garbage).

Section 5.2.4.3 discusses project-related mortality for birds in the Point Thomson area. While birds could be killed by vehicle strikes, collisions with aircraft and buildings, and/or by encountering the heat due to the flare, project-induced mortality is unlikely to have population level effects for birds migrating to the area for breeding, foraging, nesting, or molting. It is anticipated that waste control and enforced rules against personnel feeding wildlife will minimize artificial attraction of predators (i.e., grizzly bears and Arctic fox). Project-induced mortality is determined to be not significant, and is depicted as Y (NS) on Table 7-8.

Past External Impacts

Past activities in the area of consideration for bird species could have had effects on the habitat or created additional disturbance or mortality for these species (see Table 7-2 for a list of potential external actions). Past external actions in the area that had the potential to impact bird populations include:

- Military operations particularly at the Bullen Point DEW line station – impacts to habitat due to gravel placement, disturbance and mortality due to military operations
- Oil and gas exploration, seismic investigations and drilling in the Badami and Point Thomson Units - impacts to habitat due to gravel placement, disturbance and mortality due to exploration activities both onshore and offshore.
- Construction and operation of the Badami facility – loss and alteration of habitat due to gravel placement, disturbance and mortality due to construction and operations activities and presence of facility buildings.
- Scientific research and surveys conducted in the area (in particular a United States Geological Service [USGS] study on long-tailed ducks conducted from Flaxman Island in 1999 and 2000) could have caused disturbance and mortality, but are not likely to have caused habitat alteration or loss.
- Subsistence hunting - could add to any mortality or disturbance.
- Global pollutants - could also add to any mortality or disturbance from project actions. However, documentation of geographic coverage of contaminants in birds in Alaska is poor (ISER and ANSC 1999).

Previous oil and gas exploration and development and military activities in the region contributed to loss of bird habitat due to placement of gravel and gravel mining to support the developments. This is shown as a Y on Table 7-8 under "Lingering Influence from Past External Actions" since associated habitat impacts remain (i.e., the presence of the pads and roads and indirect impacts such as changes in surface hydrology and creation of thermokarsts). However, the relative area of impact is small compared to the total bird habitat available in the region (small exploration pads, small footprint for the Badami facility, only one military site at Bullen Point about 14 mi [23 km] to the west of the proposed CPF). In addition, habitat is not considered to be a limiting factor for the bird populations present in the area, and any lingering impacts on habitat are likely to be not significant.

The magnitude of past impacts on bird species due to disturbance from these external activities is unknown, but lingering population effects on non-threatened species are unlikely. The majority of the disturbance impacts were small scale, short-term, and, for the case of recent development at Badami and exploration drilling at Sourdough and Slugger, generally mitigated. Therefore, Table 7-8 shows an N for "Lingering Influence from Past External Effects" for disturbance.

Mortality due to past hunting and exposure to global pollutants is minimal relative to non-threatened bird species populations. Therefore, it is assumed there are no lingering influences from past mortality on on-threatened bird species. This is depicted as N for "Lingering Influences from Past External Effect" in Table 7-8.

Present and Potential Future External Actions

The following external actions, both human controlled and natural events have been identified as potentially contributing to bird habitat, disturbance, and mortality effects in the vicinity of the Point Thomson project:

- Badami – future expansion of onshore facilities could be required to support development in the Slugger Unit. Potential impacts to birds include habitat loss due to gravel placement, and disturbance and mortality due to project activities.
- Far West Pad, Slugger Development, and Sourdough Development – impacts to bird habitat, and disturbance and mortality impacts due to construction and operation of pad facilities could be realized due to development of these areas. Effects on the marine environment could occur if it became necessary to dredge offshore of either the Badami or proposed Point Thomson dock. Potential impacts to marine birds and waterfowl include disturbance and mortality.
- Gas Sales at Point Thomson - impacts could occur to the bird community if it became necessary to enlarge pads, or if dredging was required offshore of the proposed Point Thomson dock.
- Scientific Research and Surveys – annual bird surveys and other research efforts could cause disturbance and mortality.
- Subsistence hunting - could also add to any mortality or disturbance from project actions.
- Global pollutants – could cause increasing susceptibility to and bioaccumulation of contaminants such as mercury or other metals could cause a decrease in overall bird health eventually contributing to mortality impacts.
- Foggy Conditions – contribute to the incidence of bird strikes.
- Disease – a large number of long-tailed ducks is suspected to have succumbed to a virus in the past year (Anchorage Daily News June 27, 2001). Some of the dead ducks were found west of Flaxman Island during USGS surveys in the summer of 2000. USGS biologists believe that disease may be an important factor in population trends for these ducks.

Individually, any of these external factors could impact birds through habitat loss and alteration, disturbance, or mortality. They are shown as either Y or N/A on Table 7-8. However, while the potential for an impact from these actions is identified, the significance of an impact from any given action is not rated (see Section 7.2.4).

Cumulative Effects

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Facility, in conjunction with impacts from past, present, and potential future external actions, it has been determined that cumulative impacts on the bird populations in the analysis area could occur for habitat loss/alteration, disturbance, and mortality. However, the likelihood that any of the potential cumulative effects could be significant is low (see Table 7-8). The rationale for determining that the likelihood of significance will be low is based on the following assumptions:

- Nesting habitat is not limited in the region.
- Any new developments will minimize footprint and mitigate impacts to birds.
- Disturbance severe enough to create population level effects is not expected.

- Mortality from Point Thomson and other oil/gas development activities is expected to have minimal contribution.
- Mortality from subsistence hunting and scientific surveys is controlled to minimize population level impacts.
- Disease is not expected to have population level impacts in non-threatened species.

This page intentionally left blank

Table 7-8. Bird Cumulative Effect Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS											Cumulative Effect?	Likelihood that CE could be Significant	Assumptions/Rationale
			Human Controlled									Natural Events				
			Badami[1]	Far West Pad	Flaxman Island Rem.	Sourdough Dev.	Slugger Dev.	Gas Sales PTU[4]	Global Pollution	Scientific Research & Surveys	Subsistence	Foggy Conditions	Disease			
HABITAT LOSS AND ALTER-ATION	Y(NS)[3]	N[3]	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	Y	LOW	• Nesting habitat not limiting • Pt. Thomson has minimal contribution to CE • Any new developments will minimize footprint and mitigate impacts to birds
DIS-TURBANCE	Y(NS)[4]	N	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	Y	LOW	• Pt. Thomson has minimal contribution to CE • Any new developments will minimize and mitigate impacts to birds • Disturbance severe enough to create population level effects is not expected
MORT-ALITY	Y(NS)	N	Y	Y	Y	Y	Y	Y	Y[5]	Y	Y	Y[6]	Y[7]	Y	LOW	• Mortality from Pt. Thomson and other oil/gas development activities expected to have minimal contribution • Mortality from subsistence hunting and scientific surveys is controlled to minimize population level impacts • Disease not expected to have population level impacts in non-threatened species.

NOTES:

Y = Yes NS = Not significant
N = No CE = Cumulative Effect
U = Unknown
N/A = Not applicable
Dev. = Development
Rem. – Remediation

Footnotes:
[1]Potential effects if Badami facilities are expanded to support other development
[2]If larger pads/roads are needed for gas sales equipment
[3]Onshore nesting habitat not limited
[4]Short-term impacts could occur due to construction noise; however, disturbance would be greatest in winter when most birds are not present
[5]Documentation of contaminants in Alaskan birds is poor; however contaminants can add to potential mortality from other actions
[6] Foggy conditions contribute to incidence of bird strikes
[7]Long-tailed ducks in waters found off of Flaxman Is. Suspected to have succumbed to a virus (ADN, June 27, 2001)

7.3.2.5 Marine Mammals

The cumulative impact analysis for marine mammal is divided into separate discussions considering cetaceans, pinnipeds, and polar bears.

Cetaceans

Section 5.2.5 of this ER concludes that no cetaceans are expected to be within the proposed project area during winter and consequently will not be affected by winter construction activities at Point Thomson. Beluga whales are rarely seen in the Point Thomson area during the summer and are absent from the Alaskan Beaufort Sea from November through March (see Section 4.9.1.2). In autumn, most belugas migrate well offshore of the Point Thomson area, and are unlikely to be impacted by noise associated with construction or operations activities. Therefore, the Point Thomson project will not contribute to any cumulative impacts on this species. Similarly bowhead whales migrate past the Point Thomson area, and a few individuals may be encountered offshore of the project as early as late August. While project-related impacts on this species are expected to be minimal, the overall cumulative impacts are considered due to the species' status as endangered. The cumulative effects analysis for bowhead whales is provided in Section 7.3.5.7 under Threatened and Endangered Species.

Pinnipeds

The cumulative impact analysis for pinnipeds is depicted on Table 7-9 and described in the following paragraphs.

Internal Project Effects

As described in Section 5.2.5, the construction and operations activities associated with the Point Thomson Gas Cycling project can impact pinnipeds that use Lions Lagoon and nearby areas for foraging and hauling-out. The ringed seal is main pinniped found throughout the region and the only one that could be expected in the area during the winter months (see Section 4.9.2). Bearded seals can be found near the project area in the spring and summer and spotted seals are occasionally observed during this time also.

Potential project impacts on pinniped species in the area can occur due to habitat loss and alteration, behavioral disturbance, and/or mortality:

Habitat Loss and Alteration

As described in Section 5.2.5.1, long-term habitat effects are not expected for pinnipeds due to winter or summer construction activities. Increased turbidity due to gravel placement in the winter and dredging and spoils disposal in the summer is expected to be short-term and have minimal direct impact on seals. There may be some displacement of pinnipeds from the immediate area of construction due to both noise and turbidity, but this impact is discussed under the context of disturbance (see below) rather than as a habitat effect. Therefore, Table 7.9 shows the potential project effects on habitat as N/A (not applicable), and the reader is referenced to a discussion on disturbance.

Disturbance

Behavioral disturbance to pinnipeds using the project area can be induced by:

- Generation of noise and activities associated with onshore and offshore construction during both winter and summer construction periods (i.e., construction equipment, blasting associated with the gravel mine, vessels, airplanes, helicopters, and vehicles).
- Longer-term, but likely of less magnitude, generation of noise associated with operation of the facility. This could consist of generators, compressors and other machinery, drill rigs, and regular and maintenance-related vehicle traffic.

Section 5.2.5.2 concluded that winter construction sounds do not propagate very far (<40 ft [12 m]) in shallow waters. In addition, LGL and Greeneridge (2001) determined that construction of the Northstar Island, pipeline corridor, and ice roads apparently did not impact ringed seal distribution or abundance. The same study concludes that during the open water construction period the behavior or number of ringed seals may have been slightly affected, but any effects from construction activities were minor, short-term, and localized with no consequences for the ringed seal population. Since much of the construction at Point Thomson will be land-based as compared to offshore, impacts or construction are likely to be even less than those reported at Northstar.

Section 5.2.5.2 of this ER also concludes that effects of operations-related noise and disturbance on pinnipeds will consist of short-term, localized behavioral reactions. In support of this conclusion, LGL and Greenridge (2001) found that a small minority of seals present in the Northstar area reacted to aircraft over-flights by diving or showing other disturbance-related actions. Most seals showed no apparent response to the aircraft. Effects on individual seals or their populations will not be significant. For these reasons, disturbance-related impacts on pinnipeds due to Point Thomson project actions are considered to be not significant. This determination is depicted as Y (NS) on Table 7-9.

Mortality

Direct pinniped mortality from project actions could occur through:

- Collisions with vessels or barges.
- Ingestion of spilled fuels and other operations-related materials.

Section 5.2.5.3 concludes that mortality impacts on pinnipeds due to project-related vessel traffic will not occur. For example, during the open water construction season for the Northstar project LGL and Greenridge (2001) found no evidence of seal injuries or fatalities. Also this study found that during the 1999-2000 ice covered season, seal injuries and/or fatalities were not expected, nor were they found. Operations-related mortality is also not expected due to the relatively small amount of vessel traffic expected for the project (see Section 5.2.5.3). Therefore, project-induced mortality is not anticipated to occur and is depicted as N on Table 7-9.

Past External Impacts

Past activities in the area of consideration for pinnipeds (see section 7.2) could have created additional disturbance or mortality for these species. Past external actions in the area include:

- Military operations particularly at the Bullen Point DEW line station.
- Oil and gas exploration, seismic investigations and drilling in the Badami and Point Thomson Units.
- Construction and operation of the Badami facility.
- Scientific research and surveys that have been conducted in the area (in particular a United States Geological Service (USGS) study on long-tailed ducks conducted from Flaxman Island in 1999 and 2000 could have caused disturbance to seals).
- Flaxman Island Remediation - cleanup of several old exploration drill pads on the island could have caused disturbance to seals due to increased air and vessel traffic and noise from heavy equipment.
- Subsistence hunting - could also have added to any mortality or disturbance.

The magnitude of past impacts on pinnipeds due to disturbance and mortality from many of these external activities is unknown, but lingering population effects on species are unlikely. Impacts of disturbance and mortality from oil-related construction activities can be inferred as having been minimal and short term (LGL and Greenridge 2001). Therefore, Table 7-9 shows an N for no lingering influence from past external effects for the potential impacts of disturbance and mortality.

Present and Potential Future External Actions

The following external actions, both human controlled and natural events, have been identified as potentially contributing to pinniped disturbance and mortality effects in the vicinity of the Point Thomson project:

- Far West Pad, Slugger Development, Sourdough Development and/or Gas Sales at Point Thomson – disturbance to pinnipeds could occur if it became necessary to dredge offshore of either the Badami or proposed Point Thomson dock to support development of these facilities.
- Flaxman Island Remediation – continued cleanup of several old exploration drill pads on the island could cause disturbance to seals due to increased air and vessel traffic and noise from heavy equipment.
- Scientific Research and Surveys – annual surveys by aircraft and possible collaring efforts could cause disturbance or mortality for seals either due to direct or indirect effects.
- Subsistence hunting – could also add to any mortality or disturbance from project actions.
- Offshore Seismic Exploration – could contribute to disturbance or mortality effects.

Individually, many of these external factors could cause behavioral disturbance or mortality for pinnipeds. They are shown as Y, N, or N/A on Table 7-9. However, due to the expected minimal amount of offshore activities that could be associated with the external actions, and the results of LGL and Greenridge (2001) which showed minimal impacts from a large offshore construction effort, the significance of an external impact for any given action is likely to be not significant.

Cumulative Effects

From the perspective of this project, a cumulative effect of mortality is not identified for pinniped species. This is shown as an N on Table 7-9 under the cumulative effect column.

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Facility, in conjunction with impacts from present and potential future external actions, it has been determined that cumulative effects due to disturbance impacts on the pinniped populations could occur. However, the likelihood that the potential cumulative effect could be significant is low (see Table 7-9). The rationale for determining that the likelihood of significance will be low is based on the following assumptions:

- While short term disturbance is possible during construction; population level effects are not expected.
- Minimal offshore or nearshore disturbance is expected during operations.

Polar Bear

The cumulative impact analysis for polar bear is depicted on Table 7-10 and described in the following paragraphs.

Internal Project Effects

As described in Section 5.2.5, the construction and operations activities associated with the Point Thomson Gas Cycling project can impact polar bears that use onshore areas for denning. In the proposed project area, polar bears are present near the coast during the ice-covered period and infrequently during the summer (see Section 4.9.3). Pregnant females enter dens in October or November and emerge with their cubs in late March or April. Therefore, potential project impacts on polar bears can occur due to habitat loss and alteration, behavioral disturbance, and/or mortality.

Habitat Loss and Alteration

Since non-denning polar bears generally prefer areas of heavy offshore pack ice, most potential project-related habitat effects would be to denning areas on shore. Traditionally, few dens are found on the mainland in the immediate project area (see Figure 4-6). While many dens have been historically found on Flaxman Island, project activities during the denning period (October to April) will not impact the immediate vicinity of the island. As described in Section 5.2.5.1, habitat or denning sites for polar bears will be avoided; however, it may not be possible to guarantee that no den sites or potential den sites will be impacted to any degree. Therefore on Table 7-10 potential project effects on habitat are identified, but are anticipated to be not significant. This is shown as Y (NS) on the table for the "potential project effects" column.

Disturbance

Behavioral disturbance to polar bears using the project area can be induced by:

- Generation of noise and activities associated with onshore and offshore construction during both winter and summer construction periods (i.e., construction equipment, blasting associated with the gravel mine, vessels, airplanes, helicopters and vehicles, and winter drilling activities).

- Longer-term, but likely of less magnitude, generation of noise associated with operation or the facility. This could consist of generators, compressors and other machinery, drill rigs, and operations and maintenance-related vehicle traffic.
- Hazing activities required to protect project personnel.

As discussed in Section 5.2.5.2, Amstrup (1993) found that polar bears tolerated exposure to a variety of disturbances with no apparent effect on productivity. If exposed to intense disturbance during the period when they are seeking den sites, polar bears could choose less disturbed locations. They are likely to be most sensitive to disturbance late in the denning period when abandonment of a den could impact cub survival. Section 5.2.5.2 concludes that polar bears are thought to avoid loud noise, but there is no evidence that noise associated with construction or operations at oil field facilities disturbs polar bears. The impacts of occasional hazing to protect life and property will be minimized by developing mitigation actions and following wildlife interaction plans. For these reasons, a potential project effect of disturbance is identified for polar bears, but the impact is expected to be not significant. This determination is depicted as Y (NS) on Table 7-10.

Mortality

Polar bear mortality can occur through:

- Collisions with construction equipment, vehicles or vessels.
- Necessity of killing a bear to protect life and property.
- Ingestion of spilled fuels and other operations-related materials (see Section 7.3.4 for a discussion of cumulative impacts of spills).

Mortality impacts on polar bears due to project-related equipment, vehicles, and vessel traffic will be negligible. However, should a polar bear den be disturbed or a bear be attracted to cooking odors or camp activities, it may necessary to kill a threatening bear. Therefore project-induced mortality is possible, but the effect is likely to be not significant due to mitigation and avoidance measures. The effect is depicted as Y (NS) on Table 7-10.

Past External Impacts

Past activities in the area of consideration for polar bears could have had created additional disturbance or mortality for this species (Table 7-2). Past external actions in the area include:

- Military operations particularly at the Bullen Point DEW line station.
- Oil and gas exploration, seismic investigations and drilling in the Badami and Point Thomson Units.
- Construction and operation of the Badami facility.
- Flaxman Island Remediation – cleanup of several old exploration drill pads on the island could have caused disturbance and mortality to denning polar bears or could have degraded potential polar bear den habitat.
- Scientific research and surveys conducted in the area (in particular annual USFWS den surveys and collaring) could have caused disturbance and mortality.

- Subsistence hunting - could also have added to any mortality or disturbance

The magnitude of past impacts on polar bears due to disturbance from many of these external activities is unknown, but lingering population effects on polar bears are unlikely. Impacts of disturbance from oil-related construction and operations activities have been successfully mitigated in the past. In addition, Flaxman Island remains as a heavily-used polar bear denning location, even though past oil and gas exploration activities, remediation and clean-up of contaminated sites, and scientific survey staging areas have been located on the island, likely contributing to increased disturbance in the area. Therefore, there is assumed to be no lingering influence from past external actions on the polar bear population of the region due to habitat loss or disturbance. Table 7-10 depicts this conclusion as an N for both of these potential impacts under the "Lingering Influence from Past External Action" column.

A lingering effect of due to mortality from past hunting practices on polar bear population size has been identified. This is depicted as Y for mortality in Table 7-10 under the "Lingering Effects" column. However, the southern Beaufort Sea population has increased over the last 20 years (see Section 4.9.3), so the lingering effect is likely to be minimal.

Present and Potential Future External Actions

The following external actions, both human controlled and natural events, have been identified as potentially contributing to disturbance and mortality effects on polar bears in the vicinity of the Point Thomson project:

- Badami – future expansion of onshore facilities could be required to support development in the Slugger Unit. Potential impacts to polar bear include habitat loss due to gravel placement, disturbance, and mortality.
- Far West Pad – impacts to polar bear habitat, and disturbance and mortality impacts due to construction and operation of pad facilities could be realized if the pad is constructed. Effects on the marine environment could occur if it became necessary to dredge offshore of the proposed Point Thomson dock.
- Slugger Development - impacts could occur to polar bears if it became necessary to dredge the Badami dock area, or add to Badami facilities to support exploration and development of this unit. Denning habitat is not likely to impacted by infrastructure for this development since denning areas are typically not located so far inland.
- Sourdough Development - impacts could occur to polar bears if it became necessary to dredge the proposed Point Thomson dock or add additional coastal facilities to support exploration and development of this unit.
- Gas Sales at Point Thomson - impacts could occur to the polar bears if it became necessary to enlarge pads, or if dredging was required offshore of the proposed Point Thomson dock.
- Flaxman Island Remediation – cleanup of several old exploration drill pads on the island could cause potential mortality or disturbance to denning polar bears or could degrade potential polar bear den habitat.
- Scientific Research and Surveys – annual den surveys and other research efforts could cause disturbance or mortality for polar bears either due to direct or indirect effects, or due to the potential for killing a bear to protect human life.

- Subsistence hunting - could also add to any mortality or disturbance from project actions.

Individually, many of these external factors could impact habitat or cause behavioral disturbance or mortality for polar bears. They are shown as Y, N, or N/A, on Table 7-10. However, due to the expected minimal amount of offshore activities that could be associated with the external actions, and the results of observation that polar bears are apparently not disturbed by work at Flaxman island, the significance of an external impact for any given action is likely to be not significant.

Cumulative Effects

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Facility, in conjunction with impacts from present and potential future external actions, it has been determined that cumulative effects on polar bears due to habitat loss/alteration, disturbance, and/or mortality could occur. However, the likelihood that the potential cumulative effect could be significant is low (see Table 7-10). The rationale for determining that the likelihood of significance will be low is based on the following assumptions:

- Denning habitat in the Point Thomson area is not limited.
- Any new developments will minimize footprint and mitigate impacts to polar bears.
- There are no known areas of long-term polar bear displacement within the defined geographical scope.
- Polar bears regularly return to Flaxman Island where exploration and remediation has occurred.
- Population level effects not expected; the polar bear population in the region is not threatened.
- Mortality from the Point Thomson project and other oil/gas development activities is expected to have minimal contribution to the cumulative impact of mortality.
- Mortality from subsistence hunting and scientific surveys is monitored; population level effects not expected.

This page intentionally left blank

Table 7-9 Pinnipeds Cumulative Effects Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS								Cumulative Effect?	Likelihood that CE Will be significant	Assumptions/Rationale
			Far West Pad [1]	Sourdough Dev.[1]	Slugger Dev.[1]	Gas Sales PTU[1]	Flaxman Island Rem.	Scientific Research & Surveys	Subsistence Hunting	Offshore Seismic Exploration			
HABITAT LOSS and/or ALTERATION[2]	N/A[2]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DISTURBANCE	Y(NS)[3,4]	N[4]	Y	Y	Y	Y	Y	Y	Y	Y	Y	LOW	• Pt. Thomson project has minimal contribution to CE • Short term disturbance possible during construction; population level effects not expected • Minimal offshore or nearshore disturbance expected during operations
MORTALITY	N	N	N	N	N	N	N	Y	Y	N	N[5]	N/A	N/A

NOTES:
Y = Yes
N = No
N/A = Not applicable
Dev. = Development
NS = Not significant

Footnotes:
[1]Only if existing dock at Badami or proposed dock at Pt. Thomson is dredged for use by one of these other projects.
[2] Habitat effects are considered under the context of disturbance.
[3]Short-term impacts possible due to summer dredging and winter gravel placement
[4]Data collected during Northstar construction efforts showed no impact to distribution or abundance of ringed seals (LGL and Greenridge 2001)
[5]From the perspective of this project there is no cumulative effect since there is no expected impact on direct mortality from development of Point Thomson

Table 7-10. Polar Bear Cumulative Effect Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS								Cumulative Effect?	Likelihood that CE Could Be Significant	Assumptions/Rationale
			Badami	Far West Pad	Sourdough Dev.	Slugger Dev.	Gas Sales PTU	Scientific Research & Surveys	Subsistence Hunting	Flaxman Island Remediation			
HABITAT LOSS and/or ALTERATION[2]	Y(NS)[1]	N[2]	Y	Y[3]	N[4]	N[4]	Y	N/A	N/A	Y	Y	LOW	• Pt. Thomson project has minimal contribution to CE • Denning habitat not limited • Any new developments will minimize footprint and mitigate impacts to polar bear • No known areas of long-term displacement within project geographical scope
DISTURBANCE	Y(NS)[5]	N[6]	Y	Y	N[4]	N[4]	Y	Y	Y	Y	Y	LOW	• Pt. Thomson project has minimal contribution to CE • Any new developments will mitigate disturbance impacts to polar bear • No known areas of long-term displacement within project geographical scope • Population level effects not expected; population not threatened • Polar bears return to Flaxman Island where exploration and remediation has occurred
MORTALITY	Y(NS)[7]	Y[8]	Y[7]	Y[9]	N[4]	N[4]	Y[7]	Y[9]	Y[9]	Y[7]	Y	LOW	• Mortality from Pt. Thomson project and other oil/gas development activities expected to have minimal contribution • Mortality from subsistence hunting and scientific surveys is controlled; population level effects not expected • Population is not threatened

NOTES:
Y = Yes
N = No
U = Unknown
N/A = Not applicable
NS = Not significant
Dev. = Development

Footnotes:
[1]Active denning sites will be avoided
[2]No known areas of long-term displacement within analysis scope
[3]In an area with several former den sites
[4]Dens and area use not anticipated so far inland
[5]Individuals are thought to avoid loud noise but there is no evidence that noise associated with construction or operation disturbs polar bears.
[6]Continued use of numerous den sites on Flaxman Island even though exploration, remediation, and scientific surveys have taken place there.
[7]Impact exists due to potential need to kill a bear to protect life or property, however, the potential that this will happen is very low
[8]Potential lingering effect from past hunting efforts
[9]Could add to potential mortality from project

7.3.2.6 Terrestrial Mammals

The Central Arctic Caribou Herd (CAH) and the Porcupine Caribou Herd (PCH) were identified as the caribou herds of interest in the ER. The CAH has eastern and western segments that utilize different calving and insect relief ranges (Section 4.10.1). The two CAH segments are not isolated from each other in their winter range. In addition, there is some exchange of caribou between the two segments among years. However, caribou that join with one of the segments in a given year are not known to move between segments within a year. The CAH eastern segment range includes the Point Thomson area, whereas the western segment does not range east of the Sagavanirktok River. Therefore, only the CAH eastern segment is brought forward for discussion in this cumulative effect analysis. The geographic scope of the cumulative analysis is redefined as from the Sagavanirktok River east to the Tamayariak River, south to the Brooks Range, and north to the barrier islands for the CAH eastern segment. The PCH geographic scope is the same as the CAH eastern segment for west, north, and south boundaries, but is extended to Kaktovik on the eastern boundary in this cumulative effect analysis.

The geographic scope for muskoxen, grizzly bear, Arctic fox, and moose ranges from the Badami Facility east to the Canning River, north to the barrier islands, and to the southern boundary of the Point Thomson Unit. The CAH and PCH are analyzed separately due to the difference in their summer and winter ranges. Muskoxen, grizzly bear, Arctic fox, and moose are grouped together as "terrestrial mammals" for analysis.

Cumulative effect analyses for CAH, PCH, and terrestrial mammals are discussed in the following sub-sections and summarized in Tables 7-11 through 7-13.

Internal Project Effects

As discussed in Section 5.2.6, potential effects of the Point Thomson Gas Cycling Project on terrestrial mammals are limited to habitat loss and alteration, disturbance, and mortality. The following project actions have been identified as potentially contributing to these effects:

Habitat Loss and Alteration

- Habitat loss due to placement of gravel for construction of roads, pads, and airstrip.
- Habitat alteration due to ice road construction; dust fallout; potential obstruction of flow due to presence of roads, pads, and airstrip; and thermokarst.

Disturbance

- Noise and visual disturbance from construction, operations, and maintenance activities.
- Noise from vehicular traffic.
- Gravel roads, pads, airstrip, and pipeline could disturb movement of terrestrial mammals.

Mortality

- Strikes by vehicles.
- Direct take for protection of human life and property (only relevant for grizzly bear and Arctic fox).

- Increase in prey populations due to new food sources (i.e., garbage and personnel feeding wildlife).

Central Arctic Caribou Herd - Eastern Segment

Habitat loss due to gravel placement will cause long-term alteration of 9,404,666 ft^2 (873,693 m^2) of habitat used by the CAH. Section 5.2.6.1 concludes that although the habitats are important to caribou, they are also among the most abundant habitats in the Point Thomson area. Placement of frozen gravel during winter construction and regrading in the spring is not likely to cause dust fallout effects (Section 5.2.6.1). Dust fallout as a result of operations is anticipated to be minimal (Section 5.2.6.1). The seasonal duration of any minor impoundments during spring runoff is anticipated to be short-term. Placement of culverts or other drainage structures would minimize the potential formation of long term impoundments. Thermokarsting is a naturally occurring process on the North Slope. Minor changes due to thermokarst could occur around the gravel mine site. Therefore, loss or alteration to CAH eastern segment habitat resulting from project actions is rated as not significant, and depicted as Y (NS) on Table 7-11 for habitat in the "Potential Project Effects?" column.

Noise and visual disturbance from winter construction activities (i.e., gravel mining; gravel road, pad, and airstrip construction; drilling; and pipeline construction) will not impact CAH eastern segment since they are not in the Point Thomson area during the winter. The CAH eastern segment could be disturbed due to behavioral reactions in response to road traffic during the summer construction phases; however, this is anticipated to diminish to low levels during operations due to low traffic volume (Section 5.2.6.2). The presence of roads and pads and their associated traffic noise should cause minimal disturbance to female caribou with calves due to availability of other suitable habitat in the area. The 500 ft (152 m) separation between gravel roads and gathering pipelines from the East and West Pads to the CPF and anticipated low traffic volume minimizes disturbance of the caribou movement and improves crossing success (Section 5.2.6.2). Therefore, disturbance of the CAH eastern segment from project actions is rated as not significant, and depicted as Y (NS) on Table 7-11 for disturbance in the "Potential Project Effects?" column.

Risk of vehicle strikes by trucks and aircraft would be highest during the summer months when the CAH eastern segment are more likely to be in the Point Thomson area. Although vehicle-caused mortality is poorly documented, the number of animals killed is thought to be low in the Kuparuk and Prudhoe Bay oil fields. During early spring in the Kuparuk and Prudhoe Bay oil fields, caribou are attracted to roadside areas to forage on vegetation that has "greened up" early due to dust fallout. Although the early vegetation provides nutritious forage, exposure to traffic-related disturbance increases the risk of vehicle strikes. The amount of roads proposed and anticipated traffic rates for the Point Thomson Gas Cycling Project are minimal compared to the road system and traffic rates in the Kuparuk and Prudhoe Bay oil fields. It is unlikely that traffic on Point Thomson gravel roads would generate sufficient dust fallout to induce a "green up" effect that would attract large numbers of caribou near roadside areas. Grizzly bear could also cause caribou mortality since they are known to prey on caribou, especially calves (Section 4.10.3). It is anticipated that waste control and enforced rules against personnel feeding wildlife will minimize artificial attraction of grizzly bear to the Point Thomson area. Therefore, mortality of CAH eastern segment individuals from project actions is rated not significant. This is depicted as Y (NS) on Table 7-11 for mortality in the "Potential Project Effects?" column.

Porcupine Caribou Herd

Potential Point Thomson Gas Cycling Project effects identified above for the CAH eastern segment are the same for the PCH. However, potential impacts to the PCH are unlikely since this herd infrequently visits the Point Thomson area during summer. PCH typically approach the Beaufort Sea coast during the post-calving period until the beginning of insect season. The majority of the herd then moves southeast in to the foothills and mountains of the Brooks Range in July. The last large group of PCH documented in the Point Thomson area was in 1988 (Section 4.10.1.2). Therefore, identified habitat loss and alteration, disturbance, and mortality effects within the defined geographic area are rated as not significant for the PCH. This is depicted as Y (NS) on Table 7-12 in the "Potential Project Effects?" column.

Terrestrial Mammals

Muskoxen, grizzly bears, and moose typically frequent riparian habitats along the Arctic Coastal Plain (Sections 4.10.2, 4.10.3, and 4.10.5, respectively), whereas Arctic fox make use of a wide variety of habitats (Section 4.10.4). Riparian habitats that are used particularly by muskoxen, grizzly bears, and moose comprise less than 1% of areas impacted by the project footprint. Muskoxen are also known to make use of moist tussock and shrub tundra habitats and shrub stands along tundra streams (Section 4.10.2). These habitat types comprise less than 0.1%, respectively, of all vegetation mapped in the Point Thomson area (Table 4-4), and are not impacted by gravel placement (Table 5-3). Therefore, loss or alteration to terrestrial mammal habitat resulting from project actions is rated as not significant. This is depicted as Y (NS) on Table 7-13 for habitat in the "Potential Project Effects?" column.

Muskoxen, grizzly bears, and moose infrequently visit the Point Thomson area. Area use by Arctic fox likely occurs but has not been documented. The three fox dens located during area surveys are far removed from the project site (Section 4.10.4). Disturbance due to noise associated with Point Thomson project activities is anticipated to be minimal. Most of these species are not known to frequent the project area and Arctic fox readily habituate to noise associated with oil filed activities. Therefore, disturbance of these species due to project actions is rated as not significant, and depicted as Y (NS) on Table 7-13 for disturbance in the "Potential Project Effects?" column.

There is a risk of vehicle strikes if muskoxen, grizzly bears, moose, and Arctic fox move within the Point Thomson area. However, due to enforced speed limits and wildlife interaction training for personnel this risk is considered to be minimal. Direct take of grizzly bears and Arctic fox for protection of human life and property could occur. It is anticipated that waste control and enforced rules against personnel feeding wildlife will minimize artificial attraction of grizzly bear and Arctic fox to the Point Thomson area. Therefore, mortality of terrestrial mammals from project actions is rated as not significant. This is depicted as Y (NS) on Table 7-13 for mortality in the "Potential Project Effects?" column.

Past External Effects

Past external actions pertinent to identified potential habitat, disturbance, and mortality effects for CAH, PCH, and terrestrial mammals were as follows:

Habitat

- Oil and Gas Exploration – habitat loss due to exploratory pads from the Point Thomson Unit west to the Sagavanirktok River.
- Endicott – habitat loss due to onshore gravel road from the coastline to the westward boundary of the Sagavanirktok River.
- Badami – habitat loss due to gravel roads, pads, and airstrip.

Disturbance

- Endicott – noise and visual disturbance associated with construction and operations vehicular traffic, and gravel road and pipeline could disturb movement of caribou and other terrestrial mammals.
- Badami – noise associated with construction and operations vehicular traffic, and gravel road and pipeline could disturb movement of caribou and other terrestrial mammals.

Mortality

- Endicott – strikes by vehicles on gravel road.
- Badami - strikes by vehicles; direct take for protection of human life and property (only relevant for grizzly bear and Arctic fox); and increase in prey populations due to new food sources (i.e., garbage and personnel feeding wildlife).
- Scientific Research and Surveys – mortality due to drug overdose, stress from capture, or direct kill (caribou and grizzly bear only).
- Subsistence Hunting – direct kill.
- Sport Hunting – direct kill.

Central Arctic Caribou Herd – Eastern Segment

Habitat has been lost due to past construction of gravel pads associated with past exploratory oil and gas activities; a gravel road connecting the Endicott facility to Prudhoe Bay infrastructure; and gravel roads, pads, and airstrip associated with the Badami facility. The potential that loss of these habitats has affected the CAH eastern segment depends on two factors: the percent of forage made unavailable and the carrying capacity of the area (Cronin et al. 1994). The loss of habitat due to past gravel placement is small relative to forage habitat in the defined geographic area, and the CAH population, as a whole, has been increasing since 1980 (Section 4.10.1.1). Therefore, it is assumed that there are no lingering influences due to habitat loss for the CAH eastern segment. This is depicted as N on Table 7-11 for habitat in the "Lingering Influence From Past External Actions?" column.

Noise and visual disturbance from past Endicott and Badami winter construction activities (i.e., gravel mining; gravel road, pad, and airstrip construction; drilling; and pipeline construction) did not impact the CAH eastern segment since they are not in the area during the winter. The CAH eastern segment could have been disturbed due to behavioral reactions in response to road traffic during the summer construction phases of these facilities; however, it is assumed that disturbance diminished to low levels once operations began due to reduced traffic volume. Separating the

Endicott pipeline and onshore gravel road and elevating the Badami pipeline minimized disturbance of the CAH eastern segment movements. Since the CAH population, as a whole, has not drastically declined since 1980, it is assumed there are no lingering influences due to disturbance of the CAH eastern segment at the population level. This is depicted as N on Table 7-11 for disturbance in the "Lingering Influence From Past External Actions?" column.

Although vehicle-caused mortality is poorly documented, the number of animals killed in the past is thought to be low in the Kuparuk and Prudhoe Bay oil fields. Past mortality of CAH eastern segment individuals due to traffic associated with the small amount of onshore road from Endicott and the minimal roads and airstrip at the Badami facility was not identified. Mortality from scientific research and surveys could have been caused due to drug overdoses, stress from capture, or direct kills. In addition, subsistence and sport hunting caused direct mortality of CAH eastern segment individuals. Potential mortality from these past sources would be minimal relative to population size, and is not thought to have had population level effects on the CAH eastern segment. Therefore, it is assumed that there are no lingering influences on the CAH eastern segment due to past mortality. This is depicted as N on Table 7-11 for mortality in the "Lingering Influence From Past External Actions?" column.

Porcupine Caribou Herd

Potential past external actions identified above for the CAH eastern segment are the same for the PCH. However, the potential for impacts to the PCH are much smaller since this herd infrequently visits the defined geographic area during summer. The last large group of PCH documented near the Sagavanirktok River was in 1988 (Section 4.10.1.2). Therefore, it is assumed that there are no lingering influences on the PCH due to past habitat loss, disturbance, and mortality effects in the defined geographic area. This is depicted as N on Table 7-12 for habitat, disturbance, and mortality in the "Lingering Influence From Past External Actions?" column.

Terrestrial Mammals

Muskoxen, grizzly bears, and moose infrequently visit the defined geographic area. Area use by Arctic fox likely occurs but has not been documented; however, three fox dens have been located in the defined geographic area (Section 4.10.4). Muskoxen, grizzly bears, and moose typically frequent riparian habitats, while Arctic fox make use of a wide variety of habitats. Habitat loss due to construction of gravel pads associated with past exploratory oil and gas activities; a gravel road connecting the Endicott facility to Prudhoe Bay infrastructure; and gravel roads, pads, and airstrip associated with the Badami facility is minimal relative to abundance in the defined geographic area. Therefore, it is assumed that there are no lingering influences due to habitat loss for these terrestrial mammals. This is depicted as N on Table 7-13 for habitat in the "Lingering Influence From Past External Actions?" column.

Disturbance due to noise associated with past Badami construction and operations is thought to have been minimal since most of these species are not known to frequent the area and Arctic fox readily habituate to noise associated with oil filed activities. Therefore, it is assumed that there are no lingering influences on terrestrial mammals due to disturbance. This is depicted as N on Table 7-13 for disturbance in the "Lingering Influence From Past External Actions?" column.

Due to their infrequent use of the defined geographic area, the likelihood of past strikes and mortality of terrestrial mammals by vehicles is considered to be minimal. Direct take of grizzly bears and Arctic fox for protection of human life and property could have occurred. It is assumed that waste control procedures and enforced rules against personnel feeding wildlife that were implemented in the past lowered the risk of attracting grizzly bear and Arctic fox near facilities. Mortality from scientific research and surveys of grizzly bears could have been caused due to drug overdoses, stress from capture, or direct kills. In addition, subsistence and sport hunting caused direct mortality of muskoxen, grizzly bears, moose, and Arctic fox individuals. Mortality from these sources is thought to have been minimal relative to overall population sizes, and not have had population level effects on these species with the exception of moose. There was a 75% decline in the North Slope moose population from the late 1980s to 1994 from unidentified causes, and hunting was closed in Game Management Unit 26B in 1996 (Section 4.10.5). It is assumed that there are no lingering influences on muskoxen, grizzly bear, and Arctic fox populations due to past mortality. North Slope moose populations remained low through 2000 due to unknown causes; therefore, a lingering influence due to past mortality was identified for moose. This is depicted as Y^2 on Table 7-13 for moose mortality in the "Lingering Influence From Past External Actions?" column, footnoted to indicate that no lingering influences were identified for muskoxen, grizzly bear, and Arctic fox.

Present and Potential Future External Effects

Present and potential future external actions pertinent to identified potential habitat, disturbance, and mortality effects for CAH, PCH, and terrestrial mammals were as follows:

Habitat

- Badami – habitat loss due to gravel placement if facility is expanded for support of potential future projects.
- Far West Pad - habitat loss due to potential construction of gravel pad and road.
- Sourdough Development – potential construction of gravel roads, pads, and airstrip.
- Slugger Development – potential construction of gravel roads, pads, and airstrip.
- Gas Sales Point Thomson – potential construction of additional gravel pad for gas modules(s).

Disturbance

- Endicott – noise from vehicular traffic on gravel road.
- Badami – noise and visual disturbance associated with potential facility expansion to support potential future projects.
- Far West Pad – noise and visual disturbance associated with potential construction and traffic if gravel access road is constructed.
- Sourdough Development – noise and visual disturbance associated with potential operations and vehicular traffic associated with potential gravel road(s) and airstrip, and potential pipelines could disturb movement of caribou and other terrestrial mammals.
- Slugger Development – noise and visual disturbance associated with potential operations and vehicular traffic associated with potential gravel road(s) and airstrip, and potential pipelines could disturb movement of caribou and other terrestrial mammals.

- Gas Sales Point Thomson – noise associated with gas operation of module(s).
- Ecotourism – disturbance due to sightseeing flights and increased number of visitors touring/camping in Arctic National Wildlife Refuge.

Mortality

- Endicott – strikes by vehicles on gravel road.
- Badami – strikes by vehicles; direct take for protection of human life and property (only relevant for grizzly bear and Arctic fox); and increase in prey populations due to new food sources (i.e., garbage and personnel feeding wildlife).
- Far West Pad – strikes by vehicles on potential gravel road.
- Sourdough Development - strikes by vehicles on potential gravel road(s).
- Slugger Development – strikes by vehicles on potential gravel road(s).
- Scientific Research and Surveys – potential mortality due to drug overdose, stress from capture, or direct kill (caribou and grizzly bear only).
- Subsistence Hunting – direct kill.
- Sport Hunting – direct kill.

Central Arctic Caribou Herd – Eastern Segment

Additional habitat loss could occur due to expansion of the Badami facility to support future projects and/or construction of gravel roads, pads, and airstrips for future development projects. Potential habitat loss from these external actions is depicted as Y in Table 7-11 under the Badami, Far West Pad, and Sourdough and Slugger Development columns.

Noise and visual disturbance associated with potential expansion of Badami facilities in support of future projects, construction of a Far West Pad, or construction of potential Sourdough and/or Slugger developments is expected to be minimal. Major construction and drilling activities would most likely take place in the winter when the CAH eastern segment is absent from the area, and noise associated with equipment installation in the summer would be short-term. It is also assumed that these potential construction activities would not occur at the same time. There is evidence that caribou can habituate to operations noises occurring more or less on a regular basis (Cronin et al. 1994). Gravel roads, pads, airstrips, and pipelines could also be associated with potential future development. Noise from vehicular traffic and the physical presence of gravel roads, airstrips, and pipelines could disturb CAH eastern segment movements. Ecotourism and interest in ANWR is on the rise due to the current political atmosphere. Sightseeing flights and touring/camping excursions also have the potential to disturb caribou. This is depicted as Y in Table 7-11 under the Endicott, Badami, Far West Pad, Sourdough and Slugger Development, Gas Sales Point Thomson Unit, and Ecotourism columns.

Construction of additional gravel roads in the defined geographic area could increase the risk of vehicular strikes. Mortality from scientific research and surveys, subsistence hunting, and sport hunting could cause direct mortality of CAH eastern segment individuals. This is depicted as Y in Table 7-11 under the Endicott, Badami, Far West Pad, Sourdough and Slugger Development, Scientific Research and Surveys, Subsistence Hunting, and Sport Hunting columns.

Porcupine Caribou Herd

Present and potential future external actions and potential effects identified above for the CAH eastern segment are the same for the PCH, and depicted as Y on Table 7-12.

Terrestrial Mammals

Present and potential future external actions and potential effects identified above for the CAH eastern segment are the same for the muskoxen, grizzly bears, moose, and Arctic fox, and depicted as Y on Table 7-13.

Cumulative Effects

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Project, in conjunction with potential impacts from past, present, and potential future external actions, it was determined that cumulative effects on CAH, PCH, and terrestrial mammal populations in the analysis area due to habitat loss, disturbance, and mortality could occur. This is depicted as Y in Tables 7-11, 7-12, and 7-13 under the "Cumulative Effect?" column.

The likelihood that these cumulative effects could be significant is rated as low (Tables 7-11, 7-12, and 7-13). The rationale for determining the likelihood of significance is based on the following assumptions:

Habitat

- Habitat is not limiting for CAH, PCH, and terrestrial mammals.
- Potential future projects would have small footprints.

Disturbance

- Major construction of potential future facilities would occur in the winter when animals are not present in the area.
- Traffic volumes at Badami and future facilities would be low compared to traffic in the Prudhoe Bay and Kuparuk areas.
- Separation between potential future pipelines and gravel roads would be a sufficient distance to minimize disturbance and proved for successful crossings by animals.
- Potential future aboveground pipelines would be elevated to a sufficient height to allow successful movement by animals through the area.

Mortality

- Vehicle strikes would be minimized by enforced speed limits on current and potential future gravel roads.
- Mortality associated with scientific research and surveys rarely occurs.
- Direct kills from subsistence and sport hunting are small in number compared to overall population levels and monitored by State and Federal agencies.

Table 7-11 Central Arctic Caribou Herd Eastern Segment Cumulative Effect Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS — Human Controlled: Endicott[2]	Badami	Far West Pad	Sourdough Dev.	Slugger Dev.	Gas Sales PTU	Scientific Research & Surveys	Subsistence Hunting	Sport Hunting	Ecotourism	Cumulative Effect?	Likelihood That CE Could be Significant	Assumptions/Rational
HABITAT	Y (NS)[1]	N[1]	N/A	Y[3]	Y[3]	Y[3]	Y[3]	N/A	N/A	N/A	N/A	N/A	Y[1]	LOW	• Habitat is not limiting. • Potential future projects would have small footprints.
DISTURBANCE	Y (NS)[1]	N[1]	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	Y	Y[1]	LOW	• Major construction would occur in the winter. • Traffic volumes are low. • Separation between potential future pipelines and roads. • Sufficient elevation of potential future aboveground pipelines.
MORTALITY	Y (NS)[1]	N[1]	Y	Y	Y	Y	Y	N/A	Y	Y	Y	N/A	Y[1]	LOW	• Vehicle strikes minimized by enforced speed limits. • Mortality associated with scientific work rarely occurs. • Direct kills from hunting are small and monitored.

NOTES:

Y = Yes NS = Not significant
N = No CE = Cumulative Effect
N/A = Not applicable
Dev. = Development
PTU = Point Thomson Unit

Footnotes:

[1] = Analysis limited to the eastern segment of the Central Arctic Herd.
[2] = Endicott onshore road and associated pipeline from coastline to western boundary of Sagavanirktok River.
[3] = Habitat loss due to future potential gravel road(s) and pad(s).

Table 7-12 Porcupine Caribou Herd Cumulative Effect Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS — Human Controlled: Endicott[2]	Badami	Far West Pad	Sourdough Dev.	Slugger Dev.	Gas Sales PTU	Scientific Research & Surveys	Subsistence Hunting	Sport Hunting	Ecotourism	Cumulative Effect?	Likelihood That CE Could be Significant	Assumptions/Rationale
HABITAT	Y (NS)[1]	N[1]	N/A	Y[3]	Y[3]	Y[3]	Y[3]	N/A	N/A	N/A	N/A	N/A	Y[1]	LOW	• Habitat is not limiting. • Potential future projects would have small footprints.
DISTURBANCE	Y (NS)[1]	N[1]	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	Y	Y[1]	LOW	• Major construction would occur in the winter. • Traffic volumes are low. • Separation between potential future pipelines and roads. • Sufficient elevation of potential future aboveground pipelines.
MORTALITY	Y (NS)[1]	N[1]	Y	Y	Y	Y	Y	N/A	Y	Y	Y	N/A	Y[1]	LOW	• Vehicle strikes minimized by enforced speed limits. • Mortality associated with scientific work rarely occurs. • Direct kills from hunting are small and monitored.

NOTES:

Y = Yes NS = Not significant
N = No CE = Cumulative Effect
N/A = Not applicable
Dev. = Development
PTU = Point Thomson Unit

Footnotes:

[1] = Porcupine caribou herd infrequently migrates to the Canning River area and westward to the Sagavanirktok River.
[2] = Endicott onshore road and associated pipeline from coastline to western boundary of Sagavanirktok River.
[3] = Habitat loss due to future potential gravel road(s) and pad(s).

Table 7-13 Terrestrial Mammal Cumulative Effect Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS — Human Controlled: Endicott[3]	Badami	Far West Pad	Sourdough Dev.	Slugger Dev.	Gas Sales PTU	Scientific Research & Surveys	Subsistence Hunting	Sport Hunting	Eco-tourism	Cumulative Effect?	Likelihood That CE Could be Significant	Assumptions/Rational
HABITAT	Y (NS)[1]	N	N/A	Y[4]	Y[4]	Y[4]	Y[4]	N/A	N/A	N/A	N/A	N/A	Y	LOW	• Habitat is not limiting. • Potential future projects would have small footprints.
DISTURBANCE	Y (NS)[1]	N	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	Y	Y	LOW	• Major construction would occur in the winter. • Traffic volumes are low. • Separation between potential future pipelines and roads. • Sufficient elevation of potential future aboveground pipelines.
MORTALITY	Y (NS)[1]	Y[2]	Y	Y	Y	Y	Y	N/A	Y	Y	Y	N/A	Y	LOW	• Vehicle strikes minimized by enforced speed limits. • Mortality associated with scientific work rarely occurs. • Direct kills from hunting are small and monitored.

NOTES:

Y = Yes NS = Not significant
N = No CE = Cumulative Effect
N/A = Not applicable
Dev. = Development
PTU = Point Thomson Unit

Footnotes:

[1] = Analysis limited to the muskoxen, grizzly bears, moose, and Arctic fox.
[2] = Lingering past influence for moose only; no lingering influences were identified for muskoxen, grizzly bear, or Arctic fox.
[3] = Endicott onshore road and associated pipeline from coastline to western boundary of Sagavanirktok River.
[4] = Habitat loss due to future potential gravel road(s) and/or pad(s).

7.3.2.7 *Threatened and Endangered Species*

The cumulative impact analysis for threatened and endangered species is divided into separate discussions considering bowhead whales and spectacled eiders. As described in Section 5.2.7, Steller's eiders have not been recorded in the project area and are unlikely to occur there.

Bowhead Whales

The cumulative impact analysis for bowheads is summarized on Table 7-14 and described in the following paragraphs.

Internal Project Effects

Bowhead whale migration through the Alaskan Beaufort Sea occurs in spring and autumn. The spring migration occurs in a corridor that is located well offshore of Point Thomson (see Section 4.9.1.1). During the fall migration, a few bowheads could be encountered offshore of the project area in late August until the end of the migration in early October.

Potential project impacts on bowhead whales in the area can occur due to habitat loss and alteration, behavioral disturbance, and/or mortality.

Habitat Loss and Alteration

Section 5.2.7.2 concludes that effects of construction and operation of the proposed project on bowhead whales will be minimal. However, if disposed of late in August, increased turbidity due to spoils disposal offshore of the barrier islands could overlap with the beginning of the bowhead whale fall migration. A few animals could encounter a turbidity plume should this occur. The disposal site is not known at this time, and the potential size or duration of a plume has not been characterized. However, any turbidity generated by the plume would be short-term and may not extend far offshore into the migration corridor. Mitigation to minimize the impact will include ensuring that completion of the disposal operation occurs well before the migration period. Therefore, the potential impact on whale habitat is expected to be not significant, and Table 7-14 shows this potential project effects on habitat as Y (NS).

Disturbance

Behavioral disturbance to bowheads migrating offshore of the project area could be induced by:

- Generation of noise and activities associated with onshore and offshore construction during summer construction periods (i.e., construction equipment, dredging and spoils disposal, vessels, airplanes, helicopters and vehicles).
- Longer-term, but likely of less magnitude, generation of noise associated with operation or the facility. This could consist of generators, compressors and other machinery, and operations and maintenance-related vehicle traffic.

Section 5.2.5.2 concluded that construction sounds do not propagate very far (<40ft [12 m]) in shallow waters. In addition, LGL and Greeneridge (2001) determined that even when tugs and barges operated during construction activities at Northstar, broadband sound levels diminished to 115 decibels within an average of 2.5 mi (4 km). Bowheads could detect sounds at this level, but would not be expected to react to them (Williams et al 2001). Since much of the construction at

Point Thomson will be land-based as opposed to offshore, impacts of construction and operations noise on migrating bowhead whales are likely to be even less than those observed at Northstar. Any disturbance will also be mitigated by limiting vessel traffic to inside of the barrier islands and using over-land air routes during migration periods. For this reason, disturbance-related impacts on bowhead whales due to Point Thomson project actions are considered to be not significant. This determination is depicted as Y (NS) on Table 7-14.

Mortality

Direct mortality of bowheads from project actions could occur through:

- Collisions with vessels or barges
- Ingestion of spilled fuels and other operations-related materials (see Section 7.3.4 for a discussion of cumulative impacts of spills).

It is highly unlikely that project construction or operations activities in the nearshore region of Lions Lagoon could cause direct mortality for bowhead whales. During operations, mortality is also not expected due to the relatively small amount of vessel traffic expected for the project and the fact that the whales will be migrating far offshore of the area expected to be used by project vessels. Therefore, project-induced mortality is not anticipated to be an impact for bowhead whales, and is depicted as N on Table 7-14.

Past External Impacts

Past activities in the area of consideration for bowheads could have created additional disturbance or mortality for this species (see Table 7-2). Past external actions in the area include:

- Military operations particularly at the Bullen Point DEW line station.
- Oil and gas exploration, seismic investigations and drilling in the Badami and Point Thomson Units.
- Construction and operation of the Badami facility.
- Scientific research and surveys that have been conducted in the area.
- Flaxman Island Remediation – cleanup of several old exploration drill pads on the island could have caused disturbance to bowheads due to increased air and vessel traffic and noise from heavy equipment.
- Subsistence and Commercial hunting - commercial hunting in particular has likely added to population decline.

The magnitude of past impacts on bowheads due to habitat loss and disturbance from many of these external activities is unknown, but lingering effects on whale habitat are unlikely since the area used by these species is considerably removed from onshore impacts. Since the bowhead population is listed as endangered (see Section 4.9.1.1) lingering population effects due to past development, commercial hunting practices, and other external factors have been identified. These lingering effects are depicted as Y in this column for both disturbance and mortality.

Present and Potential Future External Actions

The following external actions, both human controlled and natural events, have been identified as potentially contributing to bowhead habitat loss, disturbance, and mortality effects in the vicinity of the Point Thomson project:

- Far West Pad, Slugger Development, Sourdough Development, and/or Gas Sales at Point Thomson – habitat alteration and disturbance to bowheads could occur if it became necessary to dredge offshore of either the Badami or proposed Point Thomson dock to support development of these facilities.
- Flaxman Island Remediation – continued cleanup of several old exploration drill pads on the island could cause disturbance to these whales due to increased air and vessel traffic and noise from heavy equipment.
- Scientific Research and Surveys – annual surveys by aircraft and possible collaring efforts could cause disturbance for bowhead whales either due to direct or indirect effects
- Subsistence hunting - could also add to any mortality or disturbance from project actions
- Offshore Seismic Exploration – could contribute to disturbance or mortality effects

Individually, many of these external factors could cause behavioral disturbance or mortality for bowheads. They are shown as Y, N, or N/A on Table 7-14. However, while the potential for an impact from these actions is identified, the significance of an impact from any given action is not rated (see Section 7.2.4).

Cumulative Effects

From the perspective of this project, a cumulative effect of mortality is not identified for bowhead whales. This is shown as an N on Table 7-14 under the cumulative effect column.

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Facility, in conjunction with impacts from present and potential future external actions, it has been determined that cumulative effects on the bowhead population due to habitat alteration and disturbance could occur. However, the likelihood that the potential cumulative effect could be significant is low (see Table 7-14). The rationale for determining that the likelihood of significance will be low is based on the following assumptions:

- Incremental impact due to Point Thomson development is expected to be negligible.
- Turbidity impacts associated with other developments would be minor and are not likely to occur when whales are present.
- Bowheads typically migrate offshore of barrier islands; nearshore and onshore activities are not expected to cause an impact.
- Any offshore construction associated with Point Thomson and other developments would be timed so as not to impact migrating whales.
- Mitigation measures and non-harassment procedures would also be in place.

Spectacled Eiders

The cumulative impact analysis for spectacled eiders is summarized on Table 7-15 and described in the following paragraphs.

Internal Project Effects

As described in Section 5.2.7.1, the construction and operations activities associated with the Point Thomson Gas Cycling project can impact spectacled eiders. The project area is located at the eastern end of the species' range and large numbers of birds are not expected to be passing through (see Sections 4.11.2 and 5.2.7.1). However, one brood was observed south of Point Sweeney in July 1998. Point Sweeney is located about 2 mi (3.2 km) east of the proposed West Pad location. For this reason, and due to the fact that the spectacled eider is listed as a threatened species, potential project impacts due to habitat loss and alteration, behavioral disturbance, and/or mortality are considered:

Habitat Loss and Alteration

A brood consisting of one female and four young has been encountered in the project area. However, this sighting occurred several years ago and no other individuals have been observed in subsequent surveys (see Section 4.11.2). Most of the spectacled eiders were observed in the vicinity of the Kadleroshilik and Shavoivik rivers, located to the west of the Point Thomson Unit (see Section 4.11.2). As concluded in Section 5.2.7.1, the direct loss of habitat due to gravel placement could have a potential impact on the eiders because they prefer habitat in drained lake basins and wet coastal tundra for nesting and brood rearing. However, the footprint of the Point Thomson development is small relative to the amount of this habitat available in the area. Less than 10% of all habitats affected by gravel coverage in the Point Thomson area could be considered important habitats for use by spectacled eiders in the region. In addition, spectacled eiders have been known to use impoundments and are not expected to suffer adverse impacts if small areas of surface hydrology are changed due to ponding. Therefore on Table 7-15 potential project effects on habitat are identified, but are anticipated to be not significant. This is shown as Y (NS) on Table 7-15 for the potential project effects column.

Disturbance

Behavioral disturbance to any spectacled eiders found in the vicinity of the project area could be induced by:

- Generation of noise and activities associated with onshore and offshore construction during summer construction periods (i.e., construction equipment, vessels, airplanes, helicopters and vehicles; drilling noise is not expected to create an impact on these birds since at present drilling is only allowed during the winter months)
- Longer-term, but likely of less magnitude, generation of noise associated with operation or the facility. This noise could consist of generators, compressors and other machinery, drill rigs, and operations and maintenance-related vehicle traffic.

Behavioral disturbance of birds using habitats near the roads and pads and the types of potential effects on these species are discussed in Section 5.2.4.1. Similar responses are likely for any spectacled eiders that could use habitats near the Point Thomson facilities. Spectacled eiders have been observed to shift their distribution away from the Central Compressor Plant in the

Prudhoe Bay field, presumably due to increased noise output. A similar displacement is possible at Point Thomson depending on the expected noise of operations. Disturbance will be minimized however, due to the small potential for spectacled eiders to be found in the vicinity of the proposed Point Thomson CPF. For these reasons, a potential project effect of disturbance is identified for spectacled eiders, but the impact is expected to be not significant. This determination is depicted as Y (NS) on Table 7-15.

Mortality

Direct mortality of spectacled eiders from project actions could occur through:

- Collisions with construction equipment, vehicles, or vessels.
- Collisions with structures and aircraft.
- Flare heat-related impacts, particularly for flightless or molting birds caught under the flare tower during flare events.
- Increased predator populations (i.e., foxes, ravens, gulls) due to attraction to oil field facilities (feeding by employees, or incorrectly handled garbage).
- Ingestion of spilled fuels and other operations-related materials (see Section 7.3.4 for a discussion of cumulative impacts of spills).

There is some potential for increased mortality of spectacled eiders during poor weather conditions from collisions with elevated structures. The impact is likely to be limited because the large numbers of birds are not expected to be flying through the project areas (see Section 5.2.7.1). In addition, increased predation due to attraction of predators to the Point Thomson facilities could affect small numbers of breeding spectacled eiders. However, since so few of these birds have been observed in the project area, population level effects are not expected. The effect of mortality on spectacled eiders is considered to be not significant and is depicted as Y (NS) on Table 7-15.

Past External Impacts

Past activities in the area of consideration for spectacled eiders could have had created additional disturbance or mortality for this species (Table 7-2). Past external actions in the area include:

- Military operations particularly at the Bullen Point DEW line station.
- Oil and gas exploration in the Badami and Point Thomson Units.
- Construction and operation of the Badami facility.
- Scientific research and surveys conducted in the area could have caused disturbance and mortality.
- Subsistence hunting - while eiders are not specifically targeted by subsistence hunters, small numbers could be taken when hunting for other eiders.

The magnitude of past impacts on spectacled eiders due to disturbance from many of these external activities is unknown. However, since the species is listed as threatened and has exhibited declining population numbers, lingering impacts from any or all of these past actions are possible. Therefore, there is assumed to be lingering influence from past external actions on the spectacled eider population of the region due to habitat loss/alteration, disturbance, or mortality. Table 7-15 depicts this conclusion as a Y for all three of these potential impact categories.

Present and Potential Future External Actions

The following external actions, both human controlled and natural events, have been identified as potentially contributing to habitat loss, disturbance, and mortality effects on spectacled eiders in the vicinity of the Point Thomson project:

- Badami – future expansion of onshore facilities could be required to support development in the Slugger Unit. Potential impacts could include spectacled eider habitat loss due to gravel placement, disturbance, and mortality.
- Far West Pad, Slugger Development, and Sourdough Development - impacts to spectacled eider habitat, and disturbance and mortality impacts due to construction and operation of pad facilities could be realized due to development of these areas.
- Gas Sales at Point Thomson - impacts could occur to spectacled eider habitat if it became necessary to enlarge pads.
- Scientific Research and Surveys - annual bird surveys and other research efforts could cause disturbance or mortality.
- Subsistence hunting - could also add to any mortality or disturbance from project actions

Individually, any of these external factors could impact spectacled eiders through habitat loss and alteration, disturbance or mortality. They are shown as either Y or N/A on Table 7-15. However, while the potential for an impact from these actions is identified, the significance of an impact from any given action is not rated (see Section 7.2.4).

Cumulative Effects

Based on the analysis of potential impacts associated with the Point Thomson Gas Cycling Facility, in conjunction with impacts from present and potential future external actions, it has been determined that cumulative effects on spectacled eiders due to habitat loss/alteration, disturbance, and/or mortality could occur. However, the likelihood that any of the potential cumulative effects could be significant is low (see Table 7-15). The rationale for determining that the likelihood of significance will be low is based on the following assumptions:

- Incremental impact due to Point Thomson development expected to be negligible.
- Point Thomson region is a marginal use area for spectacled eiders; area is at the eastern edge of their range.
- Nesting habitat for spectacled eiders in the area is not limiting.
- Any new developments will minimize footprint and mitigate impacts to spectacled eiders.
- Mitigation and avoidance of observed nest sites will minimize disturbance impacts.
- Surveys will continue to determine if nesting sites in the vicinity of development are used; these areas will be protected.
- Minimal mortality from subsistence hunting or scientific surveys would not contribute to population-level effects.

Table 7-14. Bowhead Whales Cumulative Effect Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS: Far West Pad[1]	Sourdough Dev.[1]	Slugger Dev.[1]	Gas Sales PTU[1]	Flaxman Island Rem.	Scientific Research & Surveys	Offshore Seismic Exploration	Subsistence Hunting	Cumulative Effect?	Likelihood that CE Could Be Significant	Assumptions/Rationale
HABITAT LOSS and/or ALTERATION[2]	Y(NS)[2]	N	Y[1,2]	Y[1,2]	Y[1,2]	Y[1,2]	N/A	N/A	N/A	N/A	Y	LOW	• Incremental impact due to Point Thomson development expected to be negligible • Turbidity impacts associated with other developments would be very minor and are likely to occur when whales are not present
DISTURBANCE	Y(NS)[3]	Y[4]	Y	Y	Y	Y	Y	Y	Y	Y	Y	LOW	• Incremental impact due to Point Thomson development expected to be negligible • Bowheads typically migrate offshore of barrier islands; nearshore and onshore activities not expected to cause an impact • Any offshore construction associated with other developments would be timed so as not to impact migrating whales • Mitigation measures and non-harassment procedures would also be in place
MORTALITY	N	Y[4]	N	N	N	N	N	N	N	Y	N[5]	N/A	N/A

NOTES:

Y = Yes NS = Not significant

N = No CE = Cumulative Effect

N/A = Not applicable

Dev. = Development

Footnotes:

[1]Only if existing dock at Badami or proposed Point Thomson dock is dredged for use by one of these other projects.

[2] Potential habitat impacts due to lingering increased turbidity in vicinity of bowhead migration route due to possible dredging and spoils disposal; duration expected to be short-term

[3]Non-significant effects since bowheads will not be in the area during winter construction. Summer dredging efforts will occur inside the barrier islands and spoils disposal will be completed prior to the fall migration. There could be some disturbance due to boat and vessel traffic, but will be mitigated.

[4]Lingering impact from commercial and subsistence hunting

[5]From the perspective of this project there is no cumulative effect since there is no expected impact on direct mortality from development of Point Thomson

Table 7-15. Spectacled Eider Cumulative Effects Analysis Summary

POTENTIAL IMPACT	Potential Project Effects?	Lingering Influence From Past External Action?	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS							Cumulative Effect?	Likelihood That CE Could Be Significant	Assumptions/Rationale
			Badami	Far West Pad	Sourdough Dev.	Slugger Dev.	Gas Sales PTU	Scientific Research & Surveys	Subsistence Hunting			
HABITAT LOSS and/or ALTERATION	Y(NS)[1]	Y[2]	Y	Y[3]	Y[4]	Y[4]	Y	N/A	N/A	Y	LOW	• Pt. Thomson project has minimal contribution to CE • Pt. Thomson region is a marginal use area for Spectacled eiders • Nesting habitat not limiting • Any new developments will minimize footprint and mitigate impacts to these birds • Surveys will continue to determine if nesting sites in the vicinity of development are used; these areas will be protected
DISTURBANCE	Y(NS)[5]	Y[2]	Y	Y[3]	Y[4]	Y[4]	Y	Y	Y	Y	LOW	• Mitigation and avoidance of observed nest sites will minimize disturbance impacts • Pt. Thomson region is a marginal use area for Spectacled eiders • Surveys will continue to determine if nesting sites in the vicinity of development are used; these areas will be protected
MORTALITY	Y(NS)[6]	Y[2]	Y	Y	Y[4]	Y[4]	Y	Y	Y[7]	Y	LOW	• Pt. Thomson region is a marginal use area for Spectacled eiders • Minimal mortality from subsistence hunting or scientific surveys would not contribute to population-level effects

NOTES:

Y = Yes NS = Not significant
N = No CE = Cumulative Effect

N/A = Not applicable
Dev. = Development
PTU = Point Thomson Unit

Footnotes:
[1]Although spectacled eiders prefer drained lake basins and wet coastal tundra for nesting and brood rearing, the population is not expected to suffer additionally due to changes in surface hydrology potentially caused by this project.
[2]Population has declined due to unknown causes leading to listing as a threatened species
[3]Nest site previously sighted near the proposed location of this pad
[4]Not generally found this far inland; impacts could only be realized if additional infrastructure at Badami or Point Thomson is built, or roads connecting the sites to existing developments are considered
[5]Very few of these birds found in the area; mitigation and avoidance of observed nest sites will minimize disturbance impacts
[6]Potential for collisions is limited since Pt. Thomson is at the eastern end of the species' range and large numbers of these birds are not expected to be passing through the area
[7]Not specifically targeted for subsistence but a few could be taken during hunting for other eider species

7.3.3 Socioeconomic and Cultural Resources

See Table 7-2 for a detailed description of external factors under consideration for cumulative impact, and Table 7-16 for a summary of the socioeconomic cumulative effect analysis. With regard to the geographic scope of consideration for cumulative effects on socioeconomic characteristics, some specific effects are evaluated on a regional and statewide basis. Potential population and employment effects are evaluated at the village, Borough and statewide levels. Fiscal effects are evaluated at the Borough and statewide level. In addition to immediate effects in the project area, land use effects are also evaluated on a regional basis. Finally, transportation effects on the North Slope and the Dalton Highway are also evaluated.

7.3.3.1 Population

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on population, see section 5.3.1. The principal effects can be summed up as follows:

- Population change in the State of Alaska, the NSB, and in individual North Slope villages resulting from jobs created through the construction and operation of the Point Thomson project

Past, Present and Reasonably Foreseeable Future External Considerations

External oil and gas exploration and development on the North Slope has not directly impacted the population of the NSB, although employment, income and tax revenue has allowed village and regional populations to remain relatively stable. While a high percentage of Alaska residents are employed, the majority of these are not residents of the NSB and commute between the North Slope and their areas of residence. A short-term increase in population numbers in the NSB may be noted during construction phases, as such activity generally requires a larger personnel. Even so, it is likely that some percentage of these jobs will be filled by local residents, thus decreasing still further the potential for a population influx. In the long-term, few people will be required on site to maintain operation of such facilities. These personnel are likely to be residents of the NSB or elsewhere in Alaska, and the projects will have little relative impact on NSB population.

Within individual villages, even small fluctuations in population numbers can be of significant impact; however, present or projected oil and gas development is unlikely to result in a direct population increase. The villages of Nuiqsut and Kaktovik are some distance from the project, and are inaccessible by road. Project access is by barge or aircraft from Prudhoe Bay or Endicott. The availability of oil and gas employment, however, could result in an indirect effect on the village populations. The Point Thomson project could help to offset the decrease in revenue, due to declining value of the oil and gas tax base, that has been projected for the NSB over the next few years. The NSB employs about two-thirds of the resident workforce (see Section 5.3.2), and a decline in NSB revenue may make continued residence in the villages more challenging. This is discussed at greater length in Section 7.3.3.3. However, to the extent that reasonably foreseeable oil and gas projects increase employment and the revenue of the NSB, they have the potential to influence native village populations by offsetting current trends.

With respect to the State of Alaska, many employees commute to the work site, and North Slope projects involve management personnel and related businesses which are often located in Anchorage. Given reasonably foreseeable oil and gas development projects and the historically high percentage of resident hire, a significant cumulative population increase in Alaska is not expected.

No other external factors are considered important to this analysis of cumulative population change in the NSB or the State of Alaska.

7.3.3.2 Employment and Income

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on employment and income, see Section 5.3.2. The principal effects can be summed up as follows:

- Job creation on the North Slope, with high Alaska-hire targets, benefiting the residents of the NSB and the State of Alaska

Past, Present and Reasonably Foreseeable Future External Considerations

External factors, in combination with the Point Thomson project appear likely to significantly benefit the economic environment in the NSB. The further development of oil and gas projects on the North Slope has the potential to provide employment for NSB residents, benefiting individuals directly and communities through the contract services provided by local Native Corporations. Previous experience on the North Slope indicates that it is more likely that jobs will taken by residents during the construction phases, where the seasonal nature of employment is better suited to the subsistence lifestyle, than the long-term operations jobs. Nonetheless, the projected development of a number of such projects would still benefit NSB residents for some years to come.

With the current forecast of reduction in NSB revenue over the next years due to decreasing returns on oil revenue taxation (as discussed in further detail in section 7.3.3.3), and the current importance of the NSB as a regional employer, the role of new revenues from developing oil and gas projects in offsetting any reduction in NSB jobs is also significant.

Viewed cumulatively, the net climate for employment and income in the NSB as analyzed from the perspective of the Point Thomson project is significantly beneficial.

The State of Alaska also benefits from job creation and employment related to North Slope oil and gas development. Further, the oil and gas development projects positively impact the State economy due to the demand for additional management employment and support services located around Anchorage. As with the NSB, revenue from oil and gas taxes and royalties fund State programs and related employment. The cumulative effect of Point Thomson and other oil and gas development creates a significant beneficial effect by maintaining or increasing indirect employment.

Additionally, media attention regarding potential oil development in ANWR has increased tourism and recreation to the area, the benefits of which are mainly captured by Alaskan firms that operate tours out of the major cities. Although it is obvious that these effects would be beneficial, a more comprehensive analysis would be required to quantify the significance of these activities within the larger scope of the Alaskan State economy.

7.3.3.3 Public Revenue and Expenditures

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on public revenue and expenditures, see section 5.3.3. The principal effects can be summed up as follows:

- Funding for municipal employment, capital improvement plans, health and social services through incoming public revenue to the NSB and the State of Alaska derived from taxation and gas royalty revenue
- Offset of decreasing oil and gas tax base for the NSB and the State of Alaska

Past, Present and Reasonably Foreseeable Future External Considerations

Because the NSB is the municipal entity that taxes oil and gas revenue, the geographic scope for cumulative effects analysis includes the entire Borough. Similarly, the State of Alaska receives revenue from taxation and royalties associated with North Slope oil development, and is addressed in this analysis. The primary external factors for public revenues and expenditures are oil and gas development and operations on the North Slope, and current fiscal trends for both the NSB and State of Alaska.

The Point Thomson project, in combination with other pending North Slope oil and gas development, will result in significant benefits to both the NSB and the State of Alaska by providing revenue from development of oil and gas resources. Within the NSB, property tax revenues fund capital project programs and amortization of debt, health and social services, and result in the employment of NSB residents. Point Thomson and other reasonably foreseeable oil and gas revenues would partially offset a decline in public revenues associated with the decline in property value on the North Slope. The current decline in revenues makes it difficult to implement new NSB capital projects and maintain current levels of service and employment. Beneficial cumulative effects from the Point Thomson project are expected to be long term (i.e., for the life of the project).

Similarly for the State of Alaska, the decline in Prudhoe Bay oil production has resulted in a decrease in state revenues from property tax and royalties from the state owned share of the oil. In conjunction with other North Slope oil and gas development, development of Point Thomson will generate revenues that will fund State programs and services. Cumulative oil and gas development will also help offset the decline in state revenues for declining oil production.

7.3.3.4 Subsistence and Traditional Land Use

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on subsistence and traditional land use, see section 5.3.4. The principal effects can be summed up as follows:

- Disruption to subsistence use of marine resources, including whales and seals, and terrestrial resources
- Disruption, contamination or mortality of subsistence resources due to oil spills

Past, Present and Reasonably Foreseeable Future External Considerations

The cumulative impact of Point Thomson and other external factors on subsistence use of marine resources is unlikely to be great. There are two potentially harmful actions of reasonably foreseeable oil and gas development projects on marine resources: first, an increase in marine vessel traffic traveling along the coast and coming into the Point Thomson dock; and second, increased noise and activity onshore at the project site causing disturbance to marine mammals. The first of these is potentially the most significant in its impact on whales and whale migration patterns. The bowhead whale is of paramount cultural significance to the Native populations on the North Slope, and any action interfering with or altering the whales' migration pattern, and in particular driving them further offshore, would be significantly detrimental. This would have related effects of expense, safety, and harvest success of a whale hunt. Mitigation could be incorporated to avoid project related vessel traffic outside of the barrier islands during the time of the fall whale hunt. Vessel traffic may have localized impact on seals, but the Point Thomson coastline is not an important site for subsistence sealing.

Regarding the second potential impact, noise and activity onshore, this would be of less significance with the future projects as they are planned on the far side of the Point Thomson project. There is little chance that any noise from the projects would be sufficient to pass beyond the barrier islands to affect the whales. For seals, again, any impact would be localized, and neither Nuiqsut nor Kaktovik villagers depend upon the area for sealing.

Disruption to the use of terrestrial subsistence resources is also a potential impact, with the primary concern being the effects on the caribou herds. The reasonably foreseeable gas and oil developments should not, however, provide a barrier to migration, as there would still be plenty of area for caribou to pass through. The cumulative loss of habitat through development from subsistence access is not anticipated to present an adverse impact, as the lands in question are not relied upon for terrestrial subsistence use.

Competition for subsistence resources is a potential impact of the Point Thomson project. There is potential for additive cumulative effect when the increase in staff employed at Point Thomson as well as other oil and gas projects is taken into consideration. However, this effect should not be significant since appropriate mitigation measures would be enforced to prohibit project personnel from engaging in sports fishing and hunting at project sites.

The contamination and mortality of subsistence resources is a potential effect, which is amplified by additional oil and gas developments in the region. The impact related to cleanup of an oil or gas spill in any of these facilities would most likely be of short-term duration, but depending on the range and direction of impact could still be significant to local populations. Subsistence might be adversely affected by local perception of contamination, even if the actual effects were harmless or dissipated. Perceived contamination of subsistence resources and related subsistence effects, regardless of the size of a spill, can be more long-term in nature. The risk of occurrence of a spill is statistically increased by further oil and gas development in the region. However, the contribution of Point Thomson development is minimal given its location onshore and low probability of a spill reaching the marine environment.

7.3.3.5 Land Ownership, Use and Management

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on land ownership, use and management, see section 5.3.5. The principal effects can be summed up as follows:

- Regional gas and oil development in an area where activities have been limited to exploration, clean-up, and scientific studies
- Extension of relatively contiguous onshore oil and gas land use to the east

Past, Present and Reasonably Foreseeable Future External Considerations

Historically, the Point Thomson area, including Flaxman Island and the Sourdough prospect, has been explored for oil and gas resources and has been the subject of related scientific studies. These land uses have been seasonal and temporary, supported by temporary facilities. They have not resulted in a cumulative long-term change in land use, nor have they generated significant conflicts with other uses of the area (subsistence, recreation), which also tend to be seasonal and intermittent.

Development of Point Thomson could facilitate development of the Sourdough prospect by sharing infrastructure and reducing development costs. Should this occur, operational facilities and infrastructure would be developed in an area where there are no year-around structures, and there would be a long-term change in land use. Potential cumulative land use conflicts would be greatest for recreation use along the Canning River, roughly four mi (6.4 km) to the east within ANWR. Some project facilities and operational noise would be detectable to recreation users and may affect the quality of the recreational experience (see Section 7.3.3.7 for further detail), although these impacts could be, at least partially, mitigated. Historic and current subsistence use of the area is primarily opportunistic and infrequent. Cumulative land use conflicts are not expected to be significant (see Section 7.3.3.4 for further detail)

From a perspective of changes in regional land use change, development of Point Thomson will extend long-term oil and gas development eastward along the northern portion of the Arctic coastal plain. The current limits of developed oil and gas facilities on the North Slope are the Alpine field to the west and Badami to the east. Linking the Point Thomson facility to Badami with a pipeline, and potentially facilitating the development of Sourdough and Slugger prospects, would extend relatively contiguous oil and gas development on the North Slope another 30 mi (48 km) eastward.

7.3.3.6 Transportation

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on transportation, see section 5.3.6. The principal effects can be summed up as follows:

- Increase in marine, highway, and aircraft traffic into the North Slope region

- Increase in marine and aircraft traffic along the coast between Prudhoe Bay and Point Thomson

Past, Present and Reasonably Foreseeable Future External Considerations

The Point Thomson project is likely to increase the number of marine vessels traveling along the north coast between Prudhoe Bay and Point Thomson associated with construction and operation activity support. Cumulative effects would occur in conjunction with marine support for Badami and development of Sourdough and Slugger Prospects. The potential impacts of more marine traffic include disturbance or disruption of local subsistence resources and activities as well as aesthetic detraction for visitors and residents transiting the area. Various external factors potentially occurring concurrently with the Point Thomson project during its scope of operation may amplify the significance of this project impact. Other projected gas and oil developments could utilize the Point Thomson dock, and so to some extent these projects will be able to combine their resupplying journeys. These projects are likely to provide a significant increase to the marine traffic along the north coast during their construction phases, however it is likely that once in operation the increase will cease to be significant. Other sources of marine traffic are scientific research and survey teams exploring along the north coast. It is unknown to what degree these are likely to be significant during the temporal scope of the Point Thomson project, however, it is probable that they will continue at similar levels to the present, which should not cause an undue impact on local resources or the aesthetic environment.

A specific marine transportation impact is the increase in volume of annual sealifts required in order to transport project related construction modules to the North Slope. This impact would be proportionately additive for each new construction project in the region. Planning should, however, be sufficient to mitigate any adverse effect of such increases.

The Point Thomson project does not generate a significant impact on overland vehicular traffic within the North Slope as no direct land access route has been planned connecting the project with the road system. There may be some project specific construction of ice roads, and some associated traffic, but would be seasonal in nature. It is expected that the same model would be followed for other gas and oil developments projected in the region.

The Dalton Highway will experience an increase in traffic due to the Point Thomson project. The other potential gas and oil projects in the region would amplify this increase for the transportation of materials and supplies, which would be most evident during their construction phases. If such projects follow the pattern of Point Thomson, the cumulative traffic increase should not be significant.

Air traffic is the other principal transportation impact of the Point Thomson project. An increase in air trips both between the project and Prudhoe Bay, and from other principal support locations would occur. As before, projected gas and oil developments in the Point Thomson region would have a similar impact. In the case of aerial travel, another external factor is also at play. The recent media attention over oil development in ANWR has spurred an increase in tourism to that area. Such trips are generally run by charter services out of Fairbanks, and an increase in aircraft over the Point Thomson and ANWR region will most likely results. The increase in the number of aircraft flying in the region may degrade the quality of the aesthetic environment for residents and visitors, through noise and visual impacts. The increases are more likely to be limited to the summer months, and are not expected to be significant.

7.3.3.7 Recreation

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on recreation, see section 5.3.7. The principal effects can be summed up as follows:

- Impairment of localized recreational experience along the Canning River, in ANWR, and elsewhere in the Point Thomson area due to the presence of an industrial facility.

Past, Present and Reasonably Foreseeable Future External Considerations

One destination for tourism on the North Slope is the ANWR, where most visitors float down the Canning River and other rivers. This activity takes place during the summer months; currently existing oil development on the Slope is not visible from ANWR and does not affect the experience. Unlike prior North Slope development, the Point Thomson unit will be within sight and earshot of a portion of a Canning River float trip, and likewise potential future regional development (such as Sourdough) on the ANWR border. Potential Sourdough development would be closer to an airstrip used to take off from the Canning River, located about 19 mi (31 km) to the southeast of Point Thomson. Visitors coming to ANWR may consider the presence of an industrial facility to be an impairment of their recreational experience. While each additional industrial facility on the horizon would not necessarily capture the full detrimental impact of the first (Point Thomson), nonetheless, the cumulative effect of all such development on visitors floating the Canning River could be significantly adverse.

7.3.3.8 Aesthetic Value

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on aesthetic value, see section 5.3.8. The principal effects can be summed up as follows:

- Decrease in localized aesthetic environment, both visual and aural, for North Slope visitors and residents.

Past, Present and Reasonably Foreseeable Future External Considerations

The Point Thomson facility, when taken with other external effects, does have the potential to cumulatively impact the aesthetic experience for residents of the North Slope and visitors who transit the area. The increased presence of people and buildings in the region, both due to oil and gas development projects, and heightened interest in North Slope tourism and recreation, actively impair the aesthetic surroundings, with obtrusive noise and activity, unnatural visual horizon features, and occasional flares. Taken cumulatively, the aesthetic environment for North Slope residents and visitors who use the area has the potential to be significantly and adversely affected by the Point Thomson project when viewed in the context of other external effects. However, use of the area is relatively infrequent and occurs primarily during a short summer and fall season.

7.3.3.9 Cultural Resources

Internal Effects

For a detailed discussion of the potential direct and indirect effects of the Point Thomson project on cultural resources, see section 5.3.9. The principal effects can be summed up as follows:

- Disruption, artifact removal, or destruction of cultural resource sites, both identified and undiscovered, in the region.

Past, Present and Reasonably Foreseeable Future External Considerations

Any new development that increases the number of persons present in the region also increases the possibility for disruption or destruction to cultural resource sites. While measures can be taken to protect those sites which have been identified, undiscovered sites are susceptible to damage in direct correlation to the number of construction activities and people in the region. There are a number of factors that lead to an increased human presence in the eastern North Slope. These include personnel related to oil and gas exploration and development, scientific research and survey teams, and tourists and recreationalists including those present for sports fishing and hunting. Because of the ability to mitigate any potential adverse effects once sites have been discovered, however, and the inclusion of cultural resource site surveyance in the planning of any location-specific activity in the area, it is unlikely that the cumulative effect of human presence in the area will be adversely significant.

Table 7-16. Socioeconomic and Cultural Resources Cumulative Effect Analysis Summary

PROJECT IMPACT	DURATION	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS					CUMULATIVE EFFECT?	LIKELIHOOD THAT CUMULATIVE EFFECT WILL BE SIGNIFICANT	ASSUMPTIONS / RATIONALE
		Oil and Gas Exploration and Development	Pollutants	Sports Fishing and Hunting	Decrease in NSB property values / taxes	Tourism / Recreation			
POPULATION									
Population change in NSB	construction & operations	N	N	N	N	N	N		
Population change in AK	construction & operations	Y	N	N	N	N	N		
Population change in NSB villages	operations	Y	N	N	Y_+	N	Y	Low	• Employment opportunities and increases in NSB revenues would offset current declines
EMPLOYMENT									
Increase in employment opportunities in NSB	construction & operations	Y_+	N	N	Y_+	N	Y	High	• Project-generated local employment is significant in a climate of decreasing NSB and other employment opportunities
Increase in employment opportunities in AK	construction & operations	Y_+	N	Y_+	Y_+	Y_+	Y_+	High	• A high Alaska-hiring target is anticipated for this project • Project-generated Alaska-resident employment is significant given present trends in declining employment in the oil and gas sector of the Alaska economy
PUBLIC REVENUES AND EXPENDITURES									
Increased public revenues to NSB (capital improvement plans, health and social services by NSB)	operations	Y_+	n/a	N	Y_+	N	Y_+	High	• Project-generated revenue for the NSB is significant in a climate of decreasing NSB revenues
Indirect employment benefits (NSB as employer)	operations	Y_+	n/a	N	Y_+	N	Y_+	High	• Project-generated NSB revenue that funds local employment is significant in a climate of decreasing NSB and other employment opportunities
Increased public revenues to AK (capital improvement plans, health and social services by NSB)	operations	Y_+	n/a	N	Y_+	N	Y_+	High	• Project-generated revenue for the State of Alaska is significant in a climate of decreasing State of Alaska revenues
Indirect employment benefits (AK as employer)	operations	Y_+	n/a	N	Y_+	N	Y_+	High	• Project-generated State of Alaska revenue that funds state employment is significant in a climate of decreasing State of Alaska and other employment opportunities

Table 7-16. Socioeconomic and Cultural Resources Cumulative Effect Analysis Summary

PROJECT IMPACT	DURATION	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS					CUMULATIVE EFFECT?	LIKELIHOOD THAT CUMULATIVE EFFECT WILL BE SIGNIFICANT	ASSUMPTIONS / RATIONALE
		Oil and Gas Exploration and Development	Pollutants	Sports Fishing and Hunting	Decrease in NSB property values / taxes	Tourism / Recreation			
SUBSISTENCE									
Disruption of fall whale hunt	construction & operations	Y	N	N	n/a	N	Y	Low	• Incremental impact due to Point Thomson development expected to be negligible • Bowheads typically migrate offshore of barrier islands; nearshore and onshore activities not expected to cause an impact • Any offshore construction associated with other developments would be timed so as not to impact migrating whales • Mitigation measures and non-harassment procedures would also be in place
Disruption of sealing and other marine subsistence	construction	Y	N	N	n/a	N	N		
Disruption to subsistence use of terrestrial mammals	construction	Y	N	N	n/a	U	Y	Low	• Major construction would occur in the winter. • Traffic volumes are low. • Separation between potential future pipelines and roads. • Sufficient elevation of potential future aboveground pipelines.
Competition for subsistence resources	construction & operations	Y	n/a	Y	n/a	N	N		
Disruption/mortality/contamination of subsistence resources from oil spill or cleanup activities	short-term	Y	Y	n/a	n/a	Y	Y	Low	• Probability of a spill occurring is extremely low • Mitigation measures and spill prevention response measures would be in place
Perception of contamination of subsistence resources by native villages	long-term	Y	Y	n/a	n/a	Y	Y	Low	• Probability of a spill occurring is extremely low • Mitigation measures and spill prevention response measures would be in place
LAND USE									
Point Thomson area gas and oil development	operations	Y	n/a	n/a	n/a	Y	Y	High	• Facilities constructed for this project could be used to support the development at Sourdough and Slugger prospects

Table 7-16. Socioeconomic and Cultural Resources Cumulative Effect Analysis Summary

PROJECT IMPACT	DURATION	PRESENT and POTENTIAL FUTURE EXTERNAL ACTIONS					CUMULATIVE EFFECT?	LIKELIHOOD THAT CUMULATIVE EFFECT WILL BE SIGNIFICANT	ASSUMPTIONS / RATIONALE
		Oil and Gas Exploration and Development	Pollutants	Sports Fishing and Hunting	Decrease in NSB property values / taxes	Tourism / Recreation			
Extension of North Slope onshore oil and gas development to the east	operations	Y	n/a	n/a	n/a	Y	Y	High	• Project represents an expansion of oil and gas land use east of the existing development at Badami
TRANSPORTATION									
Increased vessel traffic on annual sealift	construction	Y	n/a	n/a	n/a	Y	Y	Low	• Any significant effect can be mitigated through logistical planning
Increased traffic on Dalton Hwy and within Prudhoe Bay	construction	Y	n/a	Y	n/a	Y	Y	Low	• The direct volume of increased traffic on the Dalton Highway is not significant
Increased marine traffic along coast	construction & operations	Y	n/a	n/a	n/a	Y	Y	Low	• The direct volume of increased marine traffic along the coast is not significant
Increased air traffic on the North Slope	construction & operations	Y	n/a	n/a	n/a	Y	Y	Low	• The direct volume of increased aerial traffic on the North Slope is not significant
RECREATION									
Impairment of localized recreational experience through presence of industrial facility within view and earshot	construction & operations	Y	n/a	n/a	n/a	Y	Y	High	• Introduction of construction and operation of industrial facilities and activities into a relatively undeveloped area adjacent to non-resident recreation areas
AESTHETIC VALUES									
Decrease of localized aesthetic beauty for residents	construction & operations	Y	n/a	Y	n/a	Y	Y	Low	• Borough residents infrequently use the project area
Decrease of localized aesthetic beauty for visitors	construction & operations	Y	n/a	Y	n/a	Y	Y	High	• Introduction of construction and operation of industrial facilities and activities into an undeveloped area adjacent to non-resident recreation areas
CULTURAL RESOURCES									
Disturbance to or destruction of cultural resource sites	construction	Y	n/a	Y	n/a	Y	Y	Low	• Mitigation measures for avoiding disruption to or destruction of cultural resources sites will be implemented

NOTES:
Y = Yes
Y+ = Yes (emphasizes the effect is beneficial rather than adverse)
N = No
n/a = not applicable

7.3.4 Oil Spills

In considering whether the Point Thomson project has a significant cumulative effect related to oil spills, the impact on the environment which results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions in the vicinity is considered. Cumulatively, the effect of existing and reasonably foreseeable future actions is to increase the probability that such a spill, and related adverse effects, will occur.

In addition to Pt. Thomson, the projects included in this cumulative analysis include the existing Badami oil development and the reasonably foreseeable crude oil prospects at Sourdough and Slugger. All of these projects are located onshore, thus minimizing the risk of a large offshore oil spill.

The probability of a major spill associated with the Point Thomson project is low. No significant oil spills from well blowouts associated with natural gas developments are known to have occurred. In Section 5, the probability of an oil spill at Point Thomson was discussed and determined to be similar to Badami's exploration and production spill history which consists of a total of three spills ranging from 55 to 150 gallons (209 to 570 liters) since 1987. In regards to pipeline spills, there are no records of large spills (i.e., 1,000 barrels or more) since 1981 related to North Slope production, which has over 1,100 mi (1,700 km) of onshore pipeline and has produced over 13 billion barrels through 1999 (MMS 1998). In fact, there are no large spills on record at North Slope oil wells, facilities and feeder pipelines leading to the Trans Alaska Pipeline System (TAPS) Pump Station #1 (ITC 2001). MMS (1998) estimated cumulative oil spill occurrence in northeastern National Petroleum Reserve Alaska (NPRA) is 26 to 119 spills with a total volume ranging from 104 to 476 bbl. When compared with the projected Pt. Thomson spill occurrence of about one spill per year averaging about 2.6 bbl, this data corresponds to Point Thomson contributing a negligible percentage of the total oil spills for this cumulative impact analysis. Additionally, the chance of spills occurring at multiple projects at the same time is also very low, thus reducing the overall cumulative effects from oil spills on individual resources.

Given this risk data, the following cumulative effects discussion focuses on small onshore oil releases, primarily due to pipeline and other equipment failure/leaks, consisting of crude and refined oils rather than natural gas/condensate.

7.3.4.1 Fish

Marine and diadromous fishes are widely distributed across the Beaufort Sea nearshore waters and fish exist in freshwater streams and ponds. Small numbers of fish in the immediate area of an offshore or onshore oil spill may be killed or otherwise harmed, but an oil spill assumed by this analysis is not expected to have a measurable effect on fish populations.

The cumulative effect of oil spills on fishes would depend on the number of spills, the season and time of exposure, the hydrocarbon concentration, and stage of fish development for each spill encountered. As stated previously, the risk of an offshore spill is very small at any of the projects considered in this analysis.

Onshore, over-wintering areas may be effected by contact with oil during winter spills. During summer, if a sufficiently sized spill occurred in a small fish-bearing waterbody with limited water exchange, the fish and food resources in that waterbody may be harmed or killed. Sub-lethal effects may occur, including temporary displacement and changes in growth, feeding, and productivity. Due to the low diversity and abundance of fish onshore near Point Thomson, the unlikelihood of a spill interrupting fish migrations or occurring in overwintering areas, an onshore oil spill associated with Pt. Thomson is not expected to have a measurable effect on fish populations.

While small numbers of fish in the immediate area of an oil spill may be killed or harmed, oil spills are not expected to have measurable cumulative effects on fish populations.

7.3.4.2 Whales

The cumulative effects of oil spills on whales is expected to be low since it is unlikely that any significant offshore spills will occur from any of the projects considered in this analysis. Very few bowheads occur near the study area until the migration period from September through October, and only strays are likely to travel close enough to shore to come within range of any small oil spill associated with barges or other nearshore spills from the projects considered in this analysis. Contact with spilled oil in the Beaufort Sea may cause temporary, non-lethal effects to some bowhead and beluga whales, but the amount of oil that would be required to kill a whale is not expected to occur offshore of the study area. Non-lethal effects include inhalation of hydrocarbon vapors, ingestion of oil (either directly or by contaminated prey), displacement or loss of prey to the oil spill, skin and sensory organ damage, and baleen fouling which may decrease feeding efficiency.

Activities not related to oil and gas may contribute to cumulative effects on whales. These include entrapment in fishing nets, collisions with ships, and subsistence and cultural harvest by Native Alaskan and Russian whalers under authorized quota by the International Whaling Commission.

However, offshore spills are not likely within the study area, and even less likely within the whale migration corridor located outside of the barrier islands. Therefore, the cumulative effect of oil spills on whales in the study area is expected to be unmeasurable.

7.3.4.3 Seals

Similar to whales, the cumulative effects of oil spills on seals is expected to be low since it is unlikely that any significant offshore spills will occur from any of the projects considered in this analysis. Small oil spills associated with barge leaks or other minor nearshore spills from the projects considered in this analysis may cause direct oiling of ringed or bearded seals, which may contribute to cumulative effects. Seal densities are lower inside of the barrier islands, especially during winter; however, seals are present in open-water areas during summer and early autumn. Therefore, impacts on local populations of seals may occur if oil is spilled in the coastal areas. Depending on the extent of oiling and the characteristics of the oil, externally oiled seals often survive and become clean with only temporary effects such as eye and skin irritation (MMS 1996). The size of spill required to cause seal mortality is not probable. Activities not related to oil and gas, such as Native Alaskan subsistence harvest and entrapment in nets may contribute to the cumulative effects on seals. Since a large offshore oil spill is unlikely within the study area, the risk of a seal coming into contact with spilled oil from Point Thomson is low.

7.3.4.4 Polar Bears

The cumulative risks from oil spills to polar bear habitats within the area of this analysis are lower than risks from other contributing activities. The majority of bears spend their time on the pack ice, located offshore of the barrier islands, however polar bears can be found onshore feeding on whale carcasses and they occasionally den onshore. Polar bears may not avoid oiled areas and may consume oiled prey or oil from grooming. Oiling reduces insulation quality of the fur and will cause significant thermo-regulatory problems. Ingested oil can lead to toxic internal effects including anemia and renal impairment. Indirect effects include the loss of food sources, toxic effects from ingesting contaminated prey, and possible displacement caused by disturbance during spill cleanup activities. Polar bear mortality caused by Alaska Native harvest in this area is low, since most kills are due to opportunistic kills rather than intentional hunting.

Past exploration and drilling operations have displaced a few bears but have had no known effect on the polar bear population (MMS 2001). Most likely, only the occasional onshore polar bear that is oiled due to contact with an onshore spill may be effected. Since the probability of a large spill within the study area is low, the potential for polar bears to contact spilled oil from this project is also low. Thus, Point Thomson's contribution to the cumulative effect on polar bears from spilled oil is considered to be insignificant.

7.3.4.5 Birds

The effects of an oil spill on birds will vary depending on the season. For example, spills occurring in the winter should not have an immediate effect on birds since they are not present in the area. Any oil remaining the following spring may affect birds by contact with the oil or by reduction or contamination of food sources. However, this effect would be minimized by winter cleanup efforts. A large onshore spill during the summer could cause losses of molting and broodrearing waterfowl if it enters a heavily used lake, plus smaller numbers of nesting waterfowl, shorebirds, and passerine birds. Mortality from small spills, whether originating from field pipelines or spills of refined products, is expected to be prevented by expedient cleanup. In general, Pt. Thomson is expected to be a minor contributor to the cumulative case and most spills are expected to be cleaned up before measurable cumulative effects to birds can occur.

7.3.4.6 Caribou and Other Terrestrial Mammals

Terrestrial mammals, including caribou, muskoxen, moose, grizzly bear, and fox that become oiled by direct contact with spilled oil could die from inhalation of toxic hydrocarbons or adsorption through the skin (MMS, 1996). Caribou are the most likely to contact oil spilled offshore if the oil is washed onto the beaches where caribou may go to escape from insects.

Small spills of either crude or refined petroleum products could occur onshore near pipelines, roads, and other facilities. These minor spills would have a very small additive effect on terrestrial mammal habitats near these areas since most spills occur on gravel areas and minimal vegetated area is expected to be affected (See Section 7.3.4.8). Caribou and muskoxen probably would not ingest oiled vegetation because they are selective grazers. Grizzly bears and foxes may be indirectly affected by feeding on oiled prey. Control and cleanup operations at a spill site may disturb and temporarily displace most terrestrial mammals away from the spill area, thereby avoiding contact with oil. Hence, any expected oil spills from Point Thomson and other existing and reasonably foreseeable oil and gas developments are expected to have little cumulative effect on caribou, muskoxen, moose, grizzly bear, fox and other terrestrial mammals.

7.3.4.7 Threatened and Endangered Species

Bowhead whales and spectacled eiders are on the federal threatened and endangered species list and are known to occur within the area considered for this cumulative analysis. Point Thomson is not expected have a significant contribution to the cumulative effects caused by oil spills on these species.

The Western Arctic stock of bowhead whales is listed as endangered and classified as a strategic stock by the National Marine Fisheries Service. The cumulative effects of oil spills on whales, discussed previously in Section 7.3.4.2, also pertain to bowhead whales.

Spectacled eiders are listed as threatened by U.S. Fish and Wildlife Service and are known to nest within the area considered for this cumulative analysis, specifically in the vicinity of Badami. They nest close to shore above the high tide line during June. In the unlikely event of an onshore pipeline spill in this area, nests or breeding birds could be directly affected. The cumulative effect of numerous small spills projected over the entire life of oil and gas projects considered in this cumulative analysis would more likely result in greater mortality rates than that from a pipeline leak near Badami. Although most small spills are expected to be cleaned up before many eiders come into contact with the oil, if a moderately sized onshore spill entered freshwater habitat during the summer, eider mortality could occur (MMS 2001). Overall, Point Thomson is not expected to contribute much to the cumulative effect of oil spills on eiders due to the rarity of eider occurrence in the project area.

7.3.4.8 Vegetation

Historically, construction causes more than 99% (acreage wise) of the effects on vegetation and spills cause relatively little destruction of vegetation. The additive effect of onshore spills would cause minor damage and vegetation should recover within a few years (MMS 2001).

Most onshore spills occur on gravel pads, and their effects do not reach the vegetation. A majority of oil spills cover less than 0.01 acre (<1 ha), but if the spill is a windblown mist, it may cover up to 4.8 acres (1.9 ha) (MMS 2001). In the past, only 20-35% of crude-oil spills reached areas beyond pads (MMS 2001). The corresponding proportion for refined oil is likely to be much lower. Since winter conditions exist most of the year, about 60% of the time when spills occur, the oil can be cleaned up from the snow cover before it reaches the vegetation. Thus an estimated 11% of all onshore spills could affect vegetation. Overall, past spills on Alaska's North Slope and along the TAPS have caused minor ecological damage and ecosystems have shown a good potential for recovery. For these reasons, unmeasurable cumulative effects on vegetation due to oil spills are expected.

7.3.4.9 Subsistence

The cumulative effect of oil spills on subsistence harvest is difficult to measure due in part to human perceptions and confidence regarding species health. An oil spill, if it occurred and affected any part of the bowhead whale's migration route, could impact this culturally important resource. Hunting whales, polar bears, and/or seals may be disrupted, regardless of whether sufficient numbers of these animals are available for harvest, due to traditional and cultural concerns of contamination that may make these animals less desirable. In the unlikely event of a large oil spill, subsistence resources could be affected in Kaktovik and possibly Nuiqsut. Additionally, a large spill could cause short-term but potentially significant effects to oldsquaw and other subsistence bird populations, and a large onshore pipeline spill that contacted fish-bearing streams could affect some fish populations. Details on the effects of spilled oil on each resource were discussed previously in this section.

7.3.4.10 Socioeconomic

If a large oil spill, or numerous simultaneous smaller spills occurred anywhere in the study area, cleanup activities may generate jobs. Based on the Exxon Valdez spill, Native residents were employed in cleanup work and losses of subsistence resources were alleviated by the significant increase in income by many residents. Many North Slope Borough residents have been trained in cleanup procedures and have indicated interest in participating in any cleanup response activities (Lampe 1999).

7.3.4.11 Summary

In summary, the incremental contribution of the Pt. Thomson project to any cumulative effects related to oil spills is minimal. The potential for cumulative effects due to offshore and onshore oil spills was identified. The Point Thomson project, in conjunction with existing and reasonably foreseeable future developments (Badami, Sourdough, and Slugger) are unlikely to cause offshore oil spills (see Section 7.3.4). Therefore, the potential for an oil spill from these facilities to cause a significant cumulative effect on marine resources is considered low.

Potential onshore oil spills associated with the Point Thomson project as well as the existing and reasonably foreseeable future developments described above, are anticipated to be small in volume and readily cleaned up to minimize effects. Additionally, is unlikely that large oil spills would occur at multiple locations at the same time such that the magnitude of effects is increased. Therefore, resources are expected to recover from a potential disturbance caused by an oil spill before any measurable increase in cumulative effects occurs. For these reasons, the potential for an onshore oil spill(s) from these facilities to cause a significant cumulative effect is rated as low.

7.4 CUMULATIVE EFFECTS SUMMARY

Analyses were conducted to assess the potential for project actions in combination with external actions from the past, present, and reasonable foreseeable future to cause a cumulative effect. The likelihood that an identified cumulative effect could be significant was rated as either high or low based on available information and basic assumptions. Table 7-17 summarizes the results of the cumulative effect analyses conducted for physical/chemical, biological, and socioeconomic and cultural resources.

Table 7-17 Cumulative Effects Summary
Physical/Chemical, Biological, Socioeconomic, and Cultural Resources

RESOURCE/IMPACT	CUMULATIVE EFFECT IDENTIFIED?		LIKELIHOOD THAT CUMULATIVE EFFECT COULD BE SIGNIFICANT
	Yes	No	
Physical/Chemical			
Air Quality	✓		LOW
Surface Hydrology	✓		LOW
Freshwater Quality	✓		LOW
Marine Water Quality	✓		LOW
Marine Circulation	✓		LOW
Permafrost/soils	✓		LOW
Marine Benthos			
Habitat Loss and Mortality	✓		LOW
Habitat Alteration and Disturbance	✓		LOW
Vegetation			
Habitat Loss and/or Alteration[1]	✓		LOW
Fish			
Habitat		✓	N/A
Disturbance	✓		LOW
Mortality	✓		LOW
Birds			
Habitat Loss and Alteration	✓		LOW
Disturbance	✓		LOW
Mortality	✓		LOW
Pinnipeds			
Disturbance	✓		LOW
Mortality		✓	N/A
Polar Bears			
Habitat Loss and Alteration	✓		LOW
Disturbance	✓		LOW
Mortality	✓		LOW
Central Arctic Caribou Herd			
Habitat Loss and Alteration	✓		LOW
Disturbance	✓		LOW
Mortality	✓		LOW
Porcupine Caribou Herd			
Habitat Loss and Alteration	✓		LOW
Disturbance	✓		LOW
Mortality	✓		LOW
Other Terrestrial Mammals			
Habitat Loss and Alteration	✓		LOW
Disturbance	✓		LOW
Mortality	✓		LOW
Bowhead Whales			
Habitat Loss and Alteration	✓		LOW
Disturbance	✓		LOW
Mortality		✓	N/A

Table 7-17 (Cont.) Cumulative Effects Summary
Physical/Chemical, Biological, Socioeconomic, and Cultural Resources

RESOURCE/IMPACT	CUMULATIVE EFFECT IDENTIFIED?		LIKELIHOOD THAT CUMULATIVE EFFECT COULD BE SIGNIFICANT
	Yes	No	
Spectacled Eider			
Habitat Loss and Alteration	✓		LOW
Disturbance	✓		LOW
Mortality	✓		LOW
Socioeconomics			
Population Increase		✓	N/A
Increase in Employment Opportunities	✓		HIGH
Increase in Public Revenues	✓		HIGH
Subsistence			
Disruption of fall whale hunt	✓		LOW
Disruption of other marine subsistence		✓	N/A
Disruption or competition to terrestrial subsistence resources	✓		LOW
Disruption from contamination or perception of contamination	✓		LOW
Land Use			
Extension of gas and oil development	✓		HIGH
Transportation			
Increased marine, terrestrial and aerial traffic	✓		LOW
Recreation			
Impairment of localized recreational experience	✓		HIGH
Aesthetic Values			
Decrease in localized aesthetic beauty to residents	✓		LOW
Decrease in localized aesthetic beauty to visitors	✓		HIGH
Cultural Resources			
Disturbance to Destruction of Cultural Resource sites	✓		LOW

[1]Disturbance and mortality effects considered as habitat loss.
[2]Habitat effects considered under context of disturbance

This page intentionally left blank

8.0 REFERENCES

ABR, Inc. Unpublished data.

Alaska Department of Fish and Game (ADF&G). 2001. Wildlife Notebook Series.

Alaska Dept. of Natural Resources, Div. of Oil and Gas. 1997. Oil and Gas Lease Sale 86, Central Beaufort Sea: Final Finding of the Director. Vol. I.

Alaska Department of Natural Resources (ADNR). 1978. Proposed Point Thompson Oil and Gas Lease Sale #29A, Hearing #3, Thursday, July 27th, 1978, Kaktovik, Alaska.

Alaska North Slope Eastern Region (ANSER). 2000. Alaska North Slope Eastern Region Monitoring Program, July 1999 to June 2000. Report for BP Exploration-Alaska, Inc., Anchorage, AK by ENSR, Fort Collins, CO.

ADNR. 1998. Oil and Gas Lease Sale 87, North Slope Areawide, Final Finding of the Director. Volume I.

ADNR. 2001. Oil and Gas Lease Sale, North Slope Foothills Areawide 2001, Final Finding of the Director.

Alexander, H. 1974. The Association of Aurignacoid Elements with Fluted Point Complexes in North America. In, *International Conference on the Prehistory and Palaeoecology of Western North American Arctic and Subarctic,* edited by Scott Raymond and Peter Schledermann, pp. 21-31. University of Calgary Archaeological Association. Calgary, Alberta.

Alexander, H. 1987. Putu: A Fluted Point Site in Alaska. Publication No. 17. Department of Archaeology, Simon Frazer University, Burnaby, British Columbia.

Ambrose, R. E., R. J. Ritchie, C. M. White, P. F. Schempf, T. Swem, and R. Dittrick.. 1988. Changes in the status of peregrine falcon populations in Alaska. Pages 73-82 *in* T. J. Cade, J. H.enderson, C.G. Thelander and C. M. White, eds. Peregrine Falcon Populations, their Management, and Recovery. The Peregrine Fund, Boise, ID.

Amstrup, S. C. 1993. Human disturbances of denning polar bears in Alaska. Arctic 46:246–250.

Amstrup S.C. 1995. Movement, Distribution, and Population Dynamics of Polar Bears in the Beaufort Sea, Masters Thesis. Fairbanks, AK: University of Alaska, 299 pp.

Amstrup. S.C. and C. Gardener. 1994. Polar Bear Maternity Denning in the Beaufort Sea. Journal of Wildlife Management 58:1-10

Amstrup. S.C. and D.P. DeMaster. 1988. Polar Bear, *Ursus Maritimus.* Pp. 39-56 in J.W. Lentfer (ed.). Selected marine mammals of Alaska: Species accounts with research and management recommendations. Marine Mammal Commission, Washington, D.C.

Anderson, D. 1968. *A Stone Age Campsite at the Gateway to America.* Scientific *American, 218(6).*

Anderson, D.D. 1984. Prehistory of North Alaska. In: Handbook of North American Indians, Arctic (V), edited by D. Damas. Smithsonian Institution, Washington, D.C.

Anderson, B. A. 1992. The effects of Point McIntyre/GHX-2 gravel hauling on Brant. Report for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 22 pp.

Anderson, B. A., A. A. Stickney, R. J. Ritchie, and B. A. Cooper. 1995. Avian studies in the Kuparuk Oilfield, Alaska, 1994. Report for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 29 pp.

Anderson, B. A., and B. A. Cooper. 1994. Distribution and abundance of Spectacled Eiders in the Kuparuk and Milne Point oilfields, Alaska, 1993. Report for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 71 pp.

Anderson, B. A., and S. M. Murphy. 1988. Lisburne Terrestrial Monitoring Program—1986 and 1987: The effects of the Lisburne powerline on birds. Report for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 60 pp.

Anderson, B. A., R. J. Ritchie, and A. A. Stickney. 1996. Avian studies in the Kuparuk Oilfield, Alaska, 1995. Report for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 55 pp.

Anderson, B. A., R. J. Ritchie, A. A. Stickney, and A. M. Wildman. 2000. Avian studies in the Kuparuk Oilfield, Alaska, 1999. Report for PHILLIPS Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 100 pp.

Anderson, B. A., S.M. Murphy, M. T. Jorgenson, D. S. Barber, and B. A. Kugler. 1992. GHX-1 waterbird and noise monitoring program. Report for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK, and BBN Systems and Technologies. 132 pp.

Andres, B.A. 1989. Littoral zone use by post-breeding shorebirds on the Colville River Delta, Alaska. Thesis, Ohio State University, Columbus, Ohio. 116 pp.

Andres, B.A. 1993. Foraging flights of Pacific, *Gavia pacifica*, and Red-throated, *G. stellata*, loons on Alaska's coastal plain. Canadian Field-Naturalist 107:238–240.

Andres, B. A. 1994. Coastal zone use by postbreeding shorebirds in northern Alaska. Journal of Wildlife Management 58:206-213.

Arctic Environmental Information Data Center (AEIDC). 1974. Alaska Regional Profiles. Vol. II. Arctic Region. University of Alaska, Anchorage, AK

Auerbach, N. A., M. D. Walker, and D. A. Walker. 1997. Effects of roadside disturbance on substrate and vegetation properties in arctic tundra. Ecological Applications 7:218–235.

Awbrey, F.T., J.A. Thomas, and R.A. Kastelein. 1988. Low-frequency underwater hearing sensitivity in belugas, *Delphinapterus leucas*. J. Acoust. Soc. Am. 84:2273-2275.

Bacon, G. 1982a. A cultural resource evaluation for Flaxman Island, Beaufort Sea, Alaska, in view of current hydrocarbon related development activity. Report to Exxon Co., U.S.A. Alaska Heritage Research Group, Inc., Fairbanks, Alaska.

Bacon, G. 1982b. Report of an archeological survey of two proposed drilling sites, Flaxman Island, Beaufort Sea, Alaska. Report to Exxon Co., U.S.A. Alaska Heritage Research Group, Inc., Fairbanks, Alaska.

Bacon, G. 1983. Archaeological investigation for six proposed drill sites in the ANSKAR Prospect, North Slope, Alaska. Report to Exxon Co., U.S.A. Alaska Heritage Research Group, Inc., Fairbanks, Alaska.

Bacon, G. 1985. Report on an archaeological survey of proposed drill pads within the Point Thomson Unit. Report to Exxon Co., U.S.A. Alaska Heritage Research Group, Inc., Fairbanks, Alaska.

Ballard, W. B., M. A. Cronin, R. Rodrigues, R.O. Skoog, and R. H. Pollard. 2000a. Arctic fox, *Alopex lagopus*, den densities in the Prudhoe Bay oil field, Alaska. Canadian Field-Naturalist 114:453-456.

Barry, T. W., and R. Spencer. 1976. Wildlife response to oil well drilling. Canadian Wildlife Service Progress Notes No. 67. 15 pp.

Bascom, W. 1980. Waves and beaches: The dynamics of the ocean surface, revised and updated. Anchor Books, Doubleday. New York. 366pp..

Batzli, G. O., and S. T. Sobaski. 1980. Distribution, abundance, and foraging patterns of ground squirrels near Atkasook, Alaska. Arctic and Alpine Research 12:501–510.

Batzli, G. O., F. A. Pitelka, and G. W. Cameron. 1983. Habitat use by lemmings near Barrow, Alaska. Holarctic Ecology 6:255–262.

Bee, J. W., and E. R. Hall. 1956. Mammals of northern Alaska on the Arctic Slope. University of Kansas, Museum of Natural History, Miscellaneous Publication No. 8. 309 pp.

Bergman, R. D., R. L. Howard, K. F. Abraham, and M. W. Weller. 1977. Water birds and their wetland resources in relation to oil development at Storkersen Point, Alaska. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C. Resource Publication 129. 38 pp.

Berry, A.D. and J.M. Colonell 1985. Prudhoe Bay Waterflood project seawater treatment plant: Main outfall effluent dispersion study, 9-19 April 1985. Prepared for ARCO Alaska Inc. by Entrix Inc., Anchorage, AK August 1985.

Bilgin, A. 1975. Nutrient status of surface waters as related to soils and other environmental factors in a tundra ecosystem. Ph. D. Dissertation, Rutgers Univ., New Brunswick, NJ.

Beier, J.C., and D. Wartzok. 1979. Mating behaviour of captive spotted seals (*Phoca largha*). Anim. Behav. 27(3):772-781.

Bickham, John W., Steven M. Carr, Brain G. Hanks, David W. Burton, and Benny J. Gallaway. 1989. Genetic Analysis of Population Variation in the Arctic Cisco (*Coregonus autumnalis*) Using Electrophoretic, Flow Cytometric, and Mitochondrial DNA Restriction Analyses. Biological Papers of the University of Alaska. Institute of Arctic Biology. 24: 112 – 122.

Bigg, M.A. 1981. Harbor Seal *Phoca vitulina* Linnaeus, 1758 and *Phoca largha,* Pallas, 1811. Pp. 1-27 *in* S.H. Ridgeway and F.J. Harrison (eds.). Handbook of Marine Mammals, Vol. 2 Academic Press, London. 359 pp.

Billings, W.D. and K.M. Peterson. 1980. Vegetational change and ice wedge polygons through the thaw-lake cycle in Arctic Alaska. Arctic and Alpine Research 12:413-432 Biological Report Series No. 14. 280 pp.

Boehm, P.D. 1987. Transport and Transformation Processes Regarding Hydrocarbon and Metal Pollutants in Offshore Sedimentary Environments. In: Long-Term Environmental Effects of Offshore Oil and Gas Development, D.F. Boesch and N.N Rabalais, eds. London: Elsevier Applied Science, pp. 233-286.

Bowers, P.M. 1982. The Lisburne Site: analysis and culture history of a multi-component lithic workshop in the Iteriak Valley, Arctic Foothills, Northern Alaska. Anthropological Papers of the University of Alaska, 22(1-2):70-112.

Bowers, P.M. 1983. A Status Report on the Gallagher Flint Station National Historic Landmark. USDOI BLM, Arctic Resource Area, Fairbanks, AK.

Bowers, P.M. 1999. AMS dating of the Area 22 American PaleoArctic Tradition Microblade Component at the Lisburne Site, Arctic Alaska. Current Research in the Pleistocene 16:12-14.

BP Exploration (Alaska) Inc. 1993. Looks Can Kill!: Safety and Polar Bears on the North Slope. BP Exploration (Alaska) Inc., P.O. Box 196612, Anchorage, AK 99519-6612.

BPXA. 1995. Badami Development Project, Project Description and Environmental Assessment. Prepared by BPXA. Available at BPXA, P.O. Box 196612, Anchorage, AK 99519-6612, 125 pp. + appendices.

Britch, R.P., R.C. Miller, J.P. Downing, T. Petrillo, and M. Vert. 1983. Volume II physical processes. *In* B.J. Gallaway and R.P. Britch (eds.). Environmental Summer Studies (1982) for the Endicott Development. LGL Alaska Research Associates, Inc. and Harding Technical Services. Report for SOHIO Alaska Petroleum Company, Anchorage, Alaska. 219 pp.

Britton, M.E. 1957. Vegetation of the Arctic Tundra. *in* : H.P. Hansen ed. Arctic biology. Oregon State University Press, Corvalis, OR. 26-72

Broad, A.C., H. Koch, D.T. Mason, G.M. Petrie, D.E. Schneider, and R.J. Taylor. 1978. Environmental assessment of selected habitats in the Beaufort Sea littoral system. *In:* Environmental Assessment of the Alaskan Continental Shelf. Annual report. NOAA. Boulder, CO.

Broad. A.C. 1977. Environmental assessment of selected habitats in the Beaufort and Chuckchi Sea littoral system. *In:* Environmental Assessment of the Alaskan Continental Shelf. Quarterly report. BLM/NOAA, OCSEAP. Boulder, CO.

Brown, J., R. K. Haugen, and S. Parrish. 1975. Selected climatic and soil thermal characteristics of the Prudhoe Bay region. Pages 3–11 *in* J. Brown, ed. Ecological investigations of the tundra biome in the Prudhoe Bay region, Alaska. Biol. Pap. Univ. Alaska, Spec. Rep. No. 2, Fairbanks.

Buadze, O. and Kvesitadze, G. 1997. Ecotoxicology and Environ. Safety: 36-44.

Bureau of Land Management (BLM). 1979. Beaufort Sea proposed federal/state oil and gas lease sale. Final Environmental Impact Statement. Alaska Outer Continental Shelf Region, BLM, U.S. Dept. of Interior, Anchorage, AK. 3 Vols.

Burgess, R. M. 2000. Arctic Fox. Chapter 8 *in* J. C. Truett and S. R. Johnson (eds.). The natural history of an arctic oil field: Development and the biota. Academic Press, San Diego, CA.

Burgess, R.M., J.R. Rose, P.W. Banyas, and B.E. Lawhead. 1993. Arctic fox studies in the Prudhoe Bay Unit and adjacent undeveloped area, 1992. Unpublished report by Alaska Biological Research, Inc. to BP Exploration (Alaska) Inc., Anchorage. 16p.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, A. A. Stickney, and J. R. Rose. 2000. Wildlife studies in the CD South Study Area, 2000. Final report by ABR, Inc., Fairbanks, AK, for PHILLIPS Alaska, Inc., Anchorage, AK. 84 pp.

Burgess, R. M. 1984. Investigations of patterns of vegetation, distribution and abundance of small mammals and nesting birds, and behavioral ecology of arctic foxes at Demarcation Bay, Alaska. M.S. Thesis, University of Alaska, Fairbanks. 191 pp.

Burgess, R. M., and P. W. Banyas. 1993. Inventory of arctic fox dens in the Prudhoe Bay region, 1992. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK.

Burgess, R. M., and J. R. Rose. 1993. Snow Goose. 1992 Endicott Environmental Monitoring Program. Report for U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska by Science Applications Intl. Corp., Anchorage, AK.

Burgess, R. 2001. Unpublished data. ABR, Inc. Fairbanks, AK

Buttrick, S. C. 1973. The ecological effects of vehicular traffic on frozen tundra. Thesis, Ohio State University, Columbus, Ohio.Burns J.J. and G.A. Seaman. 1985. Investigations of belukha whales in coastal waters of western and northern Alaska. II. Biology and Ecology. R.U. 612, contract NA 81RAC 00049. Rep. From Alaska Dept. of Fish and Game, Fairbanks, AK, for U.S. Nat. Oceanic & Atmos. Admin. 129 pp.

Burns, J.J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi seas. J. Mammal. 51:445-454.

Burns, J.J., and K.J. Frost. 1979. Natural history and ecology of the bearded seal, *Erignathus barbatus*. Environ. Assess. Alaskan Cont. Shelf, Final Rep. Princ. Invest., NOAA, Juneau, AK 19(1983):311-392. 565 pp. NTIS PB85-200939.

Burns, J.J., and K.J. Frost. 1983. Natural history and ecology of the bearded seal, *Erignathus barbatus*. Environ. Assess. Alaskan Cont. Shelf, Final Rep. Princ. Invest., NOAA, Juneau, AK 19(1983):311-392. 565 pp. NTIS PB85-200939.

Burns, J.J., and G.A. Seaman. 1985. Investigations of belukha whales in coastal waters of western and northern Alaska. II. Biology and ecology. R.U. 612, contract NA 81 RAC 00049. Rep. from Alaska Dept. Fish & Game, Fairbanks, AK, for U.S. Nat. Oceanic & Atmos. Admin. 129 pp.

Byrne, L.C., R.J. Ritchie, and D.A. Flint. 1994. Spectacled Eider and Tundra Swan surveys: Kuvlum corridor, Sagavanirktok River to Staines River. Unpubl. Draft Rep. for ARCO Alaska, Inc., Anchorage, Alaska.

Cade, T. J. 1960. Ecology of the peregrine and gyrfalcon populations in Alaska. Univ. Calif. Publ. Zool. 63-151-290.

Cameron, R. D. 1995. Can petroleum development depress the productivity of arctic caribou? Page 36 in Proc. 2nd Int. Arctic Ungulate Conf., Fairbanks, Alas., 13-17 August 1995.

Cameron, R. D., D. J. Reed, J. R. Dau, and W. T. Smith. 1992. Redistribution of calving caribou in response to oil field development on the Arctic Slope of Alaska. Arctic 45:338–342.

Cameron, R. D. and J. M. Ver Hoef. 1996. Declining abundance of calving caribou in an arctic oil-field complex. Proc. Northwest Sect. Meet. Wildl. Soc., 29-31 March 1996, Banff, Alberta. (abstract)

Cameron, R. D., E. Lenart, D. J. Reed, K. R. Whitten, and W. T. Smith. 1995. Abundance and movements of caribou in the oilfield complex near Prudhoe Bay, Alaska. Rangifer 15: 3–7.

Cameron, R. D., and K. R. Whitten. 1979. Seasonal movements and sexual segregation of caribou determined by aerial survey. J. Wildl. Manage. 43: 626–633.

Cameron, R.D., K.R. Whitten, and W.T. Smith. 1992. Redistribution of Calving Caribou in Response to Oil Field Development on the Arctic Slope of Alaska. *Arctic* 45(4):338-342

Campbell J. no date. Report of an archaeological reconnaissance of the Arctic Coast of Alaska and neighboring islands between the mouths of the Colville and Canning Rivers in 1974. Cobbington and Burling, Washington DC.

Cannon, T.C., B.A. Adams, D. Glass, and T. Nelson, 1987. Fish distribution and abundance. Pp. 1-129 in Endicott environmental monitoring program, final reports, 1985. Vol. 6. Report by Envirosphere Co. for Alaska District, U.S. Army Corps of Engineers, Anchorage, AK.

Carey, A.G., Jr. (ed.). 1978. Marine biota (plankton, benthos, fish). Pp. 174-237 *in* Environmental Assessment of the Alaskan Continental Shelf, Interim Synthesis: Beaufort/Chukchi. Outer Continental Shelf Environmental Assessment Program, Boulder, CO.

Carey, A.G. and R .E. Ruff. 1977. Ecological studies of the benthos in the western Beaufort Sea with special reference to bivalve mollusks. In: Polar Ocean. M.J.Dunbar, ed. Arctic Institute of North America. Calgary, Alberta.

Carroll, G. 2001. Personal communication, NSB.

Carruthers, D. R., S. H. Ferguson, and L. G. Sopuck. 1987. Distribution and movements of caribou, *Rangifer tarandus*, in the Central Arctic region of Alaska. Canadian Field-Naturalist 101: 423–432.

Carson, C.E. and K.M. Hussey. 1961. The oriented lakes of Arctic Alaska. Journal of Geology 70:417-439.

Carter, L. D. 1988. Loess and deep thermokarst basins in arctic Alaska. Pp. 706-711 *in* Proceedings of the Fifth International Conference on Permafrost, Trondheim, Norway. Volume 1. Tapir, Trondheim, Norway.

Challinor, J. L., and P. L. Gersper. 1975. Vehicle perturbation effects upon a tundra soil–plant system: II. Effects on the chemical regime. Soil Science Society of America Proceedings 39:689–695.

Chapin III, F. S., and G. R. Shaver. 1981. Changes in soil properties and vegetation following disturbance of Alaskan arctic tundra. Journal of Applied Ecology 18:605–617.

Chesemore, D. L. 1968. Notes on the food habits of arctic foxes in northern Alaska. Canadian Journal of Zoology 46:1127–1130.

Chesemore, D. L. 1975. Ecology of the arctic fox (*Alopex lagopus*) in North America—A review. Pages 143–163. *In:* M.W. Fox, editor. The wild canids: Their sytematics, behavioral ecology and evolution. Van Nostrand Reinhold Co. New York, New York. 508 pp.

Chin, H., M. Busdosh, G.A. Robillard and R.W. Firth, Jr. 1979. Environmental Studies Associated with the Prudhoe Bay Dock- Physical Oceanography and Benthic Ecology. The 1978 studies. Prepared for ARCO Oil and Gas Company by Woodward-Clyde Consultants, Anchorage, AK.

Clark, C.W., W.T. Ellison, and K. Beeman. 1986. A Preliminary Account of the Acoustic Study Conducted During the Spring 1985 Bowhead Whale, *Balaena mysticetus*, Migration off Point Barrow, Alaska. Report of the International Whaling Commission 36. Cambridge, England: International Whaling Commission, pp. 311-317.

Clarke, J.T., S.E. Moore, and D.K. Ljungblad. 1989. Observations on gray whale (*Eschrichtius robustus*) utilization patterns in the northeastern Chukchi Sea, July-October 1982-87. Can. J. Zool. 67(11):2646-2654.

Clarke, J.T., S.E. Moore, and M.M. Johnson. 1993. Observations of beluga fall migration in the Alaskan Beaufort Sea, 1982-87, and northeastern Chukchi Sea, 1982-91.

Clark, D.G. and Tinston, D. J. 1982. Human Toxicol. 1:239-247.

Clough, N. K., P. C. Patton, and A. C. Christiansen (eds.). 1987. Arctic National Wildlife Refuge, Alaska, Coastal Plain Resource Assessment Report and recommendation to the Congress of the United States and final legislative environmental impact statement. U.S. Fish and Wildlife Service, U.S. Geological Survey, and Bureau of Land Management, Washington, D.C. Vol. 1. 208 pp.

Coffing, M.W., and S. Pedersen. 1985. Caribou Hunting: Land Use Dimensions, Harvest Level, and Cultural Aspects of the Regulatory Year 1983-1984 in Kaktovik, Alaska. ADF&G Technical Paper No. 120.

Colonell, J.M. and G.J. Gallaway (eds.). 1990. An Assessment of Marine Evironmental Impacts of West Dock Causeway. Report for Prudhoe Bay Unit Owners represented by ARCO Alaska, Inc. prepared by LGL Alaska Research Associates, Inc. and Environmental Science and Engineering, Inc. Anchorage, Alaska.

Colonell, J.M. and B.J. Gallaway. 1997. Wind-driven transport and dispersion of age-0 arctic ciscoes along the Alaskan Beaufort coast. Pages 90-103 in J. Reynolds, editor. Fish ecology in arctic North America. American Fisheries Society Symposium 19, Bethesda, MD.

Colonell, J.M., and A.W. Niedoroda. 1990. Appendix B. Coastal oceanography of the Alaska Beaufort Sea. Pp. B-1–B-74 *in* Colonell, J.M., and B.J. Gallaway (eds.). An Assessment of Marine Environmental Impacts of West Dock Causeway. Report for the Prudhoe Bay Unit Owners represented by ARCO Alaska, Inc. prepared by LGL Alaska Research Associates, Inc. and Environmental Science and Engineering, Inc. Anchorage, Alaska. 132 pp. + appendices.

Cornish, H.H. and Ryan, R.C. 1965. Tox. Appl. Pharm. 7:767-771.

Council on Environmental Quality (CEQ). 1997. Considering Cumulative Effects Under the National Environmental Policy Act.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Dept. of Interior, Fish and Wildlife Service, FWS/OBS-79-31. 131 pp.

Craig. P.C. 1977a. Ecological studies of anadromous and resident populations of Arctic char in the Canning River drainage and adjacent coastal waters of the Beaufort Sea, Alaska. Arctic Gas Biological Report Series 41. 116 p.

Craig. P.C. 1977b. Arctic char in Sadlerochit Spring, Arctic National Wildlife Refuge. Arctic Gas Biological Report Series 41. 29 p.

Craig, P.C. 1984. Fish Use of Coastal Waters of the Alaskan Beaufort Sea: A Review, Transactions of the American Fisheries Society. May 1984, Vol. 113, No. 3.

Craig, P.C. 1989. An Introduction to Anadromous Fishes in the alaskan Arctic. In: Biological Papers of the University of Alaska, D.W. Norton, ed. Fairbanks, Alaska: University of Alaska Fairbanks, Institute of Arctic Biology

Craig, P.C., Griffiths, W.B., and Johnson, S.R. 1984. Trophic dynamics in an arctic lagoon. *In* P.W. Barnes, D.M. Schell, and E. Reimnitz (eds.). The Alaskan Beaufort Sea: Ecosystems and Environments. Academic Press, New York, NY. Pp. 347-380.

Craig, P.C., and L. Haldorson. 1986. Pacific salmon in the North American Arctic. Arctic 39(1):2-7.

Craig, P.C., and L. Haldorson. 1981. Beaufort Sea barrier-island-lagoon ecological process studies: Final report, Simpson Lagoon (Part 4, Fish). Pp. 384-678 *in* Environmental assessment of the Alaskan Continental Shelf, final reports of principal investigators. Vol.

7. Bureau of Land Management and National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Boulder, CO.

Craig, P.C., and G.J. Mann. 1974. Life history and distribution of arctic cisco (*Coregonus autumnalis*) along the Beaufort Sea coastline in Alaska and the Yukon Territory. Arctic Gas Biological Report Series 20. 27 p.

Craig, P.C., and P.J. McCart. 1974. Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay, AK, and the Mackenzie Delta. Arctic Gas Biological Report Series 15. 36 pp.

Craig, P.C., and P. McCart. 1975. Classification of stream types in Beaufort Sea drainages between Prudhoe Bay, Alaska and the Mackenzie Delta, N.W.T. Arctic and Alpine Research 7:183-198.

Critchlow, K.R. 1983. Fish study. Pages 1-327 in Prudhoe Bay Waterflood Environmental Monitoring Program 1982. Unpubl. Rep. by Woodward-Clyde Consultants. Available at U.S. Army Corps of Eng., Anchorage, AK. 327 pp. + Append.

Cronin, Matthew A., Warren B. Ballard, Joe Truett, and Robert Pollard, 1994. Mitigation of the Effects of Oil Field Development and Transportation Corridors on Caribou, Final Report to the Alaska Caribou Steering Committee, LGL Alaska Research Associates, Inc.

Cummings, W.C., and J.F. Fish. 1971. A synopsis of marine animal underwater sounds in eight geographic areas. U.S. Naval Undersea Res. & Devel. Cent. 97 pp. NTIS AD-A068875.

Curatolo, J. A., and S. M. Murphy. 1986. The effects of pipelines, roads, and traffic on the movements of caribou, *Rangifer tarandus*. Canadian Field-Naturalist 100:218–224.

Curatolo, J. A., and A. E. Reges. 1984. The calving ground of the Central Arctic caribou herd, 1984. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc. 55 p.

Curatolo, J. A., and A. E. Reges. 1986. Caribou use of pipeline/road separations and ramps for crossing pipeline/road complexes in the Kuparuk Oilfield, Alaska, 1985. Final report prepared by Alaska Biological Research, Fairbanks, for ARCO Alaska, Inc., Anchorage. 106 pp

Dames & Moore and J. Lobdell. 1986. Annotated Bibliography: Point Thompson Project. Exxon Company, U.S.A.

Dau, J.R. and R.D. Cameron. 1986a. Effects of a Road System on Caribou Distribution During Calving. *Rangifer* Special Issue: 95-101

Dau, J. R. 1986. Distribution and behavior of barren-ground caribou in relation to weather and parasitic insects. M.S. thesis, Univ. Alaska, Fairbanks. 149 pp.

Davis, R.A. and C.R. Evans. 1982. Offshore distribution and numbers of white whales in the eastern Beaufort Sea and Amundsen Gulf, summer 1981. Rep. from LGL Ltd., Toronto, Ont., for SOHIO Alaska Petrol. Co., Anchorage, AK, and Dome Petrol. Ltd., Calgary, Alb. 76 pp.

Day, R. H. 1998. Predator populations and predation intensity on tundra-nesting birds in relation to human development. Report for U.S. Fish and Wildlife Service, Fairbanks, AK, by ABR, Inc., Fairbanks, AK. 106 pp.

Day, R. H., and J. R. Rose. 2000. Eider surveys at USAF radar sites in northern Alaska, June 2000. Report for U.S. Fish and Wildlife Service, Northern Alaska Ecological Services, Fairbanks, AK, by ABR, Inc., Fairbanks, AK. 16 pp.

Day, R. H., R. J. Ritchie, and D. A. Flint. 1995. Spectacled and Steller's eider surveys at remote Air Force sites in Alaska, 1994. Report for EA Engineering, Science, and Technology, Redmond, WA, and The United States Air Force, Elmendorf AFB, AK, by ABR, Inc., Fairbanks, AK. 81 pp.

Department of the Interior (DOI). 1987. The Arctic National Wildlife Refuge, AK, Coastal Plain Resource Assessment.

DOI. 1998. Northeast National Petroleum Reserve-Alaska. Final Integrated Activity Plan/Environmental Impact Statement.

Derksen, D. V., K. S. Bollinger, D. Esler, K. C. Jensen, E. J. Taylor, M. W. Miller, and M. W. Weller. 1992. Effects of aircraft on behavior and ecology of molting Black Brant near Teshekpuk Lake, Alaska. Unpublished report by U.S. Fish and Wildlife Service and Department of Wildlife and Fisheries, Texas A&M University to U.S. Bureau of Land Management, Fairbanks, Alaska, and U.S. Minerals Management Service, Anchorage, Alaska. 227 pp.

Derksen, D. V., T. C. Rothe, and W. D. Eldridge. 1981. Use of wetland habitats by birds in the National Petroleum Reserve-Alaska. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C. Resource Publication 141. 27 pp.

Dickson, L. D. 1994. Nesting habitat of the Red-throated Loon, *Gavia stellata*, at Toker Point, Northwest Territories. Canadian Field-Naturalist 108:10–16.

Dixon, E. J., 1972. The Gallagher Flint Station, an Early Man site, North Slope, Arctic Alaska. Unpublished Master's thesis, Department of Anthropology, University of Alaska, Fairbanks.

Duane Miller and Associates (DMA). 1997. Geotechnical exploration, Liberty Development Project, Foggy Island Bay, Alaska. Report for BP Exploration (Alaska) Inc., Anchorage, AK.

DMA. 2001. Geotechnical Exploration Embankment Material Source, Point Thomson Development Area, North Slope, Alaska.

EBSI (Exxon Biomedical Sciences Inc.) 1996. Study No. 116894A.

Eberhardt, W. L. 1977. The biology of arctic and red foxes on the North Slope. M.S. Thesis, University of Alaska, Fairbanks. 125 pp.

Eberhardt, L. E., R. A. Garrott and W. C. Hanson. 1983. Den use by arctic foxes in northern Alaska. Journal of Mammalogy 64:97–102.

Eberhardt, L. E., and W. C. Hanson. 1978. Long-distance movements of arctic foxes tagged in northern Alaska. Canadian Field-Naturalist 92:386–389.

Eberhardt, L.E., W.C. Hanson, J.L. Bengtson, R.A. Garrott, and E.E. Hanson. 1982. Arctic fox home range characteristics in an oil-development area. Journal of Wildlife Management 46:183–190.

Ebersole, J. J., and P. J. Weber. 1983. Biological decomposition and plant succession following disturbance on the Arctic Coastal Plain, Alaska. Pages 266–271 *in* Permafrost: Fourth International Conference Proceedings. 17–22 July 1983, University of Alaska, Fairbanks. National Academy Press, Washington, D.C.

Emers, M., J. C. Jorgenson, and M. K. Raynolds. 1995. Response of arctic tundra plant communities to winter vehicle disturbance. Arctic and Alpine Research 73:905–917.

Everett, K. R. 1980. Distribution and properties of road dust along the northern portion of the haul road. Chapter 3 in Environmental engineering and ecological investigations along the Yukon River-Prudhoe Bay haul road, J. Brown and R.L. Berg, editors. CRREL report 80-19. U.S. Army Cold Regions Research Engineering Laboratory, Hanover, New Hampshire. 203 pp.

ENSR. Consulting and Engineering. 1991. Endicott Development Project NPDES Monitoring Program Permit No. AK-003866-1. Sediment quality and benthic macroinvertebrate monitoring, 1990 studies. Unpubl. manus. Available at BP Exploration (Alaska) Inc., Anchorage, AK.ENSR, 1999, Alaska North Slope Eastern Region Monitoring Program, July through September 1999.: Meteorological and air quality monitoring data from Badami station.

ESRI, 1999. ARCNews Online http://www.esri.com/news/arcnews/fall99articles/31-alaska.html

Fairbridge, R.W. 1966. The Encyclopedia of Oceanography, Vol. 1, Reinhold Publishing Co., New York.

Fairweather. 2000. Historical Blowout Study North Slope Alaska. Anchorage, AK: BPXA.

Fall, J.A. and C.J. Utermohle (eds.). 1995. An Investigation of the Sociocultural Consequences of Outer Continental Shelf Development in Alaska II: Prince William Sound. Minerals Management Service, Technical Report 160, Anchorage.

Fancy, S. G., L. F. Pank, K. R. Whitten, and W. L. Regelin. 1989. Seasonal movements of caribou in arctic Alaska as determined by satellite. Canadian Journal of Zoology 67: 644–650.

Fawcett, M., L. Moulton, and T. Carpenter. 1986. Colville River fishes: 1985 biological report. Report by Entrix for ARCO Alaska, Inc. and North Slope Borough. 138 p

Fechhelm, R.G. 1999. The effect of new breaching in a Prudhoe Bay causeway on the coastal distribution of humpback whitefish. Arctic 52:385-393.

Fechhelm, R.G., J.G. Baker, W.B. Griffiths, and D.R. Schmidt. 1989. Localized movement patterns of least cisco (*Coregonus sardinella*) and Arctic cisco (*C. autumnalis*) in the vicinity of a solid-fill causeway. Biol. Pap. Univ. Alaska 24:75–106.

Fechhelm, R.G., J.D. Bryan, W.B. Griffiths, B.J. Gallaway, and W.J. Wilson. 1994. The effects of coastal winds on the summer dispersal of young least cisco (*Coregonus sardinella*) from the Colville River to Prudhoe Bay, Alaska: A simulation model. Can. J. Fish. Aquat. Sci. 51:890-899.

Fechhelm, R.G., and D.B. Fissel. 1988. Wind-aided recruitment of Canadian arctic cisco (*Coregonus autumnalis*) into Alaskan waters. Canadian Journal of Fisheries and Aquatic Science 45:906-910.

Fechhelm, R.G. and W.B. Griffiths. 1990. The effect of wind on the recruitment of Canadian arctic cisco (*Coregonus autumnalis*) into the central Alaskan Beaufort Seas. Canadian Journal of Fisheries and Aquatic Sciences 47(11):2164-2171.

Fechhelm, R.G., W.B. Griffiths, W.J. Wilson, B.A. Trimm, and J.M. Colonell. 1996. The 1995 fish and oceanography study in Mikkelsen Bay, Alaska. Unpublished rep. Sponsored by BP Exploration (Alaska) Inc., P.O. Box 196612, Anchorage, AK 99519. 102pp. + append.

Feder, H.M., D.G. Shaw, and A.S. Naidu. 1976. The arctic coastal environment of Alaska, Vol. 1: The nearshore marine environment in Prudhoe Bay, Alaska. Institute of Marine Science, University of Alaska, Fairbanks, AK. Rept. R-76-7.

Ferguson, D. 1995. New Perspectives on the Proposed Late Pleistocene Occupation of the Gallagher Flint Station (PSM-050), North Slope, Alaska. Report to the Geist Fund Committee, University of Alaska Museum.

Fingas, M.F., W.S. Duval, and G.B. Stevenson. 1979. The Basics of Oil Spill Cleanup. Environmental Emergency Branch, Environmental Protection Service, Environment Canada.

Finley, K.J., G.W. Miller, R.A. Davis and W.R. Koski. 1983. A distinctive large breeding population of ringed seals (*Phoca hispida*) inhabiting the Baffin Bay pack ice. Arctic 36:162-173.

Field, R., F. Gerhardt, J. Tande, G. Balogh, R. McAvinchey, and J. Bart. 1988. Bird–habitat associations on the North Slope, Alaska. 1987 Progress Report. U.S. Fish and Wildlife Service, Alaska Investigations, Branch of Wetlands and Marine Ecology, Anchorage, Alaska. 70 pp.

Flint, P. L., and M. P. Herzog. 1999. Breeding of Steller's Eiders, *Polysticta stelleri*, on the Yukon-Kuskokwim Delta, Alaska. Canadian Field-Naturalist 113: 306–308.

Flint, P. L., R. B. Lanctot, J. C. Franson, T. Hollmen, J. Fischer, J. B. Grand, and B. Howell. 2001. Monitoring Beaufort Sea waterfowl and marine birds. Annual Progress Report prepared by U.S. Geological Survey, Alaska Biological Science Center, Anchorage, AK. 43 pp. + append.

Follmann, E. H. 1989. The importance of advance planning to minimize bear–people conflicts during large-scale industrial and transportation developments in the North. Pages 105–110 *in* M. Bromley, (ed.). Bear–people conflicts: Proceedings of a symposium on management strategies. NWT Department of Renewable Resources, Yellowknife, NWT. 246 pp.

Follmann, E. H., and J. L. Hechtel. 1990. Bears and pipeline construction in Alaska. Arctic 43:103–109.

Frost, K.J. and L.F. Lowry. 1981, Marine Mammals. *In:* Proceedings of a Synthesis Meeting: Beafort Sea (Sale 71) Synthesis, D.W. Norton, and W.M. Sackinger, eds. Chena Hot Spring, AK, April 21-23, 1981. Juneau, AK: USDOC, NOAA, and USDOI, MMS, pp. 43-46.

Frost, K.J. and L.F. Lowry. 1981. Feeding and trophic relationship of bowhead whales and other vertebrate consumers in the Beaufort Sea. Draft report submitted to the Nat. Mar. Fish. Serv., Nat. Mar. Mamm. Lab., Seattle, WA.

Frost, K.J. and L.F. Lowry. 1983. Demersal Fishes and Invertebrated Trawled in the Northeastern Chukchi and Western Beaufort Seas. 1976-1977. NOAA Technical Report NMFS SSRF-764. Seattle, WA: USDOC, NOAA, NMFS, 22 pp.

Frost, K.J. and L.F. Lowry. 1988. Effects of industrial activities on ringed seals in Alaska, as indicated by aerial surveys. W.M. Sackinger and M.O. Jeffires (eds.). Port and Ocean Engineering Under Arctic Conditions. Volume II. Symposium on Noise and Marine Mammals. Geophysical Institute, Univ. Alaska Fairbanks, Fairbanks, AK. Pp. 15-25.

Frost, K.J., L.F. Lowry and J.J. Burns. 1988. Distribution, abundance, migration, harvest, and stock identity of belukha whales in the Beaufort Sea. Pp. 27-40 *in* P.R. Becker (ed.). Beaufort Sea (Sale 97) information update. OCS Study MMS 86-0047. Nat. Oceanic & Atmos. Admin., Ocean Assess. Div., Anchorage, AK. 87 pp.

Frost, K.J., L.F. Lowry, R. Davis, and R.S. Suydam. 1993. Movements and behavior of satellite tagged spotted seals in the Bering and Chukchi Seas. Abstr. 10th Bienn. Conf. Biol. Mar. Mamm., Galveston, TX, Nov. 1993:50. 130 pp.

Frost, K.J., L.F. Lowry, S. Hills, G. Pendleton, and D. DeMaster. 1997. Monitoring distribution and abundance of ringed seals in northern Alaska. Rep. From Alaska Dept. Of Fish and Game, Juneau, AK, to Minerals Management Service, Anchorage, AK. Final Interim Report, May 1996-March 1997. 42 pp.

Fruge, D.J., D.W. Wiswar, L.J. Dugan, and D.E. Palmer. 1989. Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1988. U.S. Fish and Wildlife Service, Fairbanks, AK. 69 p.

Furniss, R.A. 1974. Inventory and cataloging of arctic area waters. Alaska Dept. Fish and Game. Alaska Dept. Fish and Game, Ann. Rep. 15: 1-15.

Galginaitis, M.; C. Chang; K.M. MacQueen; A.A. Dekin, Jr.; and D. Zipkin. 1984. Ethnographic Study and Monitoring Methodology of Contemporary Economic Growth, Socio-Cultural Change and Community Development in Nuiqsut, Alaska. Social and Economic Studies Program Technical Report No. 96. Alaska OCS Region, Minerals Management Service, Anchorage.

Gallaway, B.J. and R. Fechhelm. 2000. Anadromous and amphidromous fishes. P. 349-369 In: J. Truett (ed.) The natural history of an arctic oilfield. Academic Press.

Gallaway, B. J., W. J. Gazey, and L. L. Moulton. 1989. Population trends for the Arctic cisco (Coregonus autumnalis) in the Colville River of Alaska as reflected by the commercial fishery. Biological Papers of the University of Alaska. 24:153-165.

Gallaway, Benny, William Gazey, Joseph Colonell, Alan Niedoroda, and Christopher Herlugson. 1991. The Endicott Development Project – Preliminary Assessment of Impacts from the First Major Offshore Oil Development in the Alaskan Arctic. American Fisheries Society Symposium 11:42-80.

Gallaway, B. J., W. B. Griffiths, P. C. Craig, W. J. Gazey, and J. W. Helmericks. 1983. An assessment of the Colville River Delta stock of Arctic cisco-migrants from Canada? Biological Papers of the University of Alaska 21:4-23.

Garner, G. W., and P. E. Reynolds (eds). 1986. Arctic National Wildlife Refuge Coastal Plain resource assessment: Final report — Baseline study of fish, wildlife, and their habitats. U.S. Fish and Wildl. Serv., Anchorage, Alaska. 2 vols.

Garner, G. W., H. V. Reynolds, M. K. Phillips, G. E. Muehlenhardt, and M. A. Masteller. 1986. Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge. ANWR Progress Report No. FY86-12. Pages 665–690 *in* G. W. Garner and P. E. Reynolds, (eds.). Arctic National Wildlife Refuge coastal plain resource assessment, 1985 update report—Baseline study of the fish, wildlife, and their habitats. Vol. 2. U.S. Fish and Wildl. Service, Anchorage.

Garrott, R. A. 1980. Den characteristics, productivity, food habits, and behavior of arctic foxes in northern Alaska. MS Thesis, Pennsylvania State Univ., State College. 95 pp.

Garrott, R. A., L. E. Eberhardt, and W. C. Hanson. 1983. Summer food habits of juvenile arctic foxes in northern Alaska. J. Wildl. Manage. 47: 540–545.

George, J.C., and B.P. Nageak. 1986. Observations of the Colville River subsistence fishery at Nuiqsut, Alaska. Department of Wildlife Management, North Slope Borough, Barrow, AK. 35 p.

George, J.C., and R. Kovalsky. 1986. Observations of the Kupigruak Channel (Colville River) subsistence fishery, October 1985. Gersper, P. L., V. Alexander, L. A. Barkley, R. J. Barsdate, and P. S. Flint. 1980. The soils and their nutrients. *In*: J. Brown, P. C. Miller, L. L. Tieszen and F. L. Bunnell eds. An arctic ecosystem: the coastal tundra at Barrow, Alaska. Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania, USA. pp.219-254.

Gerarde, H.W. 1960. Toxicology and biochemistry of aromatic hydrocarbons. Elsevier Science Publishers, New York.

Gersper, P. L., V. Alexander, L. A. Barkley, R. J. Barsdate, and P. S. Flint. 1980. The soils and their nutrients. Pp. 219-254 *in*: J. Brown, P. C. Miller, L. L. Tieszen, and F. L. Bunnell (eds.). An arctic ecosystem: the coastal tundra at Barrow, Alaska. Dowden, Hutchinson and Ross, Stroudsburg, PA.

Glass, D., C. Whitmus, and M. Prewitt. 1990. Fish distribution and abundance. Vol. 5. Endicott environmental monitoring survey, 1986. Report by Envirosphere Company for U.S. Army Corps of Engineers, Anchorage, AK. 188 pp.

Gollop, M. A., and R. A. Davis. 1974. Gas compressor noise simulator disturbance to snow geese, Komakuk Beach, Yukon Territory, September, 1972. Arctic Gas Biological Report Series, No. 14: Chapter 8.

Gollop, M. A., J. R. Goldsberry, and R. A. Davis. 1974. Effects of gas compressor noise simulator disturbance to terrestrial breeding birds, Babbage River, Yukon Territory, June, 1972. Arctic Gas Biological Report Series, No. 14: Chapter 2.

Grant, Jonathan and Bruce Thorpe. 1991. Effects of Suspended Sediment on Growth, Respiration, and Excretion of the Soft-Shelled Clam (Mya arenaria), Department of Oceanography, Dalhousie University

Greene, C.R. 1983. Characteristics of underwater noise during construction of Seal Island, Alaska 1982. (Pp. 150-188) *In* B.J. Gallaway (ed.), Biological studies and monitoring at Seal Island, Beaufort Sea, Alaska 1982. Report from LGL Ecological Research Associates Inc., Bryan, TX, for Shell Oil Co., Houston, TX. 150 pp.

Greene, C.R. Jr. 1997. Underice drillrig sound, sound transmission loss, and ambient noise near Tern Island, Foggy Island Bay, Alaska, February 1997. Rep. from Greeneridge Sciences Inc., Santa Barbara, CA, and LGL Alaska Research Associates, Inc., Anchorage, AK, for BP Exploration (Alaska) Inc., Anchorage, AK. 22 pp.

Greene, C.R., Jr., with J.S. Hanna and R.W. Blaylock. 1997. Physical acoustics measurement (Chapter 3, p. 63) *In* W.J. Richardson (ed.), Northstar marine mammal monitoring program. 1996: marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. LGL Rep. 2121-2. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Exploration (Alaska) Inc., Anchorage, AK and Nat. Mar. Fish. Serv., Anchorage, AK and Silver Spring, MD. 245 pp.

Green, J.E., and S.R. Johnson. 1983. The distribution and abundance of ringed seals in relation to gravel island construction in the Alaskan Beaufort Sea. (Pp. 1-28) *In* B.J. Gallaway (ed.), Biological studies and monitoring at Seal Island, Beaufort Sea, Alaska 1982. Report from LGL Ecological Research Associates Inc., Bryan, TX, for Shell Oil Co., Houston, TX. 150 Pp.

Greene, C.R., Jr., and S.E. Moore. 1995. Man-made noise. Pages 101-158 *in*: W.J. Richardson et al., Marine Mammals and Noise. Academic Press, San Diego, CA.

Grider, G.W., Jr., G.A. Robilliard, and R.W. Firth, Jr. 1977. Environmental studies associated with the Prudhoe Bay dock: Coastal processes and marine benthos. Final report by Woodward-Clyde Consultants for Atlantic Richfield Company, Anchorage, AK.

Grider, G.W., Jr., G.A. Robilliard, and R.W. Firth, Jr. 1978. Environmental studies associated with the Prudhoe Bay dock: Coastal processes and marine benthos. Final report by Woodward-Clyde Consultants for Atlantic Richfield Company, Anchorage, AK.

Griffiths, W.B. 1983. Fish. Pp. 176-222 in Environmental Characterization and Biological Use of lagoons in the eastern Beaufort Sea. Report by LGL Ecological Research Assoc., Inc. for NOAA/OCSEAP Office of Marine Pollution Assessment. 434 p.

Griffiths, W.B., P.C. Craig, G.L. Walder, and G.J. Mann. 1975. Fisheries investigations in the coastal region of the Beaufort Sea (Nunaluk Lagoon, Y.T.). Arctic Gas Biological Report Series 34. 219 p.

Griffiths, W.B., J. DenBeste, and P. Craig. 1977. Fisheries investigations in a coastal region of the Beaufort Sea (Kaktovik Lagoon, Barter Island, Alaska). Arctic Gas Biol. Rep. Ser. 40. 190 p.

Griffiths, W.B., R.G. Fechhelm, L.R. Martin, and W.J. Wilson. 1996. The 1995 Endicott Development Fish Monitoring Program. Vol. I: Fish and Hydrography Data Report. Unpubl. rep. by LGL Alaska Research Assoc., Inc. Available at BP Exploration (Alaska) Inc., P.O. Box 196612, Anchorage, AK, 99519. 180 pp. + Append.

Griffiths, W.B., R.G. Fechhelm, L.R. Martin, and W.J. Wilson. 1997. The 1996 Endicott Development fish monitoring program. Vol. I: Fish and hydrography data report. Unpubl. Rep. by LGL Alaska Research Assoc., Inc. Available at BP Exploration (Alaska) Inc., P.O. Box 196612, Anchorage, AK, 99519. 193 pp. + Append.

Griffiths, William B, Robert G. Fechhelm, Benny J. Gallaway, Larry R. Martin, and William J. Wilson. 1995. Abundance Levels of Selected Fish Species, and Temperature and Salinity Patterns in the Sagavanirktok Delta, Alaska, in the Nine Years Following the Construction of the Endicott Causeway, LGL Alaska Research Associates, Inc.

Griffiths, W.B., and B.J. Gallaway. 1982. Prudhoe Bay Waterflood fish monitoring program 1981. Unpubl. Rep. by LGL Alaska Research Associates. Available at U.S. Army Corps of Eng., Anchorage, AK. 143 pp.

Hampton, P. D., and M. R. Joyce. 1985. Kuparuk bird and noise study. Report for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by Entrix, Inc., Anchorage, AK. 343 pp.

Harcharek, J. 1999. Personal communication. North Slope Borough Commission on Inupiat History Language and Culture.

Harris, R.E., G.W. Miller, R.E. Elliott, and W.J. Richardson. 1997. Seals (Chapter 4, p. 42) *In* W.J. Richardson (ed.), Northstar marine mammal monitoring program, 1996: marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. LGL Rep. 2121-2. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK, and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 245 pp.

Harding, L. H. 1976. Den-site characteristics of arctic coastal grizzly bears (*Ursus arctos* L.) on Richards Island, Northwest Territories, Canada. Canadian Journal of Zoology 54:1357–1363.

Hawkins, L. L. 1986. Tundra Swan (*Cygnus columbianus columbianus*) breeding behavior. Thesis, University of Minnesota, St. Paul, Minnesota. 145 pp.

Harwood, L.A., S. Innes, P. Norton, and M.C.S. Kingsley. 1996. Distribution and abundance of beluga whales in the Mackenzie estuary, southeast Beaufort Sea, and west Amundsen Gulf during late July 1992. Can. J. Fis. Aq. Sci. 53(10):2262-2273.

Hazard, Katherine. 1988. "Beluga Whale, *Delphinapterus leucas*." Selected Marine Mammals of Alaska: Species Accounts With Research and Management Reccommendations. Ed. Jack W. Lentfer. Washington, D.C. MMC. pp. 195-217.

Hemming, C.R. 1993. Tundra stream fish habitat investigations in the North Slope oilfields. Alaska Department of Fish and Game, Habitat Restoration Division, Fairbanks. 18 p.

Hemming, C.R. 1996. Fish surveys of selected coastal streams Sagavanirktok River to Bullen Point. 1995. Technical Report No. 96-3. Alaska Department of Fish and Game, Habitat Restoration Division, Fairbanks. 18 p.

Hicks, M. V. 1996. Moose. Federal aid in wildlife restoration management report: Survey-inventory activities 1 July 1993 – 30 June 1995. Alaska Department of Fish and Game, Division of Wildlife Conservation.

Hicks, M. V. 1998. Moose. Federal aid in wildlife restoration management report: Survey-inventory activities 1 July 1995 – 30 June 1997. Alaska Department of Fish and Game, Division of Wildlife Conservation.

Hicks, M. V. 1999. Brown Bear. Federal aid in wildlife restoration management report. Survey-inventory activities 1 July 1996 – 30 June 1998. Alaska Department of Fish and Game, Division of Wildlife Conservation.

Hill, P.S., D.P. DeMaster, and R.J. Small. 1997. Alaska Marine Mammal Stock Assessments. 1996. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-AFSC-78, 150 p.

Hoffman, D., D. Libby, G. Spearman. 1977 Nuiqsut : a study of land use values through time : NPR-A study for the North Slope Borough. North Slope Borough ; Fairbanks, Alaska : Anthropology and Historic Preservation, Cooperative Park Studies Unit.

Hohenberger, C.J., W.C. Hanson, and E.E. Burroughs. 1994. Birds of Prudhoe Bay region, northern Alaska. Western Birds25:73-103.

James, D. 1996. Central Arctic Herd. Pages 19–20 *in* M. V. Hicks, ed. Caribou. Annual performance report of survey–inventory activities, 1 July 1995–30 June 1996. Fed. Aid Wildl. Restor., Grant W-24-4, Study 3.0, Alaska Dep. Fish and Game, Juneau.

Jarrell, G.H. and K. Fredga. 1993. How many kinds of lemmings? A taxanomic overview. Pages 45-57 in N.C. Stenseth and R.A. Ims, (eds.). The Biology of Lemmings, Academic Press, NY.

Jenness, D. 1957. Dawn in Arctic Alaska. University of Minnesota Press, Minneapolis.

Jingfors, K. T. 1980. Habitat relationships and activity patterns of a reintroduced muskox population. M.S. Thesis, University of Alaska, Fairbanks. 116 pp.

Johnson, C. B. 1995. Abundance and distribution of eiders on the Colville River delta, Alaska, 1994. Draft report by Alaska Biological Research, Inc. to ARCO Alaska, Inc., Anchorage. 12 pp.

Johnson, C. B., M. T. Jorgenson, R. M. Burgess, B. E. Lawhead, J. R. Rose, and A. A. Stickney. 1996. Wildlife studies on the Colville River delta, Alaska, 1995. 4th annual report for ARCO Alaska, Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK. 154 pp.

Johnson, C. B., and B. E. Lawhead. 1989. Distribution, movements, and behavior of caribou in the Kuparuk Oilfield, summer 1988. Report for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 71 pp.

Johnson, C. B., W. B. Lentz, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1999b. Alpine Avian Monitoring Program, 1998. First annual report for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 46 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, J. E. Roth, S. F. Schlentner, A. A. Stickney, and A. M. Wildman. 2000a. Alpine Avian Monitoring Program, 1999. Second annual report for PHILLIPS Alaska, Inc., Anchorage, AK, and Anadarko Petroleum Corporations by ABR, Inc., Fairbanks, AK. 86 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1999a. Wildlife studies on the Colville River Delta, Alaska, 1998. Seventh annual report for ARCO Alaska, Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK. 102 pp.

Johnson, C. B., J. R. Rose, J. E. Roth, S. F. Schlentner, A.A. Stickney. Amd A. M. Wildman. 2000. Alpine avian monitoring program, 1999 Final rep., prepared for ARCO Alaska, Inc., and Kuukpik Unit Owners, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Johnson, C.S., M.W. McManus, and D. Skaar. 1989. Masked tonal hearing thresholds in the beluga whale. Journal of the Acoustic Society of America 85(6):2651-2654.

Johnson, P. R., and C. M. Collins. 1980. Snow pads used in pipeline construction in Alaska, 1976: construction, use and breakup. CRREL Report 80-17. U.S. Army Cold Regions Research Engineering Laboratory, Hanover, New Hampshire.

Johnson, S. R. 1994. The status of black brant in the Sagavanirktok River delta area, Alaska, 1991-1993. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc, Anchorage, AK. 19 pp.

Johnson, S. R. 2000. Lesser Snow Goose. Chapter 12, Pages 233–257 *in* Truett, J. C., and S. R. Johnson, eds. The Natural History of an Arctic Oil Field. Academic Press, New York.

Johnson, S. R., and D. R. Herter. 1989. Birds of the Beaufort Sea. BP Exploration (Alaska) Inc., Anchorage, AK. 372 pp.

Johnson, S.R. 1979. Fall observations of westward migrating white whales (*Delphinapterus leucas*) along the central Alaskan Beaufort Sea coast. Arctic 32:275-276.

Johnson, S.R., and D.R. Herter. 1989. The birds of the Beaufort Sea. BP Exploration (Alaska) Inc., Anchorage, AK. 372 pp.

Jorgenson, M.T. and M.R. Joyce. 1994. Six Strategies for Rehabilitaing Land Distributed by Oil Development by Oil Development in Arctic Alaska. *Arctic* 47(4):374-391.

Kalxdorff, Susanne B. 1998. "Distribution and Abundance of Marine Mammal Carcasses along the Beaches of the Bering, Chukchi, and Beaufort Sea, Alaska, 1995-1997." Marine

Mammals Management, Fish and Wildlife Service Region 7, Alaska. U.S. Department of the Interior. pp. 5-9

Kastak, D. and R.J. Schusterman. 1995. Aerial and underwater hearing thresholds for 100 Hz pure tones in two pinniped species. p. 71-79 *In*: R.A. Kastelein, J.A. Thomas and P.E. Nachtigall (eds.), Sensory systems of aquatic mammals. De Spil Publ., Woerden, Netherlands. 588 p.

Kelly, B.P. 1988. Ringed seal, *Phoca hispida*. Pp. 57-76 *in* J.W. Lentfer (ed.). Selected marine mammals of Alaska, species accounts with research and management recommendations. Mar. Mamm. Comm., Washington, DC.

Kertell, K. 1991. Disappearance of the Steller's Eider from the Yukon-Kuskokwim Delta, Alaska. Arctic 44: 177–187.

Kertell, K. 1993. Macroinvertebrate production and waterbird use of natural ponds and impoundments in the Prudhoe Bay Oil Field. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK. 60 pp.

Kertell, K. 1994. Water quality and Pacific Loon breeding biology on natural ponds and impoundments in the Prudhoe Bay Oil Field, Alaska. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Fairbanks, AK. 50 pp.

Kertell, K. 2000. Pacific Loon. Chapter 9, Pages 181–195 *in* Truett, J. C., and S. R. Johnson, eds. The Natural History of an Arctic Oil Field. Academic Press, New York.

Kessel, B. and D.D. Gibson. 1978. Status and distribution of Alaska birds. Studies in Avian Biology 1. Cooper Ornithological Society. Allen Press, Lawrence, KS. 100 pp.

Kertell, K., and R. Howard. 1992. Secondary productivity of impounded wetlands in the Prudhoe Bay Oil Field: Implications for waterbirds. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK. 57 pp.Kertell, K. 1991. Disappearance of the Steller's Eider from the Yukon-Kuskokwim Delta, Alaska. Arctic 44:177-187.

Kiera, E. F. W. 1979. Feeding ecology of Black Brant on the North Slope of Alaska. M.S. Thesis, Western Washington University, Bellingham, Washington. 50 pp.

King, J. G. 1973. The use of small airplanes to gather swan data in Alaska. Wildfowl 24:15–20.

Kinnetic Laboratories, Inc. 1983. Oceanographic Engineering Services, Point Thomson Development Project. Meteorological and oceanographic data.

Klein, D. R., G. D. Yakushkin, and E. B. Pospelova. 1993. Comparative habitat selection by muskoxen introduced to northeastern Alaska and the Taimyr Peninsula, Russia. Rangifer 13:21–25.

Klinger, L.F., D.A. Walker, and P.J. Webber. 1983. The Effects of Gravel Roads on Alaskan Arctic Coastal Plain Tundra. *In:* Permafrost Fourth International Conference Proceedings. 17-22 July 1983, University of Alaska, Fairbanks, AK. Washington DC: National Academy Press, pp 628-33.

Koski, W.R., R.A. Davis, G.W. Miller and D.E. Withrow. 1993. Reproduction. Pp. 239-274 *in* J.J. Burns, J.J. Montague, and C.J. Cowles (eds.). The bowhead whale. Spec. Publ. 2. Soc. Mar. Mamm., Lawrence, KS. 787 pp.

Kunz, M. and R. Reanier. 1994. Paleoindians in Beringia: Evidence from Arctic Alaska. *Science* 263:660-662.

Larned, W. W., T. Tiplady, B. Stehn, and B. Platte. 1999. Eider breeding population survey, Arctic Coastal Plain, Alaska, 1997–1998. U.S. Fish and Wildlife Service, Migratory Bird Management, and Ecological Services, Anchorage, AK. 22 pp

Larned, W., R. Platte, and R. Stehn. 2001. Eider breeding population survey, Arctic Coastal Plain, Alaska, 1999–2000. U.S. Fish and Wildlife Service, Migratory Bird Management, and Ecological Services, Anchorage, AK. 42 pp.

Lawhead, B. E. 1988. Distribution and movements of Central Arctic Herd caribou during the calving and insect seasons. Pages 8–13 *in* Reproduction and calf survival. Proc. 3rd North Am. Caribou Workshop. 4–6 November 1987, Chena Hot Springs, AK. Alaska Dep. Fish and Game, Juneau. Wildlife Tech. Bull. No. 8.

Lawhead, B. E., L. C. Byrne, and C. B. Johnson. 1993. Caribou synthesis, 1987–1990. 1990 Endicott Environmental Monitoring Program Final Report, Vol. V. [released Mar. 1994] Report for U.S. Army Corps of Engineers, Alaska District, Anchorage, AK, by Science Applications International Corp., Anchorage, AK. Various pages.

Lawhead, B. E., and R. D. Cameron. 1988. Caribou distribution on the calving grounds of the Central Arctic Herd, 1987. Report for ARCO Alaska, Inc., and Kuparuk River Unit, Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK, and Alaska Dep. Fish and Game. 59 pp.

Lawhead, B. E., and J. A. Curatolo. 1984. Distribution and movements of the Central Arctic caribou herd, summer 1983. Final report prepared by Alaska Biological Research, Fairbanks, for ARCO Alaska, Inc., Anchorage. 52 pp.

Lawhead, B. E., and L. N. Smith. 1990. Caribou. 1988 Endicott Environmental Monitoring Program Final Report, Vol. IV. [released Apr. 1993] U.S. Army Corps of Engineers, Alaska District, Anchorage. Report for Science Applications International Corp., Anchorage. var. pag.

Lawson, D. E. 1986. Response of permafrost terrain to disturbance: a synthesis of observations from northern Alaska, U.S.A. Arctic and Alpine Research 18:1–17.

Lenart, E.A. 1998. 8 January Memo to D. James, Alaska Dep. Fish and Game, Fairbanks.

Lentfer, J. W. 1972. Polar bear sea-ice relationships. International Conference on Bear Research and Management 2:165-171.

Lentfer, J.W. 1974. Discreteness of Alaska polar bear populations. International Congress of Game Biologists 11:323-329.

Lentfer, J. W. and R. J. Hentzel. 1980. Alaska polar bear denning. *In*: C. J. Martinka and K. L. McArthur, eds. Bears-their biology and management. Fourth International Conference on Bear Research and Management. 1977. Kalispell, Montana. Bear Biology Association Conference Ser. No. 3. pp 101-108.

LGL Alaska Research Associates, Inc. 1990. The Endicott Development fish monitoring program—analysis of 1988 data. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and the North Slope Borough, Barrow, AK.

LGL Alaska Research Associates, Inc. 1991. The Endicott Development fish monitoring program—analysis of 1989 data. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and the North Slope Borough, Barrow, AK.

LGL Alaska Research Associates, Inc. 1992. The Endicott Development fish monitoring program—analysis of 1990 data. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and the North Slope Borough, Barrow, AK.

LGL Alaska Research Associates, Inc. 1993. Yukon Gold transportation corridor-Draft Environmental Assessment. Prepared for BP Exploration (Alaska) Inc., Anchorage, AK.

LGL Alaska Research Associates, Inc. 1993. The Endicott Development fish monitoring program—analysis of 1991 data. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and the North Slope Borough, Barrow, AK.

LGL Alaska Research Associates, Inc. 1994a. The Endicott Development fish monitoring program—analysis of 1992 data. Report for BP Exploration (Alaska) Inc. Anchorage, AK, and North Slope Borough, Barrow, AK.

LGL Alaska Research Associates, Inc. 1994b. The Endicott Development fish monitoring program—analysis of 1993 data. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK.

LGL Alaska Research Associates, Inc. 1999. Aerial Surveys of Molting Waterfowl in the Barrier Island-Lagoon System Between the Stockton Islands and Flaxman Island, Alaska, 1998 .

LGL Alaska Research Associates, Inc. 2000a. 1999 Bullen Point to Staines River Large Mammal Distribution. Large mammal distribution (caribou calving and post-calving, musk oxen, and grizzly bear), mosquito and oestrid activity indices.

LGL Alaska Research Associates, Inc. 2000b. 1999 Point Thomson Unit Nearshore Marine Fish Study. Marine fish survey conducted in Lions Bay.

LGL and Greeneridge. 1996. Northstar marine mammal monitoring program. 1995: Baseline surveys and retrospective analyses of marine mammal and ambient noise data from the central Alaskan Beaufort Sea. LGL Rep. 2101-2. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Exploration (Alaska) Inc., Anchorage, AK. 104 pp.

LGL and Greeneridge. 1997. Marine mammal and acoustical monitoring of BPXA's seismic program in the Alaskan Beaufort Sea. 1997. 90 day report. LGL Rep. TA2150-1. Report from LGL Ltd., King City, Ont., and Greeneridge Sciences, Inc., Santa Barbara, CA, for BP Exploration (Alaska) Inc., Anchorage, AK.

LGL and Greeneridge. 2001. Monitoring of Industrial Sounds, Seals, and Whale Calls During Construction of BP's Northstar Oil Development, Alaska Beaufort Sea, 2000. Draft Report. Report from LGL Ltd., King City, Ont., and Greeneridge Sciences, Inc., Santa Barbara, CA, for BP Exploration (Alaska) Inc., Anchorage, AK and National Marine Fisheries Service, Anchorage, AK and Silver Spring, MD.

LGL Ltd. 1974. Disturbance to birds by gas compressor noise simulators, aircraft, and human activity in the Mackenzie Valley on the North Slope, 1972. Arctic Gas

LGL and Woodward-Clyde Consultants. 1996. The 1995 Fish and oceanography study in Mikkelsen Bay, Alaska. Report to BP Exploration (Alaska) Inc., Anchorage, AK. 102 p + appendices.

LGL Alaska Research Associates, Inc., Woodward-Clyde Consultants, Applied Sociocultural Research. 1998. Liberty Development Project, Environmental Report. General information, affected environment (including socio-economic), environmental consequences, and mitigation measures.

LGL Alaska Research Associates, Inc., Woodward-Clyde Consultants, Lazy Mountain Research, Applied Sociocultural Research, Jack Lobdell and Associates, Northern Economics, Inc., OASIS Environmental, Inc., and HCG, Inc. 1999. Point Thomson Area Development 1998 Environmental Study Results and Baseline Environmental Statement. Prepared for Point Thomson Working Interest Owners, Anchorage, AK. var. pages.

Libbey, D. 1981. Cultural resource site identification. In, *Cultural Resources in the mid-Beaufort Sea Region.* North Slope Borough, Barrow, Alaska.

Ljungblad, D.K., S.E. Moore and J.T. Clarke. 1986. Assessment of bowhead whale (*Balaena mysticetus*) feeding patterns in the Alaskan Beaufort and northeastern Chukchi seas via aerial surveys, fall 1979-84. Rep. Int. Whal. Comm. 36:265-272.

Lobdell, J. 1980. Coastal and Barrier Island Archaeological Localities in the Beaufort Sea of Alaska: Colville to Staines Rivers. Environmental Conservation Dept., ARCO Oil and Gas Company, Anchorage, Alaska.

Lobdell, J. 1992a. Yukon Gold Exploration Wells Archaeological and Cultural Resources Reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage.

Lobdell, J. 1992b. West Staines and South Staines Exploration Wells Archaeological and Cultural Resources Reconnaissance, North Slope, Alaska. Chevron U.S.A., Inc., Houston.

Lobdell, J. 1992c. Central Staines Exploration Wells Field Environmental Review

Lobdell, J. 1992d. Central Creek Pingo: An Arctic Small Tool and Historic Hunting Station of the Arctic Coastal Plain. ARCO Alaska, Inc., Anchorage.

Lobdell, J. 1997a. 1997 BPXA Exploration Program Archaeological and Cultural Resources Reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage.

Lobdell, J. 1997b. 1996 Sourdough Exploration Well Sites Archaeological and Cultural Resources Reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage.

Lobdell, J. 1998. PTAC 1998/99 Exploration and Appraisal Well Sites Archaeological and Cultural Resources Reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage.

Lobdell, J. and G. S. Lobdell. 2000. Final Report: Point Thomson Unit Archaeological and Cultural Resources Reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage.

Lowry, L.F. no date. The spotted seal (*Phoca largha*). Alaska Dept. Fish & Game.

Lowry, L.F. 1993. Foods and feeding ecology. Pp. 201-238 *in* J.J. Burns, J.J. Montague, and C.J. Cowles (eds.). The bowhead whale. Spec. Publ. 2. Soc. Mar. Mamm., Lawrence, KS. 787 pp.

Lowry, L.F. and K.J. Frost. 1984. Foods and feeding of bowhead whales in western and northern Alaska. Sci. Rep. Whales Res. Inst. 35:1-16.

Mackay, D., A. Di Guardo, S. Paterson, and C. Cowan. 1996. Environmental Toxicology and Chemistry 15(9):1627-1637.

MacLean, S. F., B. M. Fitzgerald, and F. A. Pitelka. 1974. Population cycles in arctic lemmings: winter reproduction and predation by weasels. Arctic and Alpine Research 6:1-12.

Macpherson, A. H. 1969. The dynamics of Canadian arctic fox populations. Can. Wildl. Service Rep. Series — No. 8. 52 pp.

Maki, Alan W. 1992. Annual Review of Measured Risks: The Environmental Impacts of the Prudhoe Bay, Alaska, Oil Filed. Evironmental Toxicology and Chemistry, Vol 11, pp. 1691-1707. Pergamon Press Ltd.

Makihara, J. S. 1983. The effects of coal dust on surface albedo and thaw depth in northern Alaska. Abstract in Final Proceedings, Permafrost: Fourth International Permafrost Conference. National Academy Press, Washington, D.C.

Mallory, C.R. 1998. A Review of Alaska North Slope Blowouts, 1974-1997. Document II-9 in Preliminary Analysis of Oil Spill Response Capability in Broken Ice to Support Request for Additional Information for Northstar oil Spill Contingency Plan, Vol. II. Anchorage, AK: BPXA and ARCO Alaska.

Martin, P. D. 1997. Predators and scavengers attracted to locales of human activity. Pages 6-19–6-24 *in* NPR–A Symposium Proceedings. OCS Study MMS 97-0013, U.S. Department of the Interior, Minerals Management Service, Anchorage, Alaska.

Martin, P. D., and C. S. Moitoret. 1981. Bird populations and habitat use, Canning River delta, Alaska. Unpublished report, U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge, Fairbanks, Alaska. 188 pp.

McIntyre, J. W. 1994. Loons in freshwater lakes. Hydrobiologia 279/280:393–413.

McKendrick, J.D. 1981. Response of arctic tundra to intensive muskox grazing. Agroborealis 13:73–79

McKendrick, J. D. 1987. Plant succession on disturbed sites, North Slope, Alaska, USA. Arctic and Alpine Research 19:554-565.

McKendrick, J. D., and W. M. Mitchell. 1978. Fertilizing and seeding oil-damaged arctic tundra to effect vegetation recovery, Prudhoe Bay, Alaska. Arctic 31:296-304.

McLean, I. G. 1985. Seasonal patterns and sexual differences in the feeding ecology of arctic ground squirrels (*Spermophilus parryii plesius*). Canadian Journal of Zoology 63:1298–1301.

McLean, I. G., and A. J. Towns. 1981. Differences in weight changes and the annual cycle of male and female arctic ground squirrels. Arctic 34:249–254.

Miles, P.R., C.I. Malme, and W.J. Richardson. 1987. Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales in the Alaskan Beaufort Sea. BBN Rep. 6509; OCS Study MMS 87-0084. Rep. from BBN Labs Inc., Cambridge, MA, and LGL Ltd., King City, Ontario, Canada, for U.S. Minerals Management Service, Anchorage, AK. 341 pp. NTIS PB88-158498.

Miller, F.L. and A. Gunn. 1979. Responses of Peary Caribou and Muskoxen to Turbo-Helicopter Harrassment, Prince of Wales Island, Northwest Territories 1976-77. Canadian Wildlife Service Occasional Papers No. 40. Ottawa, Ontario, Canada:L Canadian Wildlife Service, 90pp.

Miller, G.W., R.E. Elliott, W.R. Koski, and W.J. Richardson. 1997. Whales (Chapter 5, p. 115) *In* W.J. Richardson (ed.), Northstar marine mammal monitoring program, 1996: marine mammal and acoustical monitoring of the seismic program in the Alaskan Beaufort Sea. LGL Rep. 2121-2. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Exploration (Alaska) Inc., Anchorage, AK and Nat. Mar. Fish. Serv., Anchorage, AK and Silver Spring, MD. 245 pp.

Miller, G. W. R. E. Elliot and W. J. Richardson. 1998. Ringed seal distribution and abundance near potential oil development sites in the central Alaskan Beaufort Sea Spring 1997. Draft Report LGL Limited Report TA2160-3.

Minerals Management Service (MMS). 1987a. Beaufort Sea sale 97 final environmental impact statement. MMS OCS EIS/EA 87-0069. U.S. Dept. of Interior, MMS, Alaska Outer Continental Shelf Region, Anchorage, AK.

MMS. 1987b. Chukchi Sea sale 109 final environmental impact statement. MMS OCS EIS/EA 87-0110. U.S. Dept. of Interior, MMS, Alaska Outer Continental Shelf Region, Anchorage, AK.

MMS. 1990a. Barrow, Nuiqsut, and Kaktovik Public Hearing Transcripts for Beaufort Sea Sale 124, April 17-19, 1990. Beaufort Sea planning area oil and gas lease sale 124. Final Environmental Impact Statement. MMS OCS EIS/EA MMS 90-0063. U.S. Dept. of Interior, MMS, Alaska Outer Continental Shelf Region, Anchorage, AK.

MMS. 1996. Beaufort Sea planning area oil and gas lease sale 144. Final Environmental Impact Statement. MMS OCS EIS/EA MMS 96-0012. U.S. Dept. of Interior, MMS, Alaska Outer Continental Shelf Region, Anchorage, AK.

MMS. 1997a. Beaufort Sea planning area oil and gas lease sale 170. Draft Environmental Impact Statement. MMS OCS EIS/EA MMS 97-0011. U.S. Dept. of Interior, MMS, Alaska Outer Continental Shelf Region, Anchorage, AK.

MMS, 1990. Subsistence Resource Harvest Patterns: Kaktovik, Special Report No. 9.

MMS, 1990. Subsistence Resource Harvest Patterns: Nuiqsut, Special Report No. 8.

MMS. 2001. Liberty Development and Production Plan. Draft Environmental Impact Statement., Volumes 1,2,3.

Mohlman. 1996. Personal communication.

Montgomery Watson (MW). 1997. Liberty Island Route Water/Sediment Sampling. Anchorage, AK: BPXA.

MW. 1998. Liberty Island Route Water/Sediment Sampling, March 18-19, 1998. Anchorage, AK: BPXA.

Moore S.E. and R.R. Reeves. 1993. Distribution and Movement. In: The Bowhead Whale Book, J.J. Burns, J.J. Montague, and C.J. Cowles, eds. Special Publication of The Society of Marine Mammology, 2. Lawrence, K.S.: The Society for Marine Mammology, 313-386

Moitoret, C. S. 1998. Surveys of nesting Common Eiders and other breeding birds on Beaufort Sea offshore islands, 1978–1991. Unpublished report by U.S. Fish and Wildlife Service, Northern Ecological Services, Fairbanks, AK. 21 pp.

Moitoret, C. S., T. R. Walker, and P. D. Martin. 1996. Predevelopment surveys of nesting birds at two sites in the Kuparuk Oilfield, Alaska. Unpublished report by U.S. Fish and Wildlife Service, Northern Alaska Ecological Services, Fairbanks, Alaska.

Monda, M. J., J. T. Ratti, and T. R. McCabe. 1994. Reproductive ecology of tundra swans on the Arctic National Wildlife Refuge, Alaska. J. Wildlife Management 58: 757–773.

Mould, E. D. 1977. Movement patterns of moose in the Colville River area, Alaska. Thesis, University of Alaska, Fairbanks. 82 pp.

Moore, S.E., J.T. Clarke and M.M. Johnson. 1993. Beluga distribution and movements offshore northern Alaska in spring and summer, 1980-84. Rep. Int. Whal. Comm. 43:375-386.

Moulton, L.L. 1989. Recruitment of arctic cisco (*Coregonus autumnalis*) into the Colville Delta, Alaska, in 1985. Biological Papers of the University of Alaska 24:107-111.

Moulton, L.L. 1994. The 1993 Endicott Development fish monitoring program. Vol. II: The 1993 Colville River fishery. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 60 pp. + Append.

Moulton, L.L. 1995. The 1994 Endicott Development fish monitoring program. Vol. II: The 1994 Colville River fishery. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 58 pp. + Append.

Moulton, L.L. 1996. The 1995 Endicott Development fish monitoring program. Vol. II: The 1995 Colville River fishery. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 59 pp. + Append.

Moulton, L.L. 1997. The 1996 Endicott Development fish monitoring program. Vol. II: The 1996 Colville River fishery. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 60 pp. + Append.

Moulton, L.L. 2001. Fish utilization of habitats in the CD-North exploration area, 1999-2000. Report to Phillips Alaska, Inc. Lopez Island, WA. 30p.

Moulton, L.L., and Fawcett. 1984. Oliktok Point fish studies--1983. Report by Woodward-Clyde Consultants, Inc. for Kuparuk River Unit, ARCO Alaska, Inc. Anchorage, AK.

Moulton, L.L., and L.J. Field. 1988. Assessment of the Colville River fall fishery 1985-1987. Report for ARCO (Alaska) Inc., Anchorage, AK.

Moulton, L.L., and L.J. Field. 1991. The 1989 Colville River fishery. The 1989 Endicott Development fish monitoring program (Vol. III). Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 320 pp. + Append.

Moulton, L.L., and L.J. Field. 1994. The 1992 Colville River fishery. The 1992 Endicott Development fish monitoring program (Vol. II). Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 53 pp. + Append.

Moulton, L.L., B.J. Gallaway, M.H. Fawcett, W.B. Griffiths, K.R. Critchlow, R.G. Fechhelm, D.R. Schmidt, and J.S. Baker. 1986. 1984 central Beaufort Sea fish study. Waterflood monitoring program fish study. Report for U.S. Army Corps of Engineers, Alaska District, Anchorage, AK.

Moulton, L.L., L.C. Lestelle, and L.J. Field. 1992. The 1991 Colville River fishery. The 1991 Endicott Development fish monitoring program (Vol. III). Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 49 pp. + Append.

Moulton, L.L., L.C. Lestelle, and L.J. Field. 1993. The 1991 Colville River Fishery. The 1991 Endicott Development fish monitoring program (Vol. III). Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 41 pp. + Append.

Moulton, L.L., L.J. Field, and R. Kovalsky. 1990. The 1988 Endicott Development fish monitoring program. Vol. IV: The 1988 fall gill net fisheries for ciscos in the Colville River, Alaska. Report for BP Exploration (Alaska) Inc., Anchorage, AK, and North Slope Borough, Barrow, AK. 36 pp. + Append.

Muller, S.W. 1947. Permafrost or Permanently Frozen Ground and Related Engineering Problems, p. 223.

Murphy, S. M., and B. A. Anderson. 1993. Lisburne Terrestrial Monitoring Program-The effects of the Lisburne Development Project on geese and swans, 1985-1989. Report for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 202 pp.

Murphy, S. M., and B. E. Lawhead. 2000. Caribou. Chapter 4, Pages 59–84 in J. Truett and S. R. Johnson, eds. The Natural History of an Arctic Oil Field: Development and the Biota. Academic Press, San Diego, CA.

Murphy, S. M., D. E. Russell, and R. G. White. 2000. Modeling energetic and demographic consequences of caribou interactions with oil development in the Arctic. Rangifer, Special Issue No. 12: 1–3.

Murray, D. F., and R. Lipkin. 1987. Candidate threatened and endangered plants of Alaska. University of Alaska Museum, Fairbanks, AK. 76 pp.

Murray, D. F., and R. Lipkin. 1997. Alaska rare plant field guide. U. S. Dept. Interior, Office of Equal Opportunity, Washington, D.C.

Nelson, R.R., J.J. Burns and K.J. Frost. n.d. The bearded seal (*Erignathus barbatus*). Alaska Dept. Fish and Game.

Nerini, M.K., H.W. Braham, W.M. Marquette and D.J. Rugh. 1984. Life history of the bowhead whale, *Balaena mysticetus* (Mammalia: Cetacea). J. Zool., Lond. 204:443-468.

Nickles, J. R., R. Field, J. Parker, R. Lipkin, and J. Bart. 1987. Bird–habitat associations on the North Slope, Alaska. Progress Report, Fiscal Year 1986. U.S. Fish and Wildlife Service, Alaska Investigations, Branch of Wetlands and Marine Ecology, Anchorage, Alaska. 96 pp.

National Marine Mammal Laboratory (NMML). 1998. 1998 Alaska Stock Assessment. From website "http:\\nmml.afsc.noaa.gov/education/cetaceans/bowhead1.htm".

Noel, L. E. 1998. Bullen Point to Staines River large mammal distribution, summer 1997. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK.

Noel, L. E., and D. W. Funk. 1999. Vegetation and land cover in the Point Thomson Unit Area, Alaska, 1998. Final report prepared for BP Exploration (Alaska) Inc., Anchorage, Alaska, by LGL Alaska research Associates, Anchorage, Alaska. 14 pp. plus appendices.

Noel, L. E., and S. R. Johnson. 1997. The status of Snow Geese in the Sagavanirktok River Delta area, Alaska: 1997 monitoring program. Report prepared for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK, and LGL Limited, Environmental Research Associates, Sidney, BC. 20 pp.

Noel, L. E., and S. R. Johnson. 2001a. The Status of Snow Geese in the Sagavanirktok River Delta Area, Alaska: 1999 Monitoring Program. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK, and LGL Limited, Sydney, BC.

Noel, L. E., and S. R. Johnson. 2001b. The Status of Snow Geese in the Sagavanirktok River Delta Area, Alaska: 2000 Monitoring Program. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK, and LGL Limited, Sydney, BC.

Noel, L. E., S. R. Johnson, and P. F. Wainwright. 1999a. Aerial surveys of molting waterfowl in the barrier island-lagoon system between the Stockton Islands and Flaxman Island, Alaska, 1998. Final report prepared for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK, and LGL Limited, Environmental Research Associates, Sidney, BC. 53 pp.

Noel, L. E., S. R. Johnson, and P. F. Wainwright. 2000. Aerial surveys of molting waterfowl in the barrier island-lagoon system between Spy Island and Brownlow Point, Alaska, 1999. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK, and LGL Limited, Environmental Research Associates, Sidney, BC. 64 pp. + append.

Noel, L.E., and J.C. King. 2000. Large mammal distribution in the Badami Study Area, summer 1999. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates. Inc., Anchorage, AK.

Noel, L. E., and J. C. King. 2000a. Bullen Point to Staines River large mammal distribution, summer 1999. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK.

Noel, L. E., and T. L. Olson. 1999a. Bullen Point to Staines River large mammal distribution, summer 1998. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates. Inc., Anchorage, AK.

Noel, L. E., and T. L. Olson. 1999b. Large mammal distribution in the Badami study area, summer 1998. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK.

Noel, L. E.and C. J. Perham. 1999. Nesting status of the Pacific Eider and other barrier island nesting birds on Flaxman Island and the Maguire Islands, Alaska, 1998. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK.

Noel, L. E., C. J. Perham, and S. R. Johnson. 1999c. The status of Snow Geese in the Sagavanirktok River Delta area, Alaska: 1998 monitoring program. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK, and LGL Limited, Environmental Research Associates, Sidney, BC. 22 pp.

Noel, L. E., R. J. Rodrigues, and S. R. Johnson. 2001. Nesting status of the Common Eider and other barrier island nesting birds in the central Alaskan Beaufort Sea, summer 2000. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK. 34 pp. + append.

Noel, L. E., C. T. Schick, and S. R. Johnson. 1996. Quantification of habitat alterations and bird use of impoundments in the Prudhoe Bay Oil Field, Alaska, 1994. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK. 48 pp. + append.

North, M. R. 1986. Breeding biology of Yellow-billed Loons on the Colville River Delta, Arctic Alaska. M.S. Thesis, North Dakota State University, Fargo, North Dakota. 109 pp.

North, M. R., J. L. Schwerin, and G. A. Hiemenz. 1984. Waterbird studies on the Colville River delta, Alaska: 1984 summary report. Unpublished progress report by Office of Special Studies, U.S. Fish and Wildlife Service, Anchorage, Alaska. 18 pp.

North Slope Borough (NSB), 1980. Qiniqtuagaksrat Utuqqanaat Inuuniagninisiqun, The Traditional Land Use Inventory for the Mid-Beaufort Sea, Volume 1.

Ovendon, L. 1986. Hydroseral histories of the Old Crow peatlands, northern Yukon. Ph. D. Dissertation, Univ. of Toronto.

Ouellet, P. 1979. Northern whales [LP phonograph record]. Cat. No. 19. Music Gallery Editions, Toronto, Ont.

Palmer, D.E. and L.J. Dugan. 1990. Fish population characteristics of Arctic National Wildlife Refuge coastal waters, summer 1989.U.S. Fish and Wildlife Service, Fairbanks, AK.

Payne, J.R., G.D. McNabb, L.E. Hachmeister, B.E. Kirstein, J.R. Clayton, C.R. Phillips, R.T. Redding, C.L. Clary, G.S. Smith, and G.H. Farmer. 1987. Development of a Predicting Model for Weathering of Oil in the Presence of Sea Ice. OCS Study, MMS 89-0003. OCSEAP Final Reports of Principal Investigators Vo.. 59 (Nov. 1988). Anchorage, AK: USDOC, NOAA, OCSEAP, and USDOI, MMS, Alaska OCS Region, pp. 147-465.

Pedersen, S., and M.W. Coffing. 1984. Caribou Hunting: Land Use Dimensions and Recent Harvest Patterns in Kaktovik, Northeast Alaska. ADF&G Techinical Paper No. 92.

Pedersen, Sverre. 1990. Caribou Hunting: Land Use Dimensions, Harvest Level, and Selected Aspects of The Hunt During Regulatory Year 1987-88 in Kaktovik, Alaska, Technical Paper No. 172, ADF&G, Division of Subsistence, Technical Paper Series.

Pedersen, S. 1995. An Investigation of the Sociocultural Consequences of Outer Continental Shelf Development in Alaska. Chapter 22 *in* J.A. Fall and C.J. Utermohle (eds.). Social and Economic Studies Program Technical Report No. 160. Alaska OCS Region, Minerals Management Service, Anchorage.

Perham, C. J. 2000. Arctic fox den distribution and activity between the Sagavanirktok and Staines rivers, Alaska, including the Point Thomson Unit area. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates. Inc., Anchorage, AK.

Petersen, M. R., P. L. Flint, W. W. Larned, and J. B. Grand. 1999. Monitoring Beaufort Sea waterfowl and marine birds. Annual Progress Report prepared by U.S. Geological Survey, Alaska Biological Science Center, Anchorage, AK. 33 pp.

Pitelka, F. A. 1957. Some characteristics of microtine cycles in the Arctic. Pages 73–88. *in* H.P. Hansen, (ed.). Arctic biology: 18th Annual Colloquium. Oregon State University Press, Corvallis.

Pitelka, F. A. 1974. An avifaunal review for the Barrow region and the North Slope of arctic Alaska. Arctic and Alpine Research 6:161-184.

Pollard, R. H. 1994. Distribution of large mammals in the Badami Development Area, Alaska, summer 1994. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK.

Pollard, R. H., and L. E. Noel. 1995. Distribution of large mammals between the Sagavanirktok and Staines rivers, Alaska, summer 1995. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK.

Quackenbush, Lori Trent. 1988. "Spotted Seal, *Phoca largha*". Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations._Ed. Jack W. Lentfer. Washington, D.C.: MMC. pp. 107-14.

Quackenbush, L., R. S. Suydam, K. M. Fluetsch, and C. L: Donaldson. 1995. Breeding biology of Steller's eiders nesting near Barrow, Alaska, 1991-1994. Technical Report NAES-TR-95-03. Fairbanks Alaska: USDOI, FWS. 53 pp.

Quakenbush, L. and J.F. Cochrane. 1993. Report on the Conservation Status of the Steller's Eider (*Polysticta Stelleri*), a Candidate Threatened and Endangered Species. Unpublished report. Anchorage, AK: USDOI, FWS. 26 pp.

Quimby, R. 1974. Grizzly bear. Arctic Gas Biological Report Series 24: Chapter 2.

Quimby, R., and D. J. Snarski. 1974. A study of fur-bearing mammals associated with gas pipeline routes in Alaska. Chapter II *in* R. D. Jakimchuk (ed.). Distribution of moose, sheep, muskox and furbearing mammals in northeastern Alaska. Arctic Gas Biological Report Series, Volume Six. Report by Renewable Resources Consulting Services, Ltd.

Quinlan, S.E. and W.A. Lehnhausen. 1982. Arctic Fox, Alopex Lagopus, Predation on Nesting Common Eiders, *Somateria Mollissma,* at Icy Cape, Alaska. *Canadian Field Naturalist* 96 (4):462-466

Racine, C. H. 1977. Tundra disturbance resulting from a 1974 drilling operation in the Cape Espenberg area, Seward Peninsula, Alaska. Unpublished report to U.S. Department of Interior, National Park Service, Anchorage, Alaska.

Ray, C., W.A. Watkins, and J.J. Burns. 1969. The underwater song of *Erignathus* (bearded seal). Zoologica (N.Y.) 54(2):79-83 + plates, phono. record.

Reanier, R. 1995. The Antiquity of Paleoindian Materials in Northern Alaska. *Arctic Anthropology* 32(1):31-50.

Reimintz, E., and D.M. Mauer, 1978, Storm Surges on the Beaufort Sea Shelf, Open File Report 78-593, U.S. Dept. of the Interior, Geological Study, 18 pp.

Reynolds, H. V. 1979. Population biology, movements, distribution and habitat utilization of a grizzly bear population in NPR–A. Pages 129–182. *In:* Studies of selected wildlife and fish and their use of habitats on and adjacent to NPR–A 1977–1978. Vol. 1. NPR–A Work Group 3, Field Study 3, U. S. Department of Interior, Anchorage, Alaska.

Reynolds, P. E. 1992a. Population dynamics of muskoxen on the Arctic Coastal Pla*In:* Productivity and dispersal as a natural regulator of population size in the 1002 area of the Arctic National Wildlife Refuge. Work subunit IVb. Pages 148–164. *in* T.R. McCabe, B. Griffith, N.E. Walsh, and D.D. Young, (eds.). Terrestrial research: 1002 area—Arctic National Wildlife Refuge, interim report, 1988–1990. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Reynolds, P. E. 1992b. Seasonal differences in the distribution and movements of muskoxen (*Ovibos moschatus*) in northeastern Alaska. Rangifer 13:171–172.

Reynolds, P. E. 1995. Patterns of dispersal in an expanding muskox population in northeastern Alaska. Presented at Second International Arctic Ungulate Conference, 13–17 August 1995, Fairbanks, Alaska. [abstract]

Reynolds, P. E., J. D. Herriges, and M. A. Masteller. 1986. Ecology of muskoxen in the Arctic National Wildlife Refuge, Alaska, 1982–1985. Pages 573–631 *in* G. W. Garner, and P. E. Reynolds, (eds.). Arctic National Wildlife Refuge coastal plain resource assessment: 1985 update report—Baseline study of the fish, wildlife, and their habitiats. Vol. 2. ANWR Progress Report No. FY86-2, U.S. Fish and Wildlife Service, Anchorage, Alaska.

Ritchie, R.J. and ABR. personal communication.

Ritchie, R. J. 1991. Effects of oil development on providing nesting opportunities for Gyrfalcons and Rough-legged Hawks in northern Alaska. Condor 93:180–184.

Ritchie, R. J. 2001. Aerial surveys for Brant and Snow Geese, Barrow to Fish Creek delta and Snow Goose banding near the Ikpikpuk River delta, Alaska, 2000. Annual report for North Slope Borough, Dept. of Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 22 pp.

Ritchie, R. J., P. W. Banyas, A. A. Stickney, R. M. Burgess, and J. G. King. 1990. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1989. Report for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 138 pp.

Ritchie, R. J., and R. M. Burgess. 1993. Aerial Surveys for Snow Geese on the Arctic Coastal Plain of Northwest Alaska, 1993. Final report for Department of Wildlife Management, North Slope Borough, Barrow, AK, by Alaska Biological Research, Inc., Fairbanks, AK.

Ritchie, R. J., R. M. Burgess, and R. S. Suydam. 2000. Status and nesting distribution of Lesser Snow Geese, *Chen caerulescens caerulescens*, and Brant, *Branta bernicla nigricans*, on the western Arctic Coastal Plain, Alaska. Canadian Field-Naturalist 114: 395–404.

Ritchie, R. J., and J. G. King. 2000. Tundra Swans. Chapter 10, Pages 197–220 *in* Truett, J. C., and S. R. Johnson, eds. The Natural History of an Arctic Oil Field. Academic Press, New York.

Ritchie, R. J., A. A. Stickney, P. W. Banyas, and J. G. King. 1991. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1990. Report for ARCO Alaska, Inc. and BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 103 pp.

Ritchie, R. J., and A. M. Wildman. 2000. Aerial surveys of cliff-nesting raptors in the National Petroleum Reserve–Alaska (NPR-A), 1999. Report for Bureau of Land Management, Fairbanks, AK, by ABR, Inc., Fairbanks, AK. 39 pp.

Reimintz, E., and D.M. Mauer. 1978. Storm Surges on the Beaufort Sea Shelf, Open File Report 78-593, U.S. Dept. of the Interior, Geological Study, 18 pp.

Reub, G.S., J.D. Durst, and D.R. Glass. 1991. Fish distribution and abundance. Vol. 6, Chap. 1, Part IV. Endicott Environmental Program, final reports, 1987. Unpubl. Rep. by Envirosphere Co. Available at U.S. Army Corps of Eng., Anchorage, AK. 60 pp.

Richardson, W.J. (ed.) 1997. Northstar Marine Monitoring Program, 1996: Marine mammal acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. Final report. LGL Ltd. Report TA 2121-2. Prepared for BP Exploration (Alaska) Inc., Anchorage, AK and National Marine Fisheries Services by LGL, Ltd. And Greeneridge Sciences, Inc.

Richardson, W.J., C.R. Greene Jr., C.I. Malme, and D.H. Thomson. 1995a. Marine mammals and noise. Academic Press, San Diego, CA. 576 pp.

Richardson, W.J., C.R. Greene, Jr., J.S. Hanna, W.R. Koski, G.W. Miller, N.J. Patenaude, and M.A. Smultea. 1995b. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska—1991 and 1994 phases.

OCS Study MMS 95-0051. Rep. from LGL Ltd., King City, Ont., for U.S. Minerals Manage. Serv., Herndon, VA. 539 pp.

Richardson, W.J., J.P. Hickie, R.A. Davis, D.H. Thomson, and C.R. Greene. 1989. Effects of offshore petroleum operations on cold water marine mammals: a literature review. API Publication No. 4485. American Petroleum Institute, Washington, DC. 385 pp.

Richardson, W.J., M.A. Fraker, B. Würsig, and R.S. Wells. 1985. Behaviour of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea: reactions to industrial activities. Biol. Conserv. 32(3):195-230.

Robus, M. A. 1981. Muskox habitat and use patterns in northeastern Alaska. Thesis, University of Alaska, Fairbanks. 116 pp.

Robus, M. A. 1984. Summer food habits of muskoxen in northeastern Alaska. Pages 81–85. *In:* D. R. Klein, R.G. White, and S. Keller, editors. Proceedings First International Muskox Symposium Biological Papers of the University of Alaska, Special Report No. 4, Fairbanks.

Roby, D. D. 1978. Behavioral patterns of barren-ground caribou of the Central Arctic Herd adjacent to the Trans-Alaska Oil Pipeline. Thesis, University of Alaska, Fairbanks. 200 pp.

Rodrigues, R., R. O. Skoog, and R. H. Pollard. 1994. Inventory of arctic fox dens in the Prudhoe Bay oil field, Alaska. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by LGL Alaska Research Associates. Inc., Anchorage, AK.

Rothe, T., and L. Hawkins. 1982. Whistling Swan study — Colville River delta, Alaska. Unpublished report by U.S. Fish and Wildlife Service, Special Studies, Anchorage, Alaska. 5 pp.

Rothe, T. C., C. J. Markon, L. L. Hawkins, and P. S. Koehl. 1983. Waterbird populations and habitats of the Colville River delta, Alaska. 1981 Summary Report. U.S. Fish and Wildlife Service, Special Studies, Anchorage, Alaska. 67 pp.

Roudabush, R.L.1965. Tox. Appl. Pharm. 7:559-565.

Russell, D. E., A. M. Martell, and W. A. C. Nixon. 1993. Range ecology of the Porcupine Caribou Herd in Canada. Rangifer, Special Issue No. 8. 167 pp.

S.L. Ross Environmental Research Ltd. 1998. Blowout and Spill Probability Assessment for the Northstar and Liberty Oil Development Projects in the Alaskan North Slope. Prepared for BP Exploration (Alaska), Inc.

Schell D.M. and S.M. Saupe. 1993. Feeding and Growth as indicated by Stable Isotopes. In: The Bowhead Whale Book, J.J. Burns, J.J. Montague, and C.J. Cowles, eds. Special Publication of the Society for Marine Mammology, 2. Lawrence, K.S.: The society for Marine Mammology, 491-509pp.

Schevill, W.E., and B. Lawrence. 1949. Underwater listening to the white porpoise (*Delphinapterus leucas*). Science 109(2824):143-144.

Schevill, W.E., W.A. Watkins, and C. Ray. 1963. Underwater sounds of pinnipeds. Science 141(3575):50-53.

Schmidt, D.R., W.B. Griffiths, D.K. Beaubien and C.J. Herlugson. 1991. Movement of young-of-the-year arctic ciscoes across the Beaufort Sea coast, 1985-1988. American Fisheries Society Symposium 11:132-144.

Seaman, G. A., G. F. Tande, D. L. Clausen, and L. L. Trasky. 1981. Mid-Beaufort coastal habitat evaluation study: Colville River to Kuparuk River. Report to the North Slope Borough by Alaska Department of Fish and Game. 199p.

Seaman, G.A., K.J. Frost, and L.F. Lowry. 1986. "Investigations of Belukha Whales in Coastal Waters of Western and Northern Alaska. I. Distribution, Abundance, and Movements." Outer Continental Shelf Environmental Assessment Program, Final Reports of Principal Investigators._Vol. 56. Prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration Ocean Assessments Division and U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region. Washington, D.C.: OSDOC. 153-220.

Schlesinger, W. H. 1991. Biogeochemistry: an analysis of global change. Academic Press, San Diego, CA. 443 pp.

Sedinger, J. S., and A. A. Stickney. 2000. Black Brant. Chapter 11, Pages 221–232 *in* Truett, J. C., and S. R. Johnson, eds. The Natural History of an Arctic Oil Field. Academic Press, New York.

Shideler, D. 1999. Grizzly bear use of the Pt. Thomson area cluster, 1999. Report by Alaska Department of Fish and Game, Fairbanks, AK.

Shideler. ADF&G, Personal communication.

Shideler, R., and J. Hechtel. 1993. Oilfield grizzly project—1993 summary. Unpublished report by Alaska Department of Fish and Game, Fairbanks. 6 pp.

Shideler, R., and J. Hechtel. 1995a. Grizzly bear use of oilfields around Prudhoe Bay, Alaska. Paper presented at 10th International Conference on Bear Research and Management, 16–20 July 1995, Fairbanks, Alaska. [abstract]

Shideler, R., and J. Hechtel. 1995b. Grizzly bear use of the North Slope oil fields. Paper presented at North Slope Environmental Studies Conference, 9–10 March 1995, BP Exploration (Alaska) Inc., Anchorage. [abstract]

Shideler, R., and J. Hechtel. 2000. Grizzly bear. Chapter 6, Pages 105–132 *in* J. C. Truett and S. R. Johnson (eds.). The natural history of an arctic oil field: Development and the biota. Academic Press, San Diego, CA.

Simpson, S. G., J. Barzen, L. Hawkins, and T. Pogson. 1982. Waterbird studies on the Colville River delta, Alaska. 1982 Summary Report. U.S. Fish and Wildlife Service, Special Studies, Anchorage, Alaska. 24 pp.

Simpson, S. G., M. E. Hogan, and D. V. Derksen. 1980. Behavior and disturbance of molting Pacific Black Brant in arctic Alaska. Unpublished report by U.S. Fish and Wildlife Service, Anchorage, Alaska. 27 pp.

Sjare, B.L., and T.G. Smith. 1986a. The relationship between behavioral activity and underwater vocalizations of the white whale, *Delphinapterus leucas*. Can. J. Zool. 64(12):2824-2831.

Sjare, B.L., and T.G. Smith. 1986b. The vocal repertoire of white whales, *Delphinapterus leucas*, summering in Cunningham Inlet, Northwest Territories. Can. J. Zool. 64(2):407-415.

Small, R.J. and D.P. DeMaster. 1995. Alaska marine mammal stock assessments 1995. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-AFSC-57. 93 Pp.

Sjolander, S., and G. Agren. 1976. Reproductive behavior of the Yellow-billed Loon *Gavia adamsii*. Condor 78:454–463.

Skoog, R. O. 1968. Ecology of the caribou (*Rangifer tarandus granti*) in Alaska. Ph.D. thesis, Univ. California, Berkeley. 699pp.

Smith, T. G. 1976. Predation of ringed seal pups by the arctic fox. Canadian Journal of Zoology 54: 1610–1616.

Smith, T. G. 1980. Polar bear predation of ringed and bearded seals in the land-fast sea ice habitat. Canadian Journal of Zoology 58:2201-2209.

Smith, K. G., and P. G. Connors. 1993. Postbreeding habitat selection by shorebirds, water birds, and land birds at Barrow, Alaska: A multivariate analysis. Canadian Journal of Zoology 71:1629–1638.

Smith, L. N., L. C. Byrne, C. B. Johnson, and A. A. Stickney. 1994. Wildlife studies on the Colville River delta, Alaska, 1993. Unpublished report by Alaska Biological Research, Inc. to ARCO Alaska, Inc., Anchorage, Alaska. 95 pp.

Smith, T. E. 1989. The role of bulls in pioneering new habitats in an expanding muskox population on the Seward Peninsula, Alaska. Canadian Journal of Zoology 67:1096–1101.

Smith, W. T., and R. D. Cameron. 1992. Caribou responses to development infrastructures and mitigation measures implemented in the Central Arctic region. Pages 79–86 *in* T. R. McCabe, B. Griffith, N. E. Walsh, and D. D. Young, editors. Terrestrial research: 1002 area—Arctic National Wildlife Refuge, interim report 1988–1990. U. S. Fish and Wildl. Serv., Anchorage.

Spatt, P. D. 1978. Seasonal variation of growth conditions on a natural and dust impacted *Sphagnum* (Sphagnaceae) community in northern Alaska. Thesis, University of Cincinnati, Cincinnati, Ohio. 103 pp.

Spatt, P. D., and M. C. Miller. 1981. Growth conditions and vitality of *Sphagnum* along the Alaska Pipeline Haul Road. Arctic 34:48–54.

Spindler, M. A. 1978. Bird populations and habitat use on the Okpilak River delta area, Arctic National Wildlife Range, 1978. Unpublished report by U.S. Fish and Wildlife Service, Arctic National Wildlife Range, Fairbanks, Alaska. 83 pp.

Steffanson, V. 1913. My Life with the Eskimo. New York: Macmillan.

Stehn, R. A., C. P. Dau, B. Conant, and W. I. Butler, Jr. 1993. Decline of Spectacled Eiders nesting in western Alaska. Arctic 46: 264–277.

Stephenson, R. O. 1999. GMU 25A, 25B, 25D, and 26C, Porcupine. Pages 186–198 *in* M. V. Hicks, ed. Management report, survey–inventory activities, 1 July 1996–30 June 1998:

Caribou. Alaska Department of Fish and Game, Federal Aid in Wildlife Restoration Grants W-24-5 and W-27-1, Study 3.0. Division of Wildlife Conservation, Juneau.

Stephenson, R. O. 1993. Subunits 26B and 26C—Central and eastern Arctic Slope. Pages 33–40 *in* S.M. Abbott, (ed.). Muskox. Alaska Department of Fish and Game, Federal Aid in Wildlife Restoration, Survey—Inventory Management Report, 1 July 1990–30 June 1992, Proj. W-23-4 and W-23-5, Study 16.0, Juneau.

Steinhauer, M.S. and Boehm. 1992. The composition and distribution of saturated an aromatic hydrocarbons in nearshore sediments, river sediments, and coastal peat of the Alaskan Beaufort Sea: Implications for detecting anthropogenic hydrocarbon inputs. Marine Environmental Research 33:223-253.

Stickney, A. A., R. J. Ritchie, B. A. Anderson, and D. A. Flint. 1993. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Sagavanirktok River, 1993. Report for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 83 pp.

Stickney, A. A., R. J. Ritchie, B. A. Anderson, and D. A. Flint. 1994. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Sagavanirktok River, 1993. Report for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 62 pp.

Stickney, A. A., R. J. Ritchie, P. W. Banyas, and J. G. King. 1992. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1991. Report for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 81 pp.

Stirling, I. 1988. Attration of Polar Bears *Ursus Maritimus* to Offshore Drilling Sites in the Eastern Beaufort Sea. *Polar Record* 24:1-8

Stirling, I. 1973. Vocalization in the ringed seal (*Phoca hispida*). J. Fish. Res. Board Can. 30(10):1592-1594.

Stirling, I. and P. Andriashek. 1992. Terrestrial maternity denning of polar bears in the eastern Beaufort Sea area. Arctic 45:363-366.

Stirling, I., and W. Calvert. 1979. Ringed seal. Pp. 66-69 *in* Mammals in the Seas. Vol. 2. Pinniped Species Summaries and Report on Sirenians. FAO Fish Ser. 5.

Stirling, I., D. Andriashek, and W. Calvert. 1981. Habitat preferences and distribution of polar bears in the western Canadian arctic. Rep. for Dome Petroleum Ltd. and Can. Wild. Serv. 49 pp.

Stirling, I., D. Andriashek, P. Latour, and W. Calvert. 1975. The distribution and abundance of polar bears in the eastern Beaufort Sea. Beaufort Sea Proj. Tech. Rep. 2., Dept. Environ., Victoria, B.C. 59 pp.

Stirling, I., M. Kingsley and W. Calvert. 1982. The distribution and abundance of seals in the eastern Beaufort Sea, 1974-79. Can. Wildl. Serv. Occas. Pap. 47. 25 pp.

Stirling, I., W. Calvert, and H. Cleator. 1983. Underwater vocalizations as a tool for studying the distribution and relative abundance of wintering pinnipeds in the high Arctic. Arctic 36(3):262-274.

Suydam, R.S., R.P. Angliss, J.C. George, S.R. Braund and D.P. DeMaster. 1995. Revised data on the subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaska Eskimos, 1973-1993. Rep. Int. Whal. Comm. 45:335-338.

Tedrow, J. C. F. 1977. Soils of the polar landscapes. Rutgers University Press, New Brunswick New Jersey, USA.

Tekmarine, Inc, 1983. Point Thomson Coastal Processes Study. Coastal survey and characterization of processes based on quantitative and historical information.

TERA (Troy Ecological Research Associates). 1993. Preliminary characterization of the breeding-season bird community in the vicinity of the Yukon Gold ice pad. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by Troy Ecological Research Associates, Anchorage, AK. 10 pp.

TERA. 1994. Preliminary characterization of summer bird use of the proposed Badami development area. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by Troy Ecological Research Associates, Anchorage, AK.

TERA. 1995. Distribution and abundance of Spectacled Eiders in the vicinity of Prudhoe Bay, Alaska: 1991–1993. Unpublished report to BP Exploration (Alaska) Inc., Anchorage. 20 pp.

TERA. 1999. The Distribution of Spectacled Eiders in the vicinity of the Pt. Thomson Unit. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by Troy Ecological Research Associates, Anchorage, AK.

TERA. 2000. The distribution of Spectacled Eiders in the vicinity of the Pt. Thomson Unit: 1999. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by Troy Ecological Research Associates, Anchorage, AK.

Terhune, J.M. and K. Ronald. 1975. Underwater hearing sensitivity of two ringed seals (*Pusa hispida*). *Can. J. Zool.* 53(3):227-231.

Thienes, H. and Haley, T.J. 1972. Clinical toxicology (5th ed.) Pennsylvania, Lea & Febiger, Philadelphia, 124-127.

Thomson, D.H., and W.J. Richardson. 1987. Integration. Pp. 449-479 *in* W.J. Richardson (ed.). Importance of the eastern Alaskan Beaufort Sea to feeding Bowhead whales, 1985-86. OCS Study MMS 87-0037. Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, for U.S. Minerals Manage. Serv. 547 pp. NTIS PB88-150271.

Thorsteinson, Lyman K., and William J. Wilson. 1983. Anadromous Fish of the Central Alaska Beaufort Sea, National Biological Service and LGL Alaska Research Associates, Inc.

Tornfelt, Evert E. and Michael Burwell 1992. Shipwrecks of the Alaskan Shelf and Shore. Prepared by the Alaska OCS Region, Minerals Management Service, U.S. Department of the Interior. Anchorage, Alaska. OCS Study MMS 92-0002. Database available electronically at http://www.mms.gov/alaska/ref/ships/index.htm.

Trans Alaska Pipeline System Owners (TAPS). 2001. Environmental Report for Trans Alaska Pipeline System Right-of-Way Renewal. Draft Report. Vol. 1 of 2. Sections 1-4.

Treacy, S.D. 1989. Aerial surveys of endangered whales in the Beaufort Sea, fall 1988. OCS Study MMS 89-0033. U.S. Minerals Manage. Serv., Anchorage, AK. 102 pp. NTIS PB90-161464.

Troy Ecological Research Associates. 1994. Preliminary characterization of summer bird use of the proposed Badami development area. Unpubl. rep. by Troy Ecological Research Associates for BP Exploration (Alaska) Inc., Anchorage, AK.

Troy, D. M. 1986. Prudhoe Bay Waterflood Project Environmental Monitoring Program Terrestrial Studies—1984. Report for Envirosphere Company, Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK. 163 pp.

Troy, D. M. 1988. Bird use of the Prudhoe Bay Oil Field during the 1986 nesting season. Report for Alaska Oil and Gas Association, Anchorage, AK, by LGL Alaska Research Associates, Inc., Anchorage, AK. 96 pp.

Troy, D. M. 1994. Distribution and abundance of Spectacled Eiders near Prudhoe Bay. Page 14 *in* North Slope Environmental Studies Conference, Anchorage, Alaska, 14–15 February 1994. BP Exploration (Alaska), Inc., Anchorage, Alaska, and ARCO Alaska, Inc., Anchorage, Alaska.

Troy, D. M. 2000. Shorebirds. Chapter 13, Pages 271–303 *in* Truett, J. C., and S. R. Johnson, eds. The Natural History of an Arctic Oil Field. Academic Press, New York.

Troy, D. M., and T. A. Carpenter. 1990. The fate of birds displaced by the Prudhoe Bay Oil Field: The distribution of nesting birds before and after P-Pad construction. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by Troy Ecological Research Associates, Anchorage, AK. 51 pp.

Truett, J. C., M. E. Miller, and K. Kertell. 1997. Effects of Arctic Alaska oil development on Brant and Snow Geese. Arctic 50: 138–146.

Truett, J.C. (ed). 1993. Guidelines for oil and gas operations in polar bear habitats. U.S. Department of Interior, Minerals Management Service, Washington, D.C. Outer Continental Shelf Study MMS 93-0008. 104 pp.

Truett, J.C. and K. Kertell. 1992. Tundra Disturbance and Ecosystem Production: Implications for Impact Assessment. *Environmental Management* 16:485-494.

Underwood, T.J., J.A. Gorden, M.J. Millard, L.A. Thorpe, and B.M. Osborne. 1995. Characteristics of selected fish populations of Arctic National Wildlife Refuge coastal waters, final report, 1988-1991. U.S. Fish and Wildlife Service, Fairbanks Fishery Research Office, Alaska Fisheries Technical Report Number 28, Fairbanks, AK

Urquhart, D. R. 1973. Oil exploration and Banks Island wildlife: Section D—Arctic fox. Unpub. report by Game Management Division, Government Northwest Territories.

URS Greiner Woodward-Clyde. 1999. Final technical Report, Physical Oceanography of the Point Thompson Unit Area: 1997 and 1998 Regional Studies.

URS. 1999. Physical Oceanography of the Point Thomson Unit Area: 1997 and 1998 Regional Studies, Meteorology, hydrodynamics, hydrographic, bathymetry, and water chemistry in Lions Lagoon.

URS. 2000. Northstar Development 1999 Baseline Ocean Dumping Study. Final Report.

URS. 2000. Point Thomson Unit 1999 Physical Oceanography/Meteorology Baseline Study.

URS. 2001. Liberty Development 2001 Sediment Quality Study. In preparation. U.S. Department of Interior (USDI). 1978. National Petroleum Reserve in Alaska – Ecological profile. Study Report 4. 105c Land-use study. Anchorage, AK. USDOI, BLM. 118 pp.

U.S. Army Corp of Engineers (USACE). 1984. Final environmental impact statement, Prudhoe Bay Oil Field, Endicott Development project. U.S. Army Corp of Engineers, Alaska District, Anchorage, AK.

USACE. 1987. 1985 Final Report for the Endicott Monitoring Program, Volume 3, Oceanographic Monitoring. Prepared by Envirosphere Company, Anchorage, AK, for the U.S. Army Corps of Engineers, Alaska District.

USACE. 1999. Final Report Environmental Impact Statement, Beaufort Sea Oil and Gas Development/ Northstar Project, Vol 3.

USACE Alaska District. 1998. Draft Environmental Impact Statement, Beaufort Sea Oil and Gas Development/ Northstar Project, Vol. 3

U.S. Fish and Wildlife Service (USFWS). 1993. Arctic National Wildlife Refuge river management plan and environmental assessment (draft). U.S. Fish and Wildlife Service. Fairbanks, AK.

USFWS. 1996. Spectacled Eider Recovery Plan. U.S. Fish and Wildlife Service, Anchorage, AK.

USFWS. 1995. Habitat conservation strategy for polar bears in Alaska. Anchorage Alaska.

USFWS, USGS, and BLM. 1987. Arctic National Wildlife Refuge, Alaska, Coastal Plain Resource Assessment.

Wahrhaftig, C. 1965. Physiographic divisions of Alaska. U.S. Geological Survey. Professional Paper 482. 50 pp.

Walker, D. A. 1983. A hierarchical tundra vegetation classification especially designed for mapping in northern Alaska. Pages 1331–1337 *in* Proceedings of the Fourth International Conference on Permafrost, July 17–22, 1983, Fairbanks, AK. National Academy Press, Washington, D. C.

Walker, D.A., D.D. Cate, J. Brown, and C. Racine. 1987. Disturbance and Recovery of Arctic Alaska Tundra Terrain: A Review of Recent Investigations. CRREL Report No. 87-11. Hanover, NH: USDOD, U.S. Army COE CRREL.

Walker, D.A. and K.R. Everett. 1987. Road Dust and It's Environmental Impact on Alaskan Taiga and Tundra. *Arctic and Alpine Research* 19:479-489

Walker, D. A., and K. R. Everett. 1991. Loess ecosystems of Northern Alaska: regional gradient and toposequence at Prudhoe Bay. Ecological Monographs 6:437-464.

Walker, D. A., K. R. Everett, P. J. Webber, and J. Brown. 1980. Geobotanical atlas of the Prudhoe Bay region, Alaska. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory Report 80-14, Hanover, New Hampshire.

Walker, D.A., N.D. Lederer, and M.D. Walker. 1985. Vegetation Changes at Permanent Transects Along the Dalton Highway and the Prudhoe Bay Spine Road. *In:* Baseline Monitoring Methods and Sensitivity Analysis of Alaskan Arctic Tundra, P.J. Webber, D.A. Walker, Komarkova, and J.J. Ebersole, Editors. Final Report to CRREL. Hanover NH: U.S. Army Cold Regions Research and Engineering Laboratory.

Walker, D. A., P. J. Webber, E. F. Binnian, K. R. Everett, N. D. Lederer, E. A. Nordstrand, and M. D. Walker. 1987. Cumulative impacts of oil fields on northern Alaskan landscapes. Science 238:757–761.

Ward, D. and P. Craig. 1974. Catalogue of streams, lakes, and coastal areas in Alaska along routes of the proposed gas pipeline from Prudhoe Bay to the Alaskan Canadian border. Arctic Gas Biological Report Series 19. p.381.

Warnock, N.D., and D.M. Troy. 1992. Distribution and abundance of Spectacled Eiders at Prudhoe Bay, Alaska: 1991. Report by Troy Ecological Research Associates for BP Exploration (Alaska) Inc., Anchorage, AK. 21 pp.

Werbe, E. 1980. Disturbance effects of a gravel highway upon Alaskan tundra vegetation. Thesis, University of Colorado, Boulder, Colorado. 153 pp.

West, R.L., and D.W. Wiswar. 1985. Fisheries investigations on the Arctic National Wildlife Refuge, Alaska, 1984. Pp. 729-777 in G.W. Garner and P.E. Reynolds, editors. Arctic National Wildlife Refuge coastal plain resource assessment: 1984 update report. U.S. Fish and Wildlife Service, Anchorage, AK.

White, C.M. and C.J. Cade. 1971. Cliff-Nesting Raptors and Ravens Along the Colville River in Arctic Alaska. *Living Bird* 10:107-150.

Whitten, K.R. Personal communication.

White, R. G., B. R. Thomson, T. Skogland, S. J. Person, D. E. Russell, D. F. Holleman, and J. R. Luick. 1975. Ecology of caribou at Prudhoe Bay, Alaska. Pages 151–201 *in* J. Brown, ed. Ecological investigations of the tundra biome in the Prudhoe Bay region, Alaska. Biol. Pap. Univ. Alaska, Spec. Rep. No. 2.

Whitten, K. R. 1995. Porcupine Herd. Pages 176–186 *in* M. V. Hicks, ed. Caribou. Management report of survey–inventory activities, 1 July 1992–30 June 1994. Fed. Aid Wildl. Restor., Grants W-24-2 and W-24-3, Stud. 3.0, Alaska Dep. Fish and Game, Juneau.

Whitten, K. R., and R. D. Cameron. 1985. Distribution of calving caribou in relation to the Prudhoe Bay Oil Field. Pages 35–39 *in* A. M. Martell and D. E. Russell, eds. Caribou and human activity. Proc. 1st N. Am. Caribou Workshop. Can. Wildl. Serv. Publ., Ottawa, Ont.

Wildman, A. M. and R. J. Ritchie. 2000. Synthesis of survey information on cliff-nesting raptors and their habitats on the North Slope, with an emphasis on Peregrine Falcons and recommendations for survey needs. Final rep. prepared for U.S. Fish and Wildlife Service, Northern Alaska Ecological Services, Fairbanks, AK, by ABR, Inc., Fairbanks, AK. 84 pp. + appendices.

Wilson, D.E. and D.M. Reeder. 1993. Mammal species of the world. A taxonomic and geographic reference. 2nd edition. Smithsonian Institution Press, Washington, D.C. 1206 pp.

Wiswar, D.W., and R.L. West. 1987. Fisheries investigations on the Arctic National Wildlife Refuge, Alaska, 1984. Pp. 778-800 in G.W. Garner and P.E. Reynolds, editors. Arctic National Wildlife Refuge coastal plain resource assessment: 1985 update report. U.S. Fish and Wildlife Service, Anchorage, AK.

Wolf, M.A.. 1956. Arch. Ind. Hlth. 14:387-398.

Wolfe, S. A. 2000. Habitat selection by calving caribou of the Central Arctic Herd, 1980–95. M.S. thesis, University of Alaska, Fairbanks. 83 pp.

Woodward-Clyde Consultants (WCC). 1981. Environmental Report for Exploration in the Beaufort Sea Federal/State Outer Continental Shelf Lease Sale. Tern Prospect. Prepared for Shell Oil Company. September 24, 1981.

WCC. 1982. Point Thomson Development Environmental Scoping Report. Marine environment, terrestrial environment, and human environment information.

WCC. 1983. Lisburne Development area: 1983 environmental studies. Final report. Report for ARCO Alaska, Inc., Anchorage, AK. 722 pp.

WCC. 1985. Lisburne development environmental studies: 1994. Vol. 2—Caribou, birds, and oceanography. Report for ARCO Alaska, Inc., Anchorage, AK, by Woodward Clyde Consultants, Anchorage, AK.

WCC and ABR. 1983. Terrestrial environmental study for Point Thomson development project. Report for Exxon Company, Thousand Oaks, CA. by Woodward Clyde Consultants, Anchorage, AK, and Alaska Biological Research, Fairbanks, AK.

Woolington, J. D. 1995. Central Arctic Herd. Pages 211–224 *in* M. V. Hicks, ed. Caribou. Management report of survey-inventory activities, 1 July 1992–30 June 1994. Fed. Aid Wildl. Restor., Grants W-24-2 and W-24-3, Stud. 3.0, Alaska Dep. Fish and Game, Juneau.

Wright, J. M., and S. G. Fancy. 1980. The response of birds and caribou to the 1980 drilling operation at the Point Thomson #4 well. Report for Exxon Company, U.S.A., Anchorage, AK, by LGL Ecological Research Associates, Inc., Fairbanks, AK. 62 pp.

Würsig, B., and C. Clark. 1993. Behavior. Pp. 157-199 *in* J.J. Burns, J.J. Montague, and C.J. Cowles (eds.). The bowhead whale. Spec. Publ. 2. Soc. Mar. Mamm., Lawrence, KS. 787 pp.

Würsig, B., E.M. Dorsey, M.A. Fraker, R.S. Payne, W.J. Richardson and R.S. Wells. 1984. Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: surfacing, respiration, and dive characteristics. Can. J. Zool. 62(10):1910-1921.

Würsig, B., E.M. Dorsey, W.J. Richardson and R.S. Wells. 1989. Feeding, aerial and play behavior of the bowhead whale, *Balaena mysticetus*, summering in the Beaufort Sea. Aquat. Mamm. 15(1):27-37.

Zeh, J.E., J.C. George and R. Suydam. 1995. Population size and rate of increase, 1978-1993, of bowhead whales, *Balaena mysticetus*. Rep. Int. Whal. Comm. 45:339-344.

Young, D. D., C. L. McIntyre, P. J. Bente, T. R. McCabe, and R. E. Ambrose. 1994. Nesting by golden eagles on the North Slope of the Brooks Range in Northeastern Alaska. Journal of Field Ornithology 66: 373–379.

This page intentionally left blank